Jan. 13, 1970 M. L. GRODER ET AL 3,489,413

TARGET SCORING SYSTEM

Filed June 28, 1967 2 Sheets-Sheet 1

Fig. 1

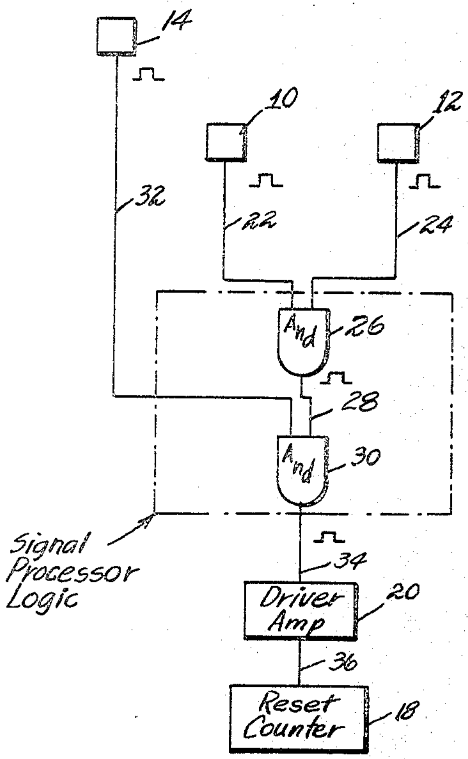


Fig. 3

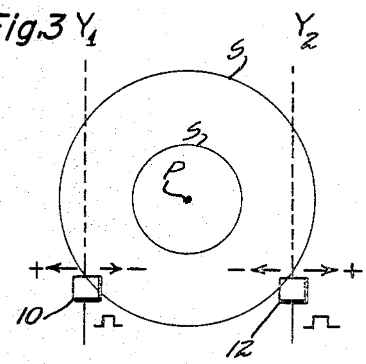


Fig. 4

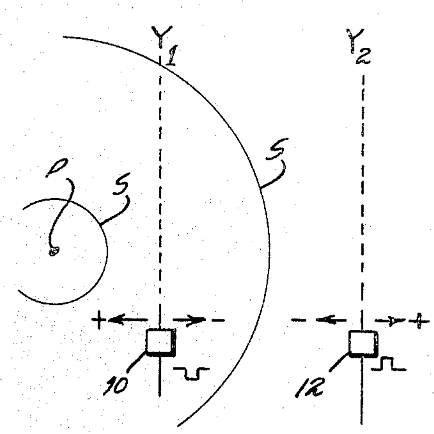


Fig. 5

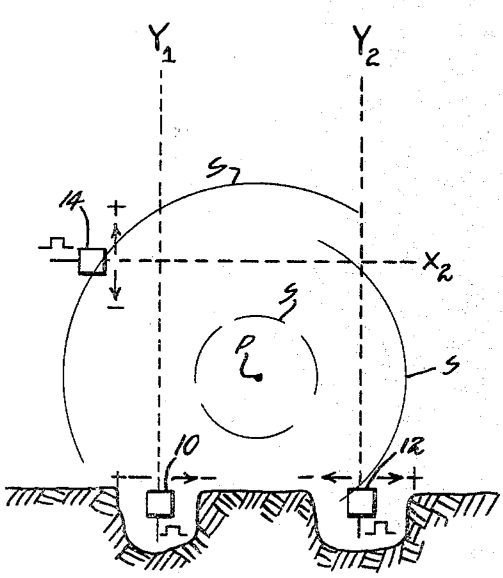
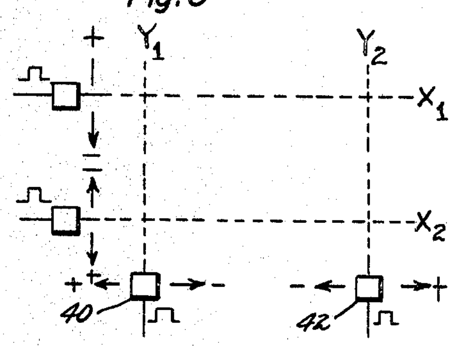


