

[54] MOVING TARGET SCREEN

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[51] Int. Cl. **F41g 11/00**

[58] Field of Search 37/25; 273/101.1; 353/11,
353/29, 35, 43-44

[56] **References Cited**

UNITED STATES PATENTS

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[57]

ABSTRACT

An electro-optical indoor training device which permits operators of one or more laser carrying weapons to aim at a realistic simulated target scene presented by a motion picture film projector. Each frame of the film contains a first portion representing a scene including at least one target area at which the laser beam of any given weapon should be directed and a second portion which is substantially opaque to laser radiation except for a transparent region thereof corresponding in location exactly to the location of the target area in the first portion of the film frame. Each weapon has a low power laser attached thereto which can be excited by actuating the weapon trigger and by automatic electronic delay, thereby firing the laser at previously determined time intervals; the laser beam, if properly aimed at preselected areas of the target scene on the projection screen, will be focused onto hit detection means, whereas an improperly aimed laser beam will impinge upon attempt detection means. Attempts and hits for all involved weapons are scored on an individual basis by electronic display means and electronic multiplexing means (when more than one weapon is to be fired) for synchronizing non-concurrent firing of the various weapons with film frame projection.

8 Claims, 10 Drawing Figures

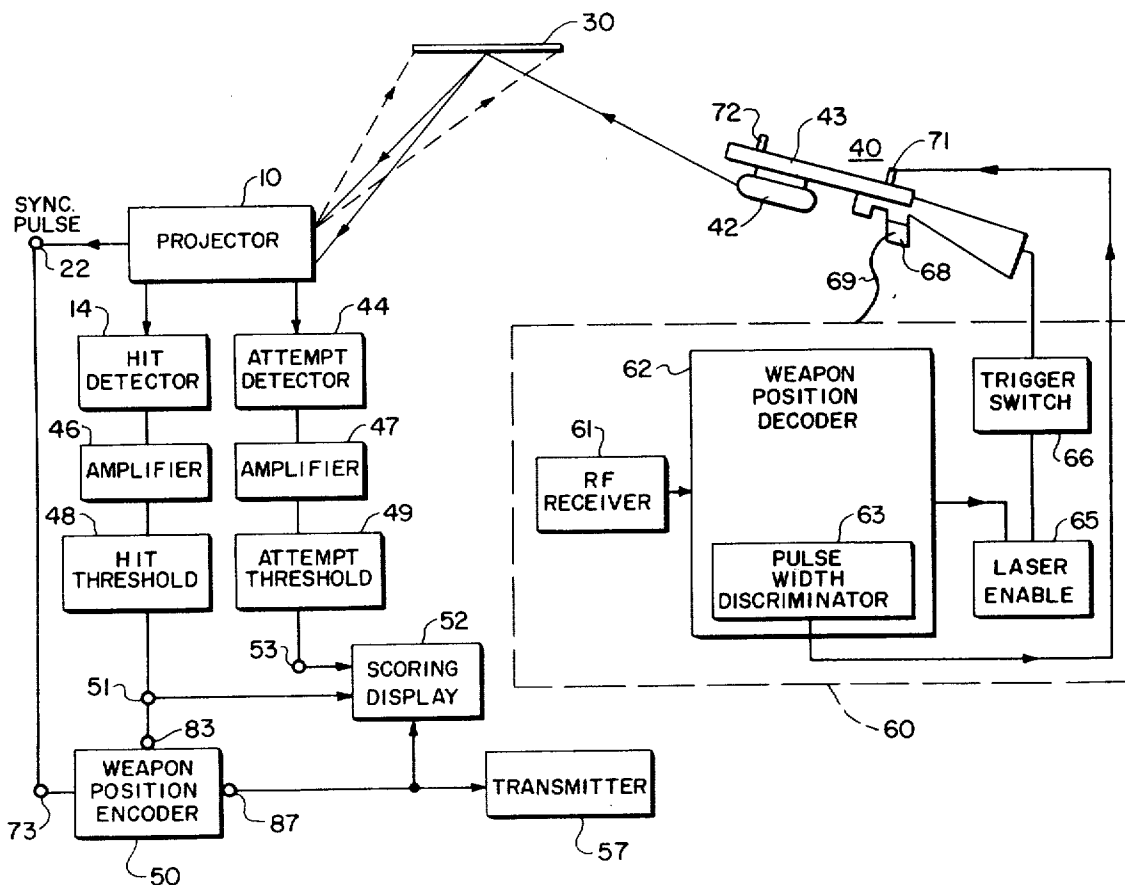


FIG. 1

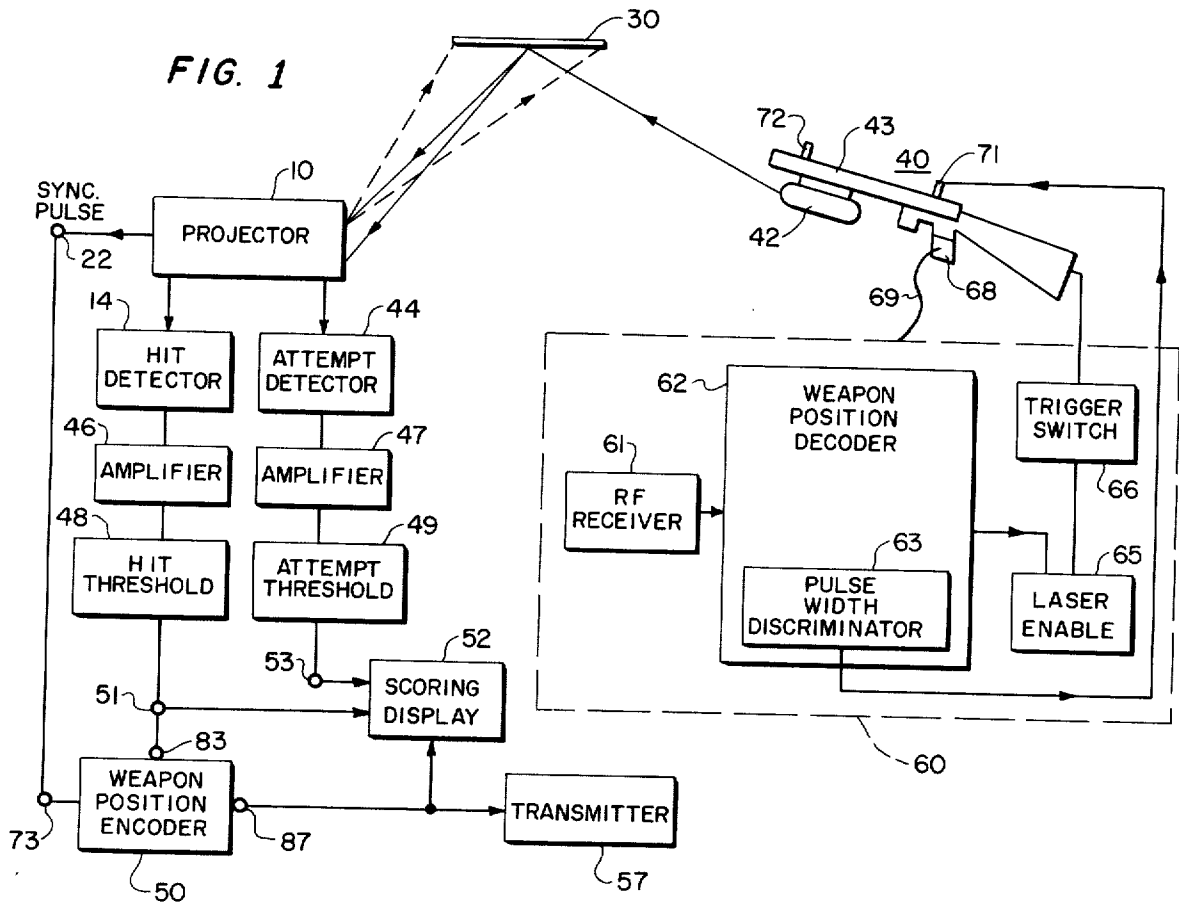


FIG. 2

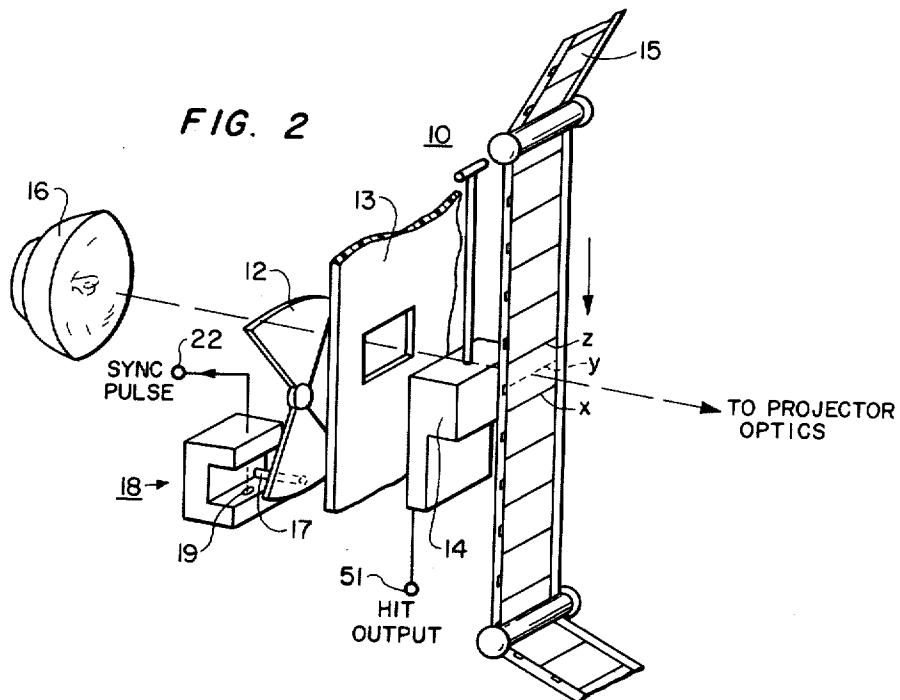


FIG. 3a

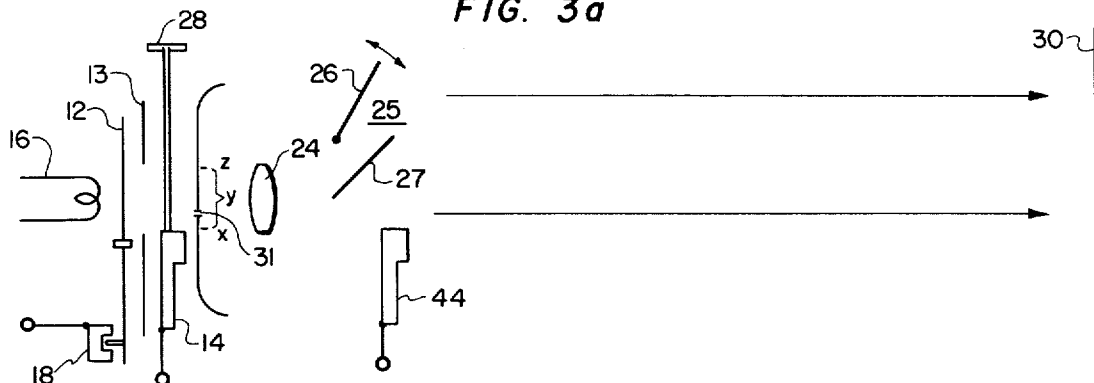


FIG. 3b

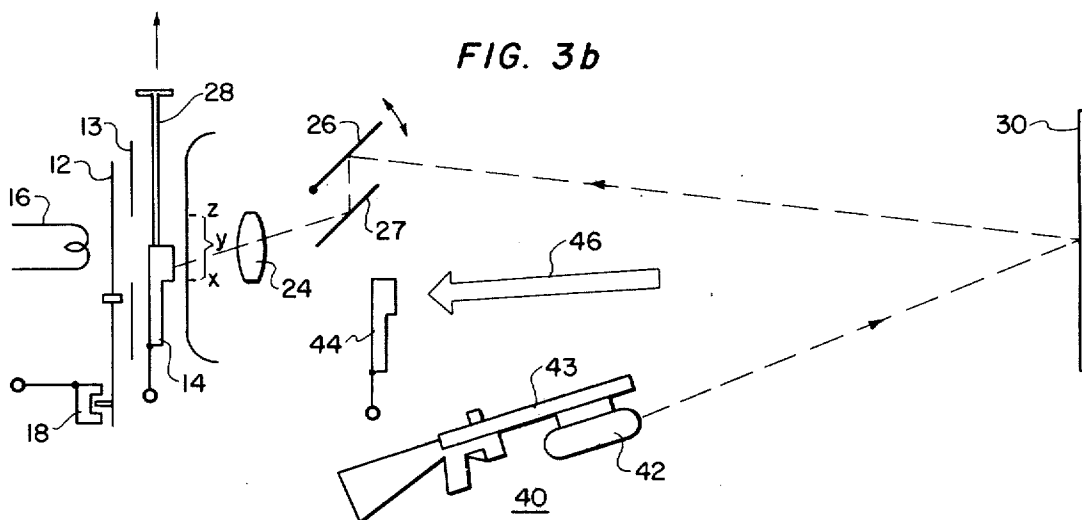


FIG. 4a

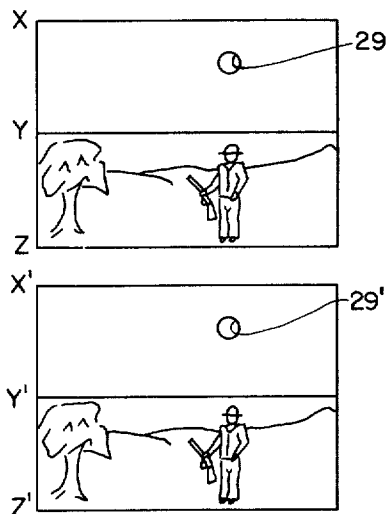


FIG. 4b

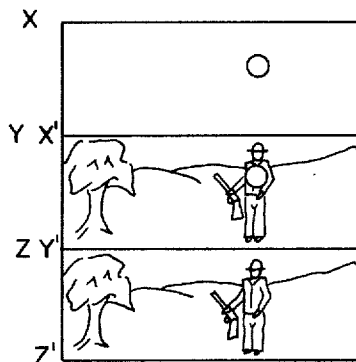


FIG. 4c

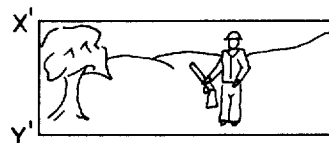
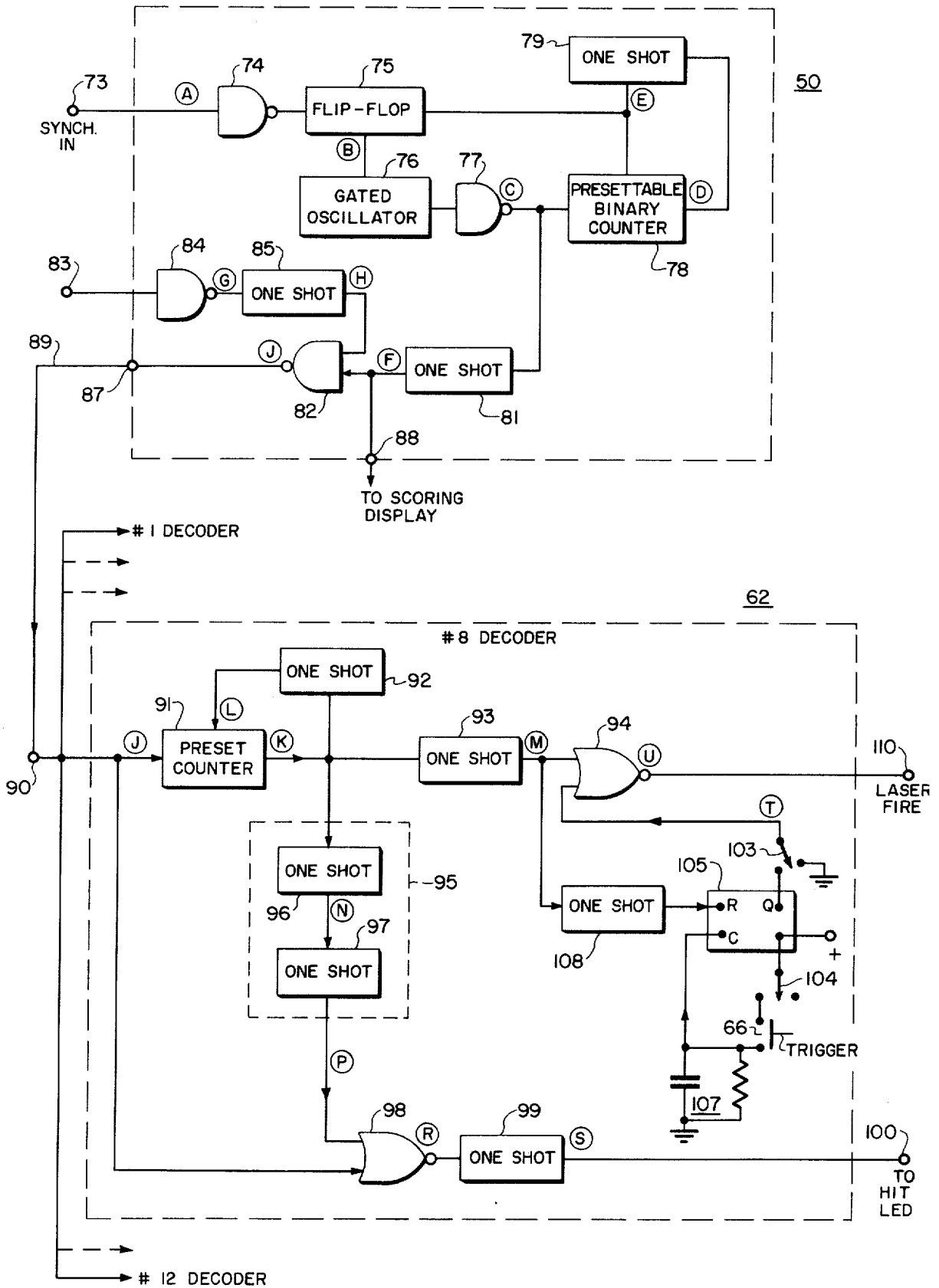