Fig. 6

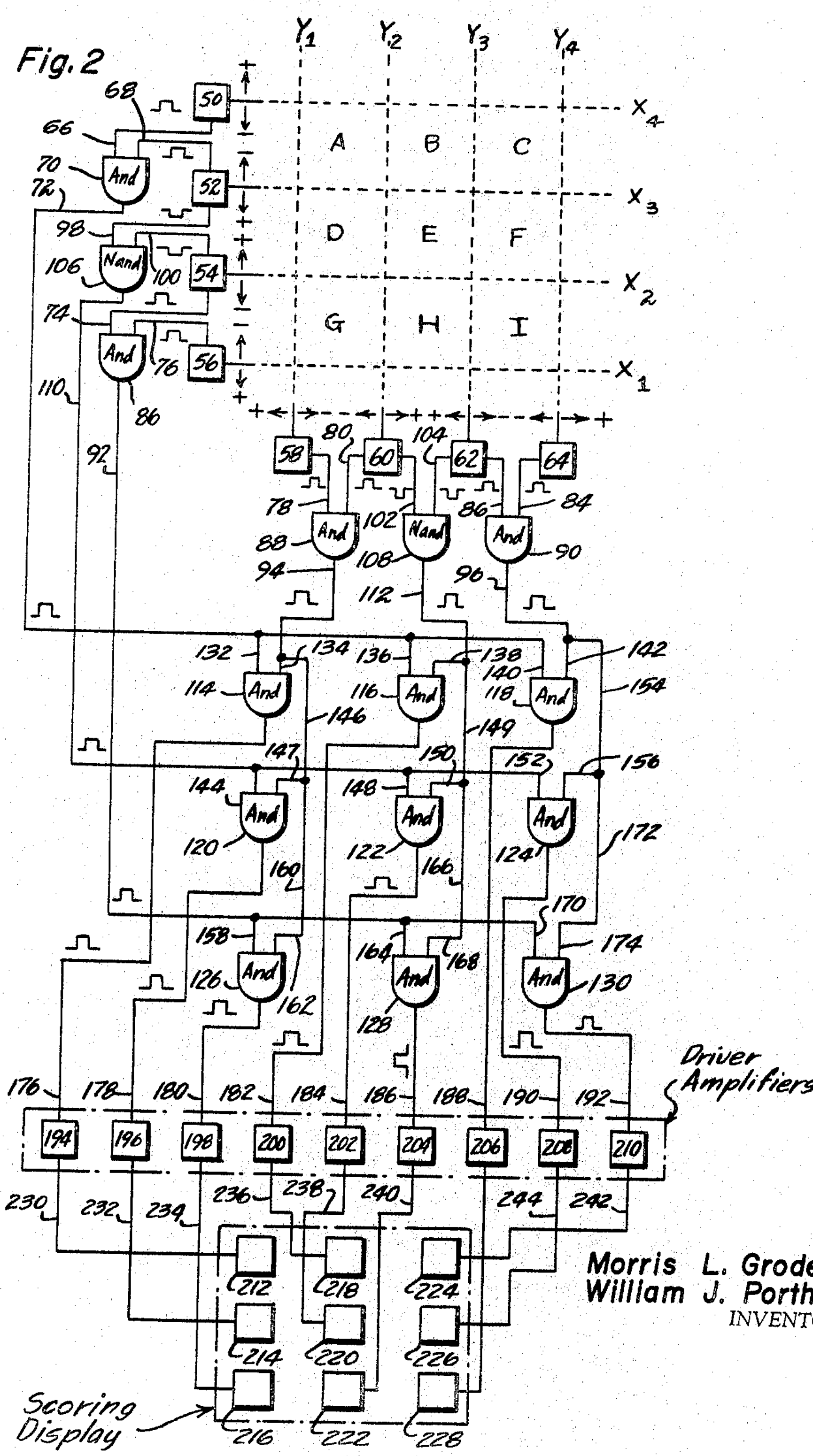


Morris L. Groder
William J. Porthouse
INVENTORS

TARGET SCORING SYSTEM

Filed June 28, 1967

Fig. 2



Morris L. Groder
William J. Porthouse
INVENTORS

United States Patent Office

3,489,413
Patented Jan. 13, 1970

3,489,413
TARGET SCORING SYSTEM

Morris L. Groder, 220 Berkeley Place, Brooklyn, N.Y. 11217, and William J. Porthouse, 1541 Oneco Ave., Winter Park, Fla. 32789

Filed June 28, 1967, Ser. No. 649,749
Int. Cl. A63b *63/00*
U.S. Cl. 273—102.2 8 Claims

ABSTRACT OF THE DISCLOSURE

This invention relates to target scoring systems and more particularly to apparatus, including bi-directional discriminating transducers, arranged to detect the penetration of projectiles through one or more monitored target zones and signal processing and logic means combined with remotely located score display means for providing immediate progressive and cumulative scoring indication.

BACKGROUND OF THE INVENTION

Target systems may be viewed as trifunctional devices. One function relates to the aiming requirement, i.e., that of presenting the trainee with a specific hit area. In actual practice, by way of examples, this may be a paper bullseye, a cardboard silhouette, or a 6′ by 6′ plywood sheet for tank targetry. It is also possible to use a nondestructible aiming target, as for example, a sheet of liquid generated by a circulating-fountain mechanism.

The second target function concerns the method of scoring a hit. A simple technique is that of examining the target for bullet holes to learn whether the projectile intersected the hit area. For rifle ranges, the target may consist of a cardboard silhouette coupled to a detector which is sensitive to the vibrations resulting from a "hit." A vibration responsive mechanism then moves the target down out of sight, thus providing a visual "hit" score. The collective device (target, vibration detector, coupling components, and target moving mechanism) is generally referred to as a pop-up target.

Some scoring systems (miss-distance scoring systems) provide information as to the location and amount of the projectile "miss."

The third target function involves selectivity capability. This refers to the scoring system's ability to reject undesired external signals which would activate the scoring mechanism. Such signals would include air currents (of sufficient force to initiate pop-up target response), heavy shock waves external to the firing-lane-of-interest, and ricochets.

Aiming targets which are used as scoring elements generally suffer from progressive decrease of their utility since they physically deteriorate each times they are impacted by a projectile. In addition, the energy paths to the vibration detectors decrease, resulting in lower reliability. Consequently, projectiles passing through the same hole are also difficult to detect. Also, where targets are lowered into pits, personnel are required to patch bullet holes and manually display hit information.

Disadvantages of pop-up target scoring includes the necessity for (1) a vibration detector which to date has proven relatively unreliable since it is subject to rapid aging, fatigue effects, and environmental erosion, thus leading to frequent servicing; (2) excessive maintenance time; (3) an appreciable number of pit men, target replacement personnel, and lane scorers who may be subject to human errors and other deficiencies; and (4) reconsideration of the systems operational inefficiency due to inactive training time during target repairs and replacement, costs of expendable parts, and rebuttals of

trainees regarding scoring decisions which in turn affects morale.

SUMMARY OF THE INVENTION

The subject invention relates to an improved target scoring system eliminating some and minimizing others of the disadvantages of conventional scoring systems by interconnecting and positioning arrays of bi-directional shock wave sensitive transducers in a manner as is described hereinafter to monitor target zone areas and respond to the shock wave generated by an in-flight projectile passing through the zone; by providing appropriate circuitry to select, condition and process the transducer signals for use in a score display system; and by providing an appropriate display system to provide indication of hit and miss data for readout and progressive storage.

DESCRIPTION OF THE DRAWING

Referring to the accompanying drawing which illustrates, schematically, by way of examples, devices incorporating the invention and utilizing shock wave responsive bi-directional transducers,

FIG. 1 is a diagrammatic view of a target scoring system utilizing three bi-directional transducers to monitor a defined single target zone and provide, remotely, hit indication;

FIG. 2 is a diagrammatic view of a target scoring system utilizing a plurality of bi-directional transducers to monitor a plurality of target zones and provide, remotely, score indication in progressive and cumulative form;

FIGS. 3 and 4 are each diagrammatic views of the arrangement of two bi-directional transducers indicating respectively the hit and miss, effect and response, of the shock waves and transducers;

FIG. 5 is a diagrammatic view of a three-transducer arrangement monitoring a target zone just above ground level; and

FIG. 6 is a diagrammatic view of a four-transducer arrangement for monitoring from elevated position a ground target zone suitable for aerial bombardment.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring initially to FIGS. 3 to 6, there is shown therein several arrays of bi-directional transducers arranged to respond to the shock wave generated by a projectile in flight.