FIG. 5



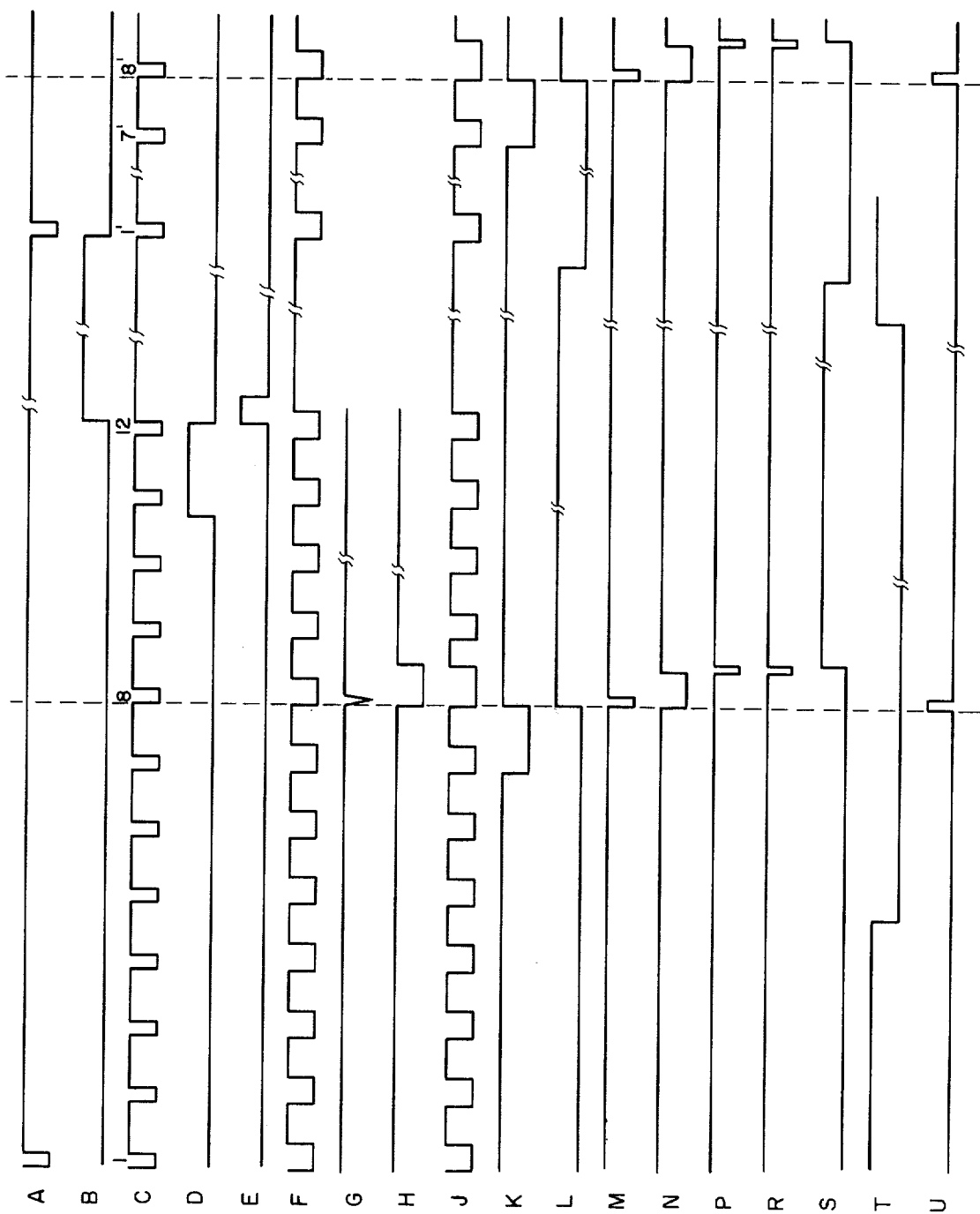


FIG. 6

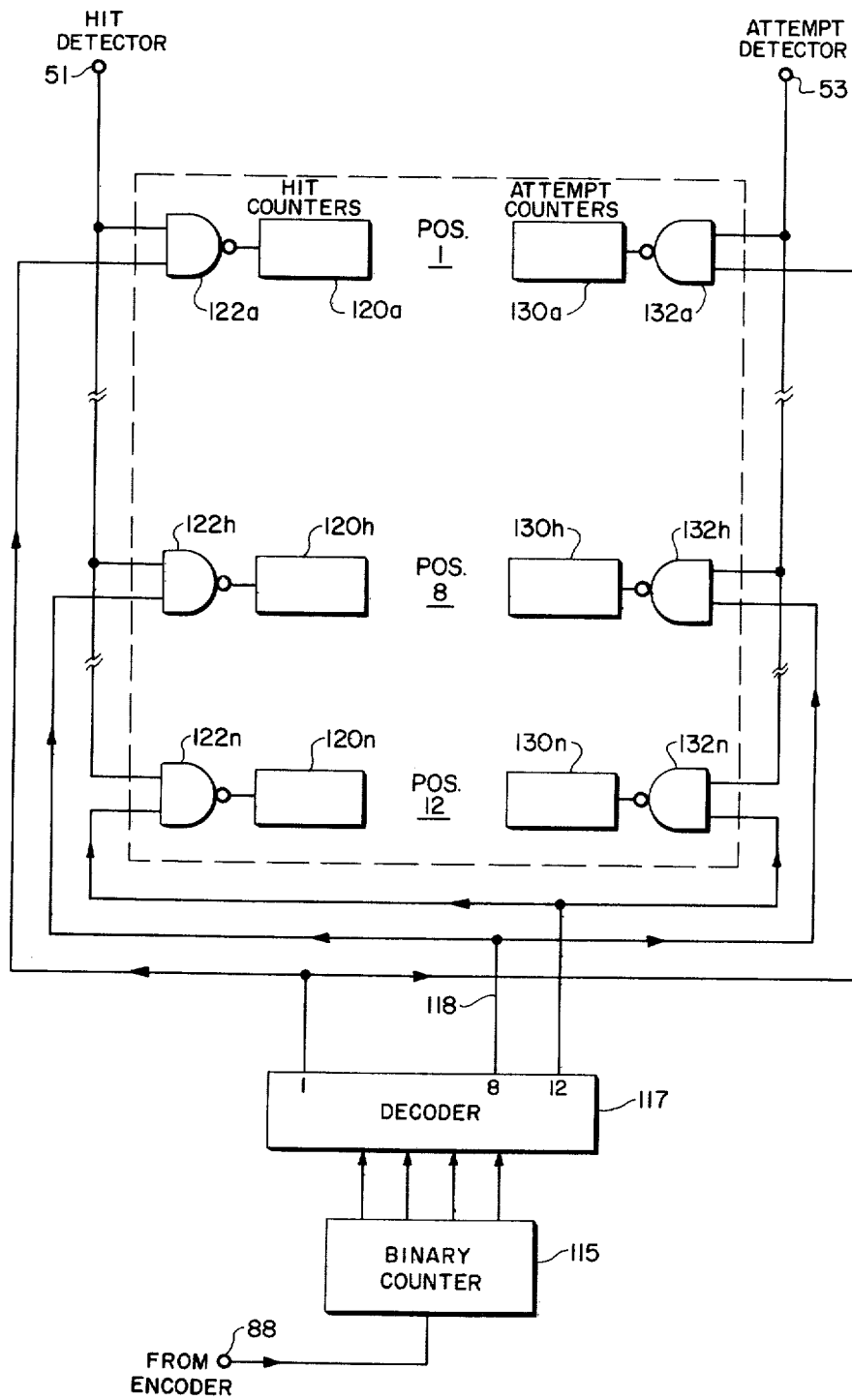


FIG. 7

MOVING TARGET SCREEN

BACKGROUND AND SUMMARY OF THE INVENTION

Existing training methods in marksmanship and firing tactics for combat troops, police, sportsmen's clubs, and other similar groups, leave much to be desired from the aspects of realism, motivation, cost and practicality. Present firing ranges are limited and sometimes inaccessible for reasons of priority, distance and weather. Except in the most sophisticated cases, the targets are stationary and relative motion must be provided, for example, by actual moving troops. Moreover, when live ammunition is used, expense, risks, and administrative problems increase considerably. For initial training in marksmanship and tactics, it is preferred to have an indoor range where a squad of men can fire against realistic moving targets from fixed positions.

The projection technique of the invention can provide multistation small arms training at simulated target ranges of 50 to 300 meters or more in an indoor area no longer than 10 meters in length. The technique provides inexpensive training in readily accessible locations, not suitable for live firing, thereby eliminating many of the problems associated with range coordination and safety. Moreover, no expenditure of ammunition is necessary to achieve a high standard of individual and unit proficiency.

The moving target screen technique of the invention makes use of modified stereo optics in a standard motion picture projector to provide the imagery for the target scene and means for determining whether a weapon operator firing at the scene with a narrow laser beam from a laser attached to the weapon has hit the target. In this technique, a motion picture film is used on which the lower half of each frame contains a normal positive image and the upper half contains an annotated mask having an opaque background on which one or more transparent apertures are located at the precise position where the targets on the image appear. The apertured mask may be placed on the film strip by animation techniques, or other processes, on a frame by frame basis. The half of the frame containing the normal scene and the other half of the frame containing the apertures are both projected onto a viewing screen.

The modified stereo optics normally provides two spaced projected frames on the viewing screen. These optics must be adjusted preliminarily to displace one of the two projected frames relative to the other such that, at the screen, the aperture(s) on one projected frame are superimposed exactly on the corresponding target(s) on the other projected frame. In this manner, the aperture area(s) of the mask are focused onto the corresponding target area(s) of the screen. A hit detector then is pulled up into the film gate behind the aperture mask and the system is ready for operation. This detector is pulled out of the film gate during the previously described initial adjustment. The fired laser beam, upon striking the surface of the screen, will be imaged onto the film mask. When the fired laser beam strikes a target on the screen (which target has been previously annotated on the mask) the laser beam energy reflects off this portion of the screen surface, and will, of course, be imaged onto the apertured portion of the film mask; this reflected laser beam passes through the clear portion (aperture) on the film, and activates the

hit detector positioned behind the mask, thus registering a hit. A laser pulse striking off-target however, will be imaged on the opaque portion of the mask and will be sufficiently attenuated to be below a preset threshold. A separate, wide-view detector can be positioned outside of the projector optical system to receive laser energy reflected from the entire screen in order to register attempts. For initial training purposes, the detector module can be moved out of the way and the weapon firers can view the relative position of the projected aperture areas and the projected scene to determine which portion of the scene constitutes the actual target area to be aimed at.

In the case of single weapon firing, the output of the hit and attempt detectors, after suitable amplification, would be applied to respective hit and attempt threshold circuits feeding a single display counter. When the weapon firer actuates the trigger, a switch is closed which permits the laser to be pulsed. When more than one weapon firer is involved, each of the weapons becomes a part of a digitally multiplexed time sharing system. A series of shutter-synchronized clock pulses are generated in synchronism with projector film frame advance and processed within an encoder wherein, by discrete address techniques, each weapon is assigned a specific clock pulse within each time cycle, during which the laser on that particular weapon may be fired. The encoded output can be either transmitted to a miniature receiver-decoder in each weapon or coupled directly to a decoder in each weapon.

All laser pulses from a given weapon striking the screen (hits and missed) are reflected onto the attempt detector and register on the attempt counter (display) for that weapon. The display is synchronized with the same encoder pulses as transmitted to the weapons, insuring that each score displayed is from the particular weapon fired in that time slot.

Real-time hit indication is provided to the firer by pulse width discrimination techniques. When the threshold circuit records a hit during a particular clock pulse, that pulse is electronically expanded. The receiver-decoder for that particular simulator recognizes the expanded pulse and provides an indication to the firer by activating a light emitting diode (LED) located behind the rifle sight. Simulator electronics — with the exception of the laser circuit, which is mounted on the barrel — can be mounted, for example, in a standard weapon magazine clip.

DESCRIPTION OF THE DRAWINGS

FIG. 1 is a block diagram of the system according to the invention;

FIG. 2 is a view illustrating a portion of the projector optics of the system of FIG. 1, including a portion of the hit detector and means for generating a synchronizing pulse;

FIG. 3a is a view illustrating fundamentals of the projection optics, showing the position of the hit detector during preadjustment;

FIG. 3b is a view illustrating fundamentals of the projection system, showing the location of the hit and attempt detectors, during actual simulated firing operation;

FIG. 4a illustrates a typical projection screen presentation prior to proper adjustment of the projection optics;

FIG. 4b illustrates a typical projector screen presentation after the projection optics has been properly adjusted, with the detector in the non-operating position;

FIG. 4c illustrates a typical projection screen presentation after proper adjustment of the projection optics and after the hit detector has been moved to the operating position;

FIG. 5 is a block diagram of the encoder and decoder used in the system of FIG. 1;

FIG. 6 includes a series of waveforms illustrating the operation of the system shown in FIGS. 1 and 5; and

FIG. 7 is a diagram illustrating a typical scoring display such as used in the system of FIG. 1.

DESCRIPTION OF PREFERRED EMBODIMENT OF THE INVENTION

FIG. 1 of the drawing illustrates a typical multiplexed time sharing system for multi-weapon operation. A series of synchronizing pulses are derived from the projector 10 and applied to a weapon position encoder 50. The synchronizing pulses are produced once during each revolution of one of the blades of the fan-shaped shutter 12 past the film image projector gate 13, as indicated in FIG. 2. The projector 10 can be any standard projector which can be modified inexpensively and readily to permit insertion of a hit detector 14 in the region between the film 15 and projector gate 13. Each frame of the film 15 of FIG. 2 must be rapidly moved into the projector gate position and held more or less fixed in that position for a discrete time interval, which by way of example, can be 6 milliseconds; during this interval, the shutter 12 blocks light emanating from the projection lamp 16. The film can be advanced in the projector 10 of FIGS. 1 and 2 at the usual rate of 24 frames per second, so that the period between shutter sync pulses is substantially 42 milliseconds. A two-blade shutter 12 is shown in FIG. 2 which blocks light from the projection lamp twice during each frame interval - once for about 6 milliseconds for frame position change, and again for about 8 milliseconds to increase the flicker rate of the projected image, in the well-known manner. The weapons are fired during the 8 millisecond period when one of the shutter blades is in front of the projector lamp 16 and no light (or film image) is projected onto the viewing screen 30. As shown in FIG. 2, a pin 17 mounted near the periphery of one of the shutter blades 12 cuts through a light beam created within the sync pulse generator unit 18. The latter unit is a commercially available unit which includes a light emitting diode (see FIG. 2) mounted in one arm of the generator unit. The light beam, indicated by dotted lines of FIG. 2, is directed across the gap between the arms of a generator unit 18 and impinges upon a photocell (not visible in FIG. 2) mounted in the opposite arm of unit 18. Also mounted within the upper arm is an amplifier from which a positive going waveform normally is derived. When the light beam is cut by the shutter pin 17, however, a negative going sync pulse (see waveform A of FIG. 6) is derived which appears at the sync pulse terminal 22 of generator unit 18.

As indicated in FIG. 3a, the projected image of each film frame of FIG. 2 is projected onto the viewing screen 30 by conventional condensing lens means 24 and by way of a half stereo/reflector 25 consisting of two mirrors 26 and 27, one of which can be tilted relative to the other. The general direction of projection of the images onto the screen is indicated in FIG. 3a by

the two solid arrows. The top and bottom boundaries of a given film frame is indicated by the small letters *x* and *z* in FIGS. 3a and 3b. The upper half *yz* of each frame of film on the projector reel contains an inverted normal positive scene, while the other (lower) half *xy* of each frame contains an annotated mask consisting of a more or less opaque background in which there are one or more clear (transparent) apertures 31. As previously pointed out, the aperture or apertures 25 is located at the same relative position on the masked portion *xy* of each film frame as the corresponding target or targets on the portion *yz* of that film frame containing the scene. In the particular example shown, the target area selected is the region of the man's chest. Consequently, the aperture 31 is located in the masked portion *xy* of the film frame in the same relative region thereof that the region of the man's chest occupies in the image portion of the film frame. If the target area were in the exact center of the film image, the aperture 31 in the masked portion *xy* would likewise be in the center thereof, etc. Only half of a stereo/reflector is required in front of the projection lens 24 since a dual-frame stereo format is not being displayed.