The transducer referred to herein is an energy sensitive device in the sense that the projectile shock wave provides the actuating energy. The bi-directional transducer provides a signal possessing predetermined characteristics when its energy pickup element is activated in either of its two responsive directions. The transducer may be any of several types and forms, as for example, strain gages, fluidic actuators, capacitive devices, electromagnetic devices, resistance devices or piezoelectric devices. The directionality indicating characteristic of the transducer output signal may be one of polarity, amplitude, frequency, phase differential, wave shape or power.

The transducer is used as a shock wave sensitive device capable of providing a signal whose pertinent characteristics are a function of the shock wave direction of arrival. The transducer pertinent output signal characteristics indicate whether the projectile has passed to one side or the other of the transducer's prime responding plane.

Thus, for example, as shown in FIG. 3, two bi-directional piezo-electric element transducers **10** and **12** are positioned to monitor a vertical target zone defined between the vertical lines Y_1 and Y_2. Transducer **10** is selected to provide a positive output pulse when its pickup element (not shown) is stressed to the left and transducer

12 is selected to produce a positive output pulse when its pickup element is stressed to the right. Thus, as shown in FIG. 3, a projectile indicated at P and producing shock waves indicated at S, actuates transducers 10 and 12 to provide positive pulse outputs which, as will be described, can be used to actuate an AND gate and a hit indicator.

As shown in FIG. 4, a projectile P passing to the left of the monitored area produces shock waves S developing a negative pulse from transducer 10 and a positive pulse from transducer 12 which outputs can be used to activate an OR gate to indicate a hit or simply not activate an AND gate and thereby indicate a miss.

In FIG. 5 is shown the use of the transducers 10 and 12 at a location below ground level (indicated) and the use of a third transducer 14 located above ground level to define, between the lines Y_1, Y_2, X_2, and ground level, a target zone. In this instance a projectile P passing through the target zone defined creates shock waves S which activates the bi-directional transducers to produce output pulses from the transducers 10, 12 and 14 which are each positive.

FIG. 1 shows a complete target system utilizing the bi-directional transducers 10, 12 and 14 in accordance with the subject invention. In FIG. 1, the positive output pulse signals from transducers 10, 12 and 14 are passed through an appropriate signal processor and logic circuitry indicated at 16 to select, condition and process the transducer signals for use in a display system which may comprise a reset counter 18 and a driver amplifier 20. It is to be understood that some conventional reset counters include built-in driver amplifier means, in which case the separate driver amplifier shown is omitted. In FIG. 1, the positive pulses indicated of the transducers 10 and 12 are passed on lines 22 and 24 to an AND gate 26 to feed on line 28 a positive output pulse (indicated) to a second AND gate 30. The positive pulse output (indicated) of transducer 14 is passed on its output line 32 to gate 30. Thus, the positive pulses from the transducers 10, 12 and 14 actuate AND gate 30 to produce on line 34 a positive actuating pulse (indicated) which is amplified in driver 20 and passed on line 36 to reset counter 18 to indicate a hit. Counter 18 is repeatedly actuated, responsive to "hits" in the target zone to provide immediate score data indication for readout or storage and is resettable for repeated use. It is to be understood that lights or other display systems could be used in place of a reset counter. Also, the logic circuitry can be arranged through OR gate so that when an initial wave form having a negative polarity is derived from any of the scorer transducers, a "miss" display will be activated.

The subject invention in addition to its useful application to ground oriented projectiles is also useful in air-to-ground target application. Thus, as shown in FIG. 6, four bi-directional transducers 40, 42, 44 and 46 are mounted on towers (not shown) above the earth to define a target zone, indicated by the lines Y_1, Y_2 and X_1, X_2. In this case, the positive pulses (indicated) resulting from a hit in the target zone are passed in pairs (i.e., the pulses from transducers 40 and 42 and the pulses from 44 and 46) through AND gate means (not shown) and driver and display circuitry (not shown) to provide hit indication. This circuitry is omitted as substantially a repetition of circuitry to be described in relation to the circuit of FIG. 2 now to be described.