Prior to actual operation, two complete single-frame format projected images *XYZ* and *X'Y'Z'* will be visible on the screen, as indicated in FIG. 4a, owing to the presence of the two separate mirrors 26 and 27. The pair of projected film frames (images) *XYZ* and *X'Y'Z'* appear inverted on the screen from the position *xyz* actually occupied by the film on the projector reel. The projected frames each includes a scene portion *YZ* and *Y'Z'* and a "masked" portion *XY* and *X'Y'* within which respective bright spots 29 and 29' appear; obviously, only a bright spot is visible on the screen within the rectangular confines indicated in FIGS. 4a and 4b as *XY* and *XY'*. The bright spots 29 and 29' of the projected frames on the screen will, of course, occupy the same position relative to the scene as in the case of the film frame in the projector gate. By adjusting the position of one of the mirrors, the two projected images *XYZ* and *X'Y'Z'* will be displaced relative to one another. The tiltable mirror 26 is adjusted until the bright spot in the annotated mask portion *X'Y'* of image *X'Y'Z'* is superimposed on the target (chest area of the man) in the scene portion *YZ* of the projected image *XYZ*, as indicated in FIG. 4b. During this procedure, the hit detector 14 of FIG. 1, also shown in FIGS. 2 and 3, is in the position indicated in FIG. 3a. After the proper initial adjustment of mirror 26 has been made, the hit detector 14 is pulled up by the handle 28 into the position shown in FIG. 3b, so as to block light from lamp 16 from passing through the lower half of the film gate, as indicated in FIG. 3b. Now, as shown in FIG. 4c, only the scene portion *YZ* and *Y'Z'* of the projected image will appear on the screen 30 and the bright spots 29 and 29' of *XY* and *X'Y'* of both projected images *XYZ* and *X'Y'Z'* are removed from the projection viewing screen 30. The weapon firers thus see only the actual target scene on the screen, without any bright spots 29 formerly projected from apertured areas 31 of the annotated mask portion *xy* of film frame *xyz*. Now that the preliminary adjustments have been completed, the reeled film in the projector is set in motion, thus providing the operators of the several weapons 40 with one or more simulated moving targets at which to aim their weapons. The basic optics for the operating condition are shown in FIGS. 1 and 3b. The laser beam

from the laser 42, mounted as shown in FIGS. 1 and 3b, on the barrel 43 of weapon 40 is directed by the corresponding weapon operator at the moving target on the viewing screen 30. The laser 42 may, by way of example, be a 0.81 micrometer gallium aluminum arsenide laser with a beam spread of about 3 milliradians. The laser output is of the order of 6 watts in a 100 nanosecond pulse, and, as such, presents no hazards to the eye of the operator(s). If a particular operator's aim is proper, the laser beam will strike the area of the image scene on the screen over which the bright spot in the annotated mask portion of the image was previously superimposed. When the laser beam strikes this area of the screen, that is, when the simulated target on the screen has been "hit," the beam will be imaged onto the film mask so as to pass through the clear portion (aperture) 31 of the mask portion xy of the film frame and will activate the hit detector 14 positioned behind the film. In other words, if light passing through the aperture 31 in the mask portion xy of the film frame is imaged onto the designated target area of the image scene in the screen 30, then optical energy (from the laser gun) at the target area of the image screen will, by the principle of optical reciprocity, be imaged onto the aperture of the mask portion of the film frame in question. A laser beam striking off-target will be imaged onto the substantially opaque portion of the mask, if not imaged off the film entirely, and will be sufficiently attenuated to be below a preset threshold so as not to activate the hit detector.

A separate attempt detector 44 which can be located outside of the projector optical system, as indicated in FIG. 3b, can view the entire screen and will respond to laser light reflected over an undefined field of view, as indicated schematically by the broad arrow 46 in FIG. 3b. As shown in FIG. 1, the response indicated by the hit and attempt detectors is amplified by respective amplifiers 46 and 47, and supplied to respective hit and attempt threshold circuits 48 and 49 which serve to insure that the amplified output from the attempt detector is insufficient to provide an output at the hit terminal 51. Although shown separately in FIG. 1, the amplifiers 46 and 47 and threshold circuits 48 and 49 may be packaged within the respective detectors 14 and 44, as indicated in FIGS. 3a and 3b. The hit detector, attempt detector and accompanying amplifiers and threshold circuits can all be mounted within the body of the projector mechanical package 10. The hit and attempt pulses are applied to a scoring display 52 which will be described in detail in discussing FIG. 7 of the drawing. The sync pulses at terminal 22 are supplied to the weapon position encoder 50 which is shown in greater detail in FIG. 5 and described in greater detail later. The encoder 50 provides a pulse train of clock pulses for the n weapons to be fired, each pulse train being synchronized with the synchronizing pulse from the projector 10. Each weapon simulator 40 is assigned a specific one of said clock pulses within each time cycle, during which time slot the particular weapon-mounted laser may be energized (fired). The encoder 50 also serves to expand electronically the clock pulse corresponding to the particular weapon whenever the firer of that weapon has hit the simulated moving target image on the screen 30. The encoder pulses are transmitted by way of a conventional transmitter 57 to the receiving location 60 which involves a compatible receiver 61 and a plurality of weapon position decoders

62, one for each weapon to be fired. Each weapon position decoder includes a pulse width discriminator 63. These components at the receiving station, along with the laser enable circuit 65 and trigger switch 66, can be disposed in a single package physically mounted in the weapon magazine clip. In other words, the receiving location 60 shown within the dotted lines in FIG. 1 can be mounted within the clip 68 of the weapon 40, as indicated by the wavy line 69. The pulse width discriminator 63 for the particular weapon simulator recognizes the received expanded pulse and supplies a pulse which activates a light emitting diode 71 mounted on the barrel of the weapon behind the weapon sight 72 to indicate to the firer that a target hit has previously occurred.

The solid state laser 42, which is mounted to the barrel of the weapon 40, is energized only after the trigger, physically a part of the weapon, is actuated to close the trigger switch 66 and when the laser enable circuit 65 simultaneously produces a suitable output (laser enable) pulse. The latter can occur only during that one of the n time slots ($n = 12$, in the case assumed) reserved for the particular weapon.

As will be explained during the description of the encoder-decoder circuit of FIG. 5, the output of the weapon position encoder 50 can be hard wired to the input of the weapon position decoder 62, in which case the transmitter and receiver can be omitted.

The operation of the system of FIG. 1 will now be described in greater detail by referring to the encoder-decoder circuit shown in FIG. 5 and the waveforms derived at various portions thereof, as illustrated in FIG. 6.