Referring to FIG. 2, there is shown a complete target scoring system incorporating the invention and monitoring a plurality of target zones A through I defined by the lines Y_1 to Y_4 and X_1 to X_4. In this arrangement, bi-directional transducers 50, 52, 54 and 56 are provided to monitor the overall zones between the lines X_1 through X_4 and transducers 58, 60, 62 and 64 are provided to monitor the overall vertical zones between the lines Y_1 through Y_4. Transducers 50 and 52 are oriented in relation to each other to provide positive output pulses (indicated) on lines 66 and 68 in response to a hit in zones A, B or C and an AND gate 70 is connected to receive the positive pulses and provide on line 72 a positive output pulse (indicated). In the same manner, the transducers 54–56, 58–60 and 62–64 monitor the respective zones GHI, GDA, and IFC, producing for hits in said respective zones, positive output pulses on lines 74–76, 78–80, and 82–84 connected respectively to AND gates 86, 88 and 90, producing positive output pulses on AND gate output lines 92, 94 and 96. The remaining associated pairs of transducers 52–54, monitoring target zones DEF, and 60–62 monitoring target zones HEB, are arranged to produce negative pulses on lines 98–100 and 102–104 to which NAND gates 106 and 108 are respectively connected. The output pulses from NAND gate 106 on line 110 and from NAND gate 108 on line 112 are positive. Additional AND gates 114, 116, 118, 120, 122, 124, 126, 128 and 130 are connected respectively through lines 132–134, 136–138, 140–142, 144–146–147, 148–149–150, 152–154–156, 158–160–162, 164–166–168, and 170–172–174 to the output lines of gates 70, 106, 86, 88, 108 and 90 as shown to provide display activating pulses derived from each of the monitored target zones A through I.

The outputs of the AND gates 114, 116, 118, 120, 122, 124, 126, 128 and 130 are passed on respective output lines 176, 178, 180, 182, 184, 186, 188, 190 and 192 to respective driver amplifiers 194, 196, 198, 200, 202, 204, 206, 208 and 210. The above mentioned drivers are connected to reset counters 212, 214, 216, 218, 220, 222, 224, 226 and 228 respectively by lines 230, 232, 234, 236, 238, 240, 242, 244 and 246.

In the above described arrangement shown in FIG. 2, a "hit" in the respective target zones A, B, C, D, E, F, G, H and I activates the respective counters 212, 214, 216, 218, 220, 224, 226 and 228.

As an aid in understanding the operation of the target system as above described and as shown in FIG. 2, several examples of projectile penetration of target zones will now be described. Thus, projectile penetration of zone A through the shock wave of the projectile energizes transducers 50 and 52 to produce respectively on lines 66 and 68 positive pulses (indicated). The positive pulses thus produced actuate the AND gate 70 to produce on line 72 a positive pulse. The same target zone A is also monitored by transducers 58 and 60, which produce respectively on lines 78 and 80, positive pulses which activate AND gate 114 and produce a positive pulse on line 94.

The positive pulse from line 72 is passed through line 132 to AND gate 114. The positive pulse from line 94 is fed through line 134 to AND gate 114. Thus, AND gate 114 is activated to pass a positive pulse on line 176 to driver amplifier 194 which amplifies the signal and passes the amplified signal on line 230 to the reset counter 212. Thus, for a projectile penetration of target zone A, counter 212 is actuated to indicate and store the "hit."

Target zone D is monitored by transducers 52 and 54 and 58 and 60. Responsive to projectile penetration of zone D, transducers 52 and 54 pass negative pulses to NAND gate 106 which passes a positive pulse to AND gate 120. At the same time, transducers 58 and 60 activate AND gate 88 and pass on lines 94, 146 and 147 a positive pulse to AND gate 120. The positive pulse output from AND gate 120 passing on line 178 is amplified in driver amplifier 196 and passed on line 232 to actuate reset counter 214. Thus, a score in zone D is indicated and stored in counter 214. In the same manner each score in the target zones A through I is immediately indicated and stored in the respective counters 212, 214, 216, 218, 220, 222, 224, 226 and 228.

Since the moving transducer element, for example the needle (not shown) on the piezoelectric element bi-directional transducer, will return to its initial position and in the process generate a signal of opposite polarity, the conditioning and processing circuitry is selected and arranged so that only the initial signal is effective to actuate the

AND and NAND gate circuitry. The processing circuit of FIG. 2 is so arranged.

It is to be noted that the transducers need not necessarily be oriented in positions parallel or perpendicular to the aiming target (not shown) edges. This is due to both the gray area and the directional sensitivity characteristics provided by the transducer. The transducers may be oriented off-line to provide outputs which produce more positive hit (or miss) sensitivities and accuracies.