The sync pulses (waveform A of FIG. 6) at encoder input terminal 73 are inverted by means of the NAND gate 74 and applied to flip flop 75 of FIG. 5 which produces the waveform B of FIG. 6. The leading edge of this waveform from flip flop 75 initiates oscillations of the gated oscillator 76 of FIG. 5. The gated oscillator output has a period of 500 microseconds; the inverted output of this gated oscillator, appearing at the output of NAND gate 77, is represented by the waveform C of FIG. 6. After receiving a given number of said inverted pulses from gated oscillator 76, shown, by way of example, as twelve, the presettable counter 78 produces an output (see waveform D of FIG. 6) which is positive-going at some selected time prior to $12 \times 500 = 6$ microseconds after each sync pulse, in the example assumed herein. Upon receipt of the 12th pulse of waveform C of FIG. 6 (6 milliseconds after arrival of the sync pulse), the output of binary counter 78, viz., waveform D of FIG. 6, goes negative. This negative-going output triggers a one-shot device 79 the output of which (waveform E of FIG. 6) is used to reset the flip flop 75 so as to preset further oscillation of gated oscillator 76 and to reset binary counter 78 to await the start of the next operating cycle commencing with the next sync pulse. The operating cycle is about 42 milliseconds in the case of a standard projector with 24 frames per second. The one-shot 79 serves to limit to twelve the number of pulses coming from the gated oscillator 76 and counted by the binary counter 78. The twelve pulses (waveform C of FIG. 6) are applied sequentially to the one-shot 81 where pulses are obtained (waveform F of FIG. 6) which are, for example, 200 per seconds wide and occur at a pulse rate of 500 microseconds. These negative-going pulses F are available at encoder output

terminal 88 and are applied to the scoring display 52. The negative-going pulses F are also applied directly to one input terminal of the NAND gate 82. When a hit pulse is derived during, say, the 8th pulse time interval as a consequence of the firer of weapon number 8 properly aiming the laser gun at the moving target on the projector screen, this hit pulse appearing at encoder input terminal 83, after polarity inversion in NAND gate 84 (see the waveform G in FIG. 6) is supplied to one-shot 85 to provide negative-going output (waveform H of FIG. 6) which serves as the other input to NAND gate 82. The waveform H of FIG. 6 from one-shot has a pulse width of 300 microseconds, as contrasted with the 200 microsecond width of the other eleven pulses in each pulse train.

The operation of the NAND gate 82 is such that an output pulse (waveform J of FIG. 6) appears at the output terminal 87 of the encoder 50 whenever a negative-going pulse appears at either or both input terminals of the NAND gate 82. In the example given, the output of encoder 50 will be a train (waveform J) of 12 pulses which, except for the eighth pulse, are of 200 microseconds duration; the eighth pulse, created by the simultaneous presence at the NAND gate 82 of the eighth output 200-microsecond pulse (eighth pulse in waveform F of FIG. 6) from the one-shot 81 and the 300 microsecond pulse (the waveform H of FIG. 6) is, of course, 300 microseconds wide.

The encoder output pulses at terminal 87 can be transmitted by means of a transmitter 57 to the decoder 60, as indicated in FIG. 1. The output of the transmitter to the decoder falls to zero during each pulse interval of 200 or 300 microsecond, as the case may be. The transmitted encoder output at terminal 87 can be received by an appropriate receiver 61 and the output of the receiver (substantially identical to waveform J of FIG. 6) is applied to the input terminal 90 of the decoder 62.

It should be pointed out that, in some cases, the transmitter-receiver between the encoder and decoder, such as shown in FIG. 1, may be replaced by the directly-wired connection, 89, illustrated in FIG. 5. Generally, however, it is preferable to use the radio link rather than the more cumbersome hard wiring between the encoder and each of the several weapon decoders. The encoder output (waveform J), or the output of receiver, as the case may be, is applied to presettable counter 91 which is preset so that the counter output swings negatively upon receipt of $(m-1)$ pulses from the encoder 50 where the decoder is the n th decoder (corresponding to the n th weapon to be fired). For example, for the eighth decoder corresponding to weapon number eight of the twelve weapons, the counter output (waveform K of FIG. 6) swings negatively upon receipt of the seventh input pulse.

The trailing (positive-going) edge of the output pulse (waveform K of FIG. 6) from the preset counter 91 is used to trigger a one-shot 92 which produces a reset pulse (waveform L of FIG. 6) for resetting the counter 91 and thereby prevent further counting of incoming pulses from the encoder 50 until the arrival of the next train of 12 pulses. This reset waveform L of FIG. 6 returns shortly thereafter to its more positive value which is retained until arrival of the trailing edge of the next output pulse from counter 91. The preset counter output pulse (waveform K of FIG. 6) is supplied also to one-shot 93 which provides one of the input pulses

(waveform M of FIG. 6) to the output NOR gate 94. By way of example, the pulse M is 60 microseconds wide.

The present counter output pulse also is applied to a pulse width discriminator 95 comprising two serially connected one-shots 96 and 97. The first of these one-shots, viz., one-shot 96, is triggered by the leading edge of waveform K and provides a pulse (waveform N of FIG. 6) of approximately 240 microseconds width. The trailing edge of the pulse N then triggers the second one-shot 97 from which a narrow pulse (waveform P of FIG. 6) of approximately 10 microseconds is obtained. The pulse P and the pulses J from the encoder are applied to the NOR gate 98. The pulses P do not arrive at NOR gate 98 until 240 microseconds after the beginning of the $n=8$ th time slot, which is essentially 240 microseconds after arrival of the hit pulse at the hit input terminal 83 of the encoder 50. Obviously, none of the normal 200-microsecond pulses J will appear at NOR gate 98 concurrently with the delayed pulse P; thus, there will be no positive-going output (waveform R of FIG. 6) from NOR gate and the one-shot 99 will remain in the normal negative state (see waveform S of FIG. 6).

If, however, a hit pulse occurs at hit input terminal 83 of the encoder, resulting in the presence of a negative-going pulse of 300 microseconds duration, a 300 microsecond pulse J appears at one input to NOR gate 98 and will occur simultaneously with the other input pulse P. The resulting positive-going pulse (waveform R of FIG. 6) of 10 microseconds width will trigger the one-shot 99 and provide a positive-going pulse (waveform S of FIG. 2) of sufficient duration and amplitude at decoder terminal 100 to energize the light emitting diode 71 on the corresponding weapon. This light-emitting diode 71 indicates to the firer of that weapon that he has scored a hit on the simulated target on the screen 30.

When the operator of the number 8 weapon actuates the trigger, that is, closes trigger switch 65, provided that the test switch 103 and switch 104 are in the closed (left hand) position in FIG. 5, the clock input (input to terminal C) of flip flop 105 is generated by virtue of the charging current flowing through the RC circuit 107 as a result of the potential appearing at the positive (V_{cc}) terminal of the flip flop 105 and ground. The $\bar{Q}$ or zero output of flip flop 105 goes negatively for a period determined by the time constant of the RC circuit 107. The flip flop 105 is reset by the arrival of the following pulse (waveform M of FIG. 6) from the one-shot 93, that is, the $\bar{Q}$ output thereof returns to its normal more positive state, as shown by the waveform T of FIG. 6. The one-shot 108, like the other one-shots and the gates, can be used for waveform sharpening. During the simultaneous presence at NOR gate 94 of negative-going pulses M and T, an output pulse (waveform U of FIG. 6) appears at the output (laser fire) terminal 110 of decoder 62. This output pulse U triggers the laser 42 on the corresponding number 8 weapon 40 into production of a laser beam which then can be directed by the weapon firer toward the simulated target on the screen.

A typical scoring display 52 located at the transmitting station is shown in FIG. 7 and includes a multi-stage binary counter 115 and a decoder 117, as well as an array of n hit counters 120a to 120n and an array of n attempt counters 130a to 130n, one for each of the n weapon positions.

In the example given, i.e., where $n=12$, the binary counter 115 would have four stages, so that $2^4=16$ different output states would be available; of these, obviously only twelve are needed. A typical binary counter 115 is illustrated on page 95 and described on pages 94 and 95 of "Digital Computer Fundamentals" by Thomas C. Bartee, 2nd edition, published by McGraw-Hill Book Company in 1966. As each pulse (waveform F of FIG. 6) arrives at the binary counter 115, the Q or ONE output from each counter stage is complemented and a different combination of ONES and ZEROS appear at the four stages. For example, upon receipt of the sixth pulse from encoder terminal 88, the outputs of the four counter stages, in the order of increasing significance, will be 1010. The decoder 117 of FIG. 7 essentially consists of a group of separate gates each connected to an appropriate combination of the Q output terminals of the flip flops in the binary counter 115. For example, an AND gate connected to the Q output terminals of the second stage and the fourth (most significant) stage of the binary counter 117 will provide an output which occurs only in response to the 6th pulse (waveform F) from the encoder 50. Similarly, only the output terminal of the fourth stage of the flip flop would be connected to the AND gate whose output represents the arrival of the 8th pulse F from encoder 50, etc. This type of decoder circuitry is well known, and is illustrated in pages 2-103 of Vol. 2 of "Basics of Digital Computers" by Murphy, published in 1958 by John F. Rider Publisher, Inc.

The separate AND gate outputs in the decoder 117 for each of the $n=12$ weapon positions is connected by a separate line to both a corresponding NAND gate 122 in the array of hit counters 120 and to a corresponding NAND gate 132 in the array of attempt counters 130. For example, the 8th pulse corresponding to weapon number 8, from the decoder 117, is connected by line 118 to the eighth NAND gate 122h in the scoring display console which is connected to the hit counter 120h for weapon 8 and also to the eighth NAND gate 132h in the scoring display console which is connected to the attempt counter 130h for weapon number 8. Similar connections are shown in FIG. 7 for two other weapon positions, namely 1 and 12. The hit detector terminal 51 is connected to an input terminal of all NAND gates 122 for the hit counter array 120 while the attempt detector terminal 52 is connected to the input terminal of all NAND gates 132 of the attempt counter array 130. If the firer of weapon number 8 scores a hit, a hit pulse G at the hit detector terminal 51 will be available at all NAND gates 122. However, only the NAND gate 122h for the number 8 weapon position of the hit counter 120 array will both input lines active. Consequently, the hit counter 120h for position number 8 will be activated upon arrival at the incoming hit pulse at hit detector terminal 51. Similarly, if the firer of weapon number 8 misses the simulated moving target on the screen, only laser energy reflected from the screen onto the attempt detector 49 would be sensed and an attempt pulse would appear at the attempt detector terminal 53; this attempt detector pulse, in combination with the pulse from decoder 117 of FIG. 7, would open NAND gate 132h and activate the attempt counter 130h in the scoring display corresponding to attempt counter array position number 8. Obviously, a counter 120 and the corresponding attempt counter 130 for any given weapon will be acti-

vated each time the firer of that weapon actuates the trigger. The hit counters 120 and attempt counters 130 of FIG. 7 can be any of several well known types of high speed electronic counting devices which can include one of many types of digital display tubes by means of which the total number of attempts and misses by each of the n weapon firers can be observed at any instant of time. It is possible to design the circuitry of the scoring display 52 so that a hit pulse must be coincident with an attempt pulse in order to register a hit on the hit counter. In this manner, any ambiguities owing to random spurious pulses of rather large amplitude will not provide an erroneous hit count on the moving display 52.

Obviously, many modifications and variations of the present invention are possible. The scope of the invention is limited only in the manner defined by the claims.

What is claimed is:

1. An electro-optical weapon firing training device comprising a film strip projector and viewing screen, at least one weapon on which is mounted a laser means to trigger a laser beam upon firing said weapon, a film strip, each frame of said film strip containing a first portion representing a scene including at least one target area at which the laser beam should be directed and a second portion which is substantially opaque to radiation from said laser except for at least one aperture region through which light from said projector can pass, the location of said aperture within said second portion being in the same relative position as the location of the target area in the first portion of said film strip, said projector including optical means for projecting each frame of said film strip onto said screen as two separate projected frame portions each having a scene portion and a bright spot whose location relative to the projected scene portion is the same as that of the aperture region relative to the first portion of said film frame, and including adjustable means for initially moving one projected frame portion on the screen relative to the other projected frame portion on the screen until the aperture region in the second projected frame portion is superimposed exactly on the corresponding target area in the scene portion of the other projected frame portion, and means responsive to correspondence between the position of the laser beam impingement upon said screen and said bright spot.

2. An electro-optical weapon firing training device according to claim 1 further including a hit detector moved into an operating position blocking that portion of the aperture gate of said projector which is juxtaposed to said second portion of a given frame of the film strip, whereby only the scene portion of said one projected frame is visible on the screen.

3. An electro-optical weapon firing training device according to claim 2 wherein said hit detector is pulled out of said projector aperture gate during the aforesaid initial relative motion of the projected frames on the screen effected by said adjusting means.

4. An electro-optical weapon firing training device according to claim 2 wherein the laser radiation reflected only from that portion of the screen on which the target area of the projected scene appears will be imaged onto the transparent aperture region of said second portion of the film frame at the projected aperture gate and will impinge upon said hit detector.

5. An electro-optical weapon firing training device according to claim 2 further including a wide-angle at-

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tempt detector positioned outside the projector optical system and responsive to laser energy reflected from the entire screen to register operator firing attempts.

6. An electro-optical weapon firing training device according to claim 5 further including separate counting display means responsive to the output of the corresponding hit and attempt detectors.

7. An electro-optical weapon firing training device according to claim 1 wherein a number of n laser-bearing weapons are used, each weapon having a trigger under control of the operator of the weapon, further including means for generating n synchronizing pulses of repetition rate equal to the projector frame rate, a weapon position decoder for each of said laser-bearing weapons, each decoder responding to one only of said clock pulses to provide a laser enable pulse to the laser of the corresponding weapon, the laser of said

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weapon producing a laser beam upon simultaneous receipt of said laser enable pulse and actuation of the weapon trigger.

8. An electro-optical weapon firing training device according to claim 7 wherein said encoder includes a pulse expander for increasing the width of that clock pulse which occurs coincidentally with a hit pulse from the hit detector and said decoder includes a pulse width discriminator for deriving an output therefrom only in response to said clock pulse of expanded width, a light emitting diode mounted on each weapon and responding to the output from said pulse width discriminator to indicate to the operator of that weapon that the simulated target area on the screen has been hit by the laser beam mounted on that weapon.

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