The aiming target (not shown) may be a visible material which presents to the trainee's eye a hit area or areas coincident with or close to the monitored target zones. Through use of this invention, the material target is still useful although it may have been too far damaged for scoring use.

In cases where shock wave perimeters are not circular, delay lines, physical shock wave forming shapes and similar wave shaping devices may be used in conjunction with transducers to effect signals so that the circular wave input is simulated. For example, if the environment distorts the waveform by conducting the shock wave faster to one particular transducer, a delay may be placed in the transducer circuit to compensate for the time distortion.

Ricochets may be identified by circuits sensitive to characteristic parameters such as direction of arrival, angle of arrival, time of arrival, energy content or signature.

The subject invention then is useful in extending the effective life of targets, by enabling heavily damaged targets to continue their function as aiming targets. The invention is also useful in effectively increasing training time by minimizing trainee standby during damaged target replacement or repair. Costs are decreased, as are the manpower requirement for maintaining and servicing pop-up devices. Reliability and positive hit-miss identification are increased through improved display and storage means. The invention also provides a non-mechanical substitute for the unreliable, inaccurate vibration sensor presently used with pop-up mechanisms. The hit signal available from the logic can be conditioned through driver amplifier means to drive a pop-up mechanism (not shown) The invention is also useful in its capability of providing a three-dimensional scoring target system for realistic as well as for blank fire training simulation.

It will be understood that various changes in the details, materials, and arrangements of parts, which have been herein described and illustrated 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.

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 of any royalties thereon or therefor.

What is claimed is:

1. Apparatus for detecting the penetration of a projectile through a target zone comprising:
   (a) transducer means including at least one pair of bi-directional transducers, each capable of producing positive and negative electrical signals dependent in polarity upon the direction of shock wave actuation and positioned to sense the passage of the projectile through said zone and provide a pair of predetermined polarized transducer output signals;
   (b) actuating means including gate means responsive to said pair of predetermined polarized transducer signals to provide in actuating output signal; and
   (c) scoring means including an indicator element responsive to said actuating output signal for indicating said penetration.

2. Apparatus in accordance with claim 1:
   (a) said transducer means including an additional bi-directional transducer positioned to further define and maintain said target zone and provide an additional actuating signal;
   (b) said scoring means including an additional gate means connected to receive and codify said actuating signals and provide an output signal to activate said indicator element.
3. Apparatus according to claim 1:
   (a) said transducer means including a plurality of pairs of bi-directional transducers positioned to monitor several respective target zones and provide pairs of transducer output signals;
   (b) said gate means including a gating element for and responsive to each pair of transducer output signals to produce an actuating signal from each gate; and
   (c) said scoring means including several indicator elements and a plurality of additional gate means each responsive to a pair of said actuating signals to provide codification of each target zone and actuate an associated one of said indicator elements.
4. Apparatus according to claim 1:
   (a) said indicator means being a reset counter.
5. Apparatus according to claim 2:
   (a) said indicator means being a reset counter.
6. Apparatus according to claim 3:
   (a) said indicator elements being reset counters.
7. Apparatus according to claim 1:
   (a) said transducer means including a plurality of shock wave responsive bi-directional transducers arranged in angularly disposed groups of adjacent transducers to monitor a plurality of target zones;
   (b) adjacent transducers being positioned to produce output pulse signals of uniform polarity responsive to a projectile shock wave produced in a monitored target zone therebetween;
   (c) said actuating means including a plurality of gating elements each connected to a pair of transducers to provide actuating signals;
   (d) said scoring means including additional gate elements connected to respond to pairs of said actuating signals to codify and actuate said indicator elements in correspondence to the target zone penetrated by the projectile.
8. Apparatus according to claim 7:
   (a) said indicator elements being reset counters to provide immediate progressive scoring.

References Cited

UNITED STATES PATENTS

2,448,587	9/1948	Green.
2,783,047	2/1957	Faxen.
2,925,582	2/1960	Mattei et al.
3,047,723	7/1962	Knapp.
3,061,727	10/1962	Roth et al.

FOREIGN PATENTS

562,468	11/1957	Belgium.

ANTON O. OECHSLE, Primary Examiner

M. R. PAGE, Assistant Examiner

U.S. Cl. X.R.

340—16