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STATEMENT OF GOVERNMENT INTEREST

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BACKGROUND OF THE INVENTION

(1) Field of the Invention

This invention relates to a circuit for triggering a strobe light or other appropriate source of illumination located between two underwater break screens.

(2) Description of the Prior Art

The Adaptable High Speed Underwater Munition (AHSUM) project needed a method to obtain photographs of underwater projectiles during the course of their test series. Prior to this time, there was no satisfactory means of obtaining the photographs that were needed, nor was there a device applicable to a variety of conditions.

The following patents, for example, disclose various types of photography, including underwater photography and circuits in connection therewith, but do not disclose a device
for controlling an underwater strobe light for the purpose of
taking underwater photographs of a high speed projectile.

U.S. Patent No. 3,690,233 to Billingsley;
U.S. Patent No. 4,418,999 to Baxter;
U.S. Patent No. 4,878,074 to Peng; and
U.S. Patent No. 5,581,078 to Sears.

Specifically, the patent to Billingsley discloses a
detecting means responsive to a passing car to produce an
indicating signal. A camera and a flash lighting unit
positioned down the road from the detecting means are
activated simultaneously to illuminate and photograph the
oncoming car. The illumination lies primarily in a spectrum
including the visible deep red, the near infra-red and the
intermediate infra-red. Only the visible deep red and the
near infra-red radiations are able to penetrate the infra-red
filtering windshield and then reflect back to the camera
through an optical filter which passes only said visible deep
red, near the infra-red and the small amount of intermediate
infra-red radiations that pass back through the windshield.
Thus the glare from ambient light is eliminated. A film
sensitized to the visible deep red and to the near infra-red
radiations is employed in the camera. The aforementioned
system provides a photograph of the driver's facial features
either during the day or at night and without causing
impairment of his vision.
The patent to Baxter discloses a synchronizing circuit which enables a desired phenomena to occur, such as the discharge of a flash illuminating means at a precise point along the path of travel of an article irrespective of the speed of the article in that path. The circuit utilizes two spaced sensors upstream of the precise point. The sensors are operable to detect the passage of the article and each sensor is connected to the respective counter. When the sensor detects the passage of the article, it starts its respective counter counting in one direction at one particular counting rate. When the second sensor detects the passage of the article, it causes its respective counter to count in the opposite direction from the value of the count in the first count at a different but faster counting rate. The circuit includes gate means which determine when the count has returned to a predetermined count to then cause said phenomena to occur.

Slaght et al. discloses a system and method for determining the relative velocities of a projectile at different portions of its path in which a plurality of signaling detector stations are arranged at predetermined intervals along such path. A common receiving station is arranged to receive signals from the detector stations through a common communication channel and has a memory unit capable of storing pulses corresponding to the signals received, and a
calculator capable of analyzing adjacent pairs of the pulses which have been produced by passage of the projectile over two or more of the path intervals monitored by the detector stations to determine the relative velocities of the projectile as it traverses the path intervals monitored by different pairs of detector stations. This information is used to study retardation properties of a projectile.

Peng discloses a dynamic particulate observation apparatus for monitoring a moving particle including a black box having an internal space enclosed therewithin, which shields the space from the infiltration of light outside; means for generating particles moving across the black box; means for emitting a flash of light within the black box at a predetermined frequency; and means for taking down the images of the particles generated by the generating means when the emitting means emits flashlights. The dynamic particulate observation apparatus according to the invention is cheap and easy to assemble, and renders all the necessary functions of a conventional dynamic particulate observation apparatus.

The patent to Sears discloses a ballistic optical camera trigger having an integrated circuit capable of converting light to a proportional frequency, wherein the integrated circuit has a fast response time and a wide dynamic range which allows it to sense positive or negative changes in light fast enough to trigger without delay for high speed imaging.
without computational delays or jitter causing interference.

The frequency output of the integrated circuit is tracked by a phase lock loop/voltage controlled oscillator to allow it to follow slow changes in light, but not fast changes in light caused by, for example, a projectile such as a bullet. The frequency output from the integrated circuit is provided to one input of a logic gate which receives at another input thereof, a shaped pulse from the phase lock loop/voltage controlled oscillator circuit, wherein the output of the logic gate is applied to a one-shot for outputting a trigger signal.

It should be understood that the present invention would in fact enhance the functionality of the above patents by providing a control device for an underwater strobe light for the purpose of taking underwater photographs, particularly in a test environment.

SUMMARY OF THE INVENTION

Therefore it is an object of this invention to provide a device for controlling a source of illumination in underwater photography.

Another object of this invention is to provide a device for controlling a strobe light in underwater high speed photography.

Still another object of this invention is to provide a device for controlling a strobe light in underwater high speed
photography, the device including a novel control circuitry.

A still further object of the invention is to provide a circuitry which is an accurate and inexpensive method to control a timed illumination of a strobe light in underwater high speed photography.

Yet another object of this invention is to provide a device and circuitry for controlling a strobe light in underwater high speed photography which is simple to manufacture and easy to use.

In accordance with one aspect of this invention, there is provided a device for controlling a strobe light in underwater high speed photography. The device includes a plurality of spaced break screen members or sensing coils, a projectile for launch through the series of break screen members, a camera having a shutter opened at a predetermined timing prior to release of the projectile and closing at a predetermined timing subsequent to release of the projectile, and a strobe light opposed to the camera for illumination at a time when the projectile passes in front of the camera. A trigger device is positioned on the break screen member positioned immediately uprange of the camera. With a time delay programmed into a Programmable Array Logic (PAL), a control circuitry receives the trigger information and creates a timed signal to control the illumination of the strobe light.
In accordance with another aspect of this invention, the control circuitry includes a first D flip-flop for receiving a signal output from a break screen upon passing of a projectile therethrough, the first D flip-flop additionally having a constant voltage applied to its D-input and a resulting latched output signal. An AND gate receives an output signal of the first D flip-flop, the AND gate additionally having a CRYSTAL_IN signal applied thereto for maintaining a stable clock to counters of the PAL, and a resulting output signal only when the latched output signal from the first D flip-flop is high. An N-bit counter receives the output signal of the AND gate, the N-bit counter outputting delay generation logic upon lapse of a predetermined length of time. A second D flip-flop receives the delay logic signal, and additionally has a constant voltage applied to it's D input and a resulting latched output signal, wherein a rising edge of an output generated by the second D flip-flop identifies a beginning of a camera activation window. A second AND gate receives the output signal of the second D flip-flop, the second AND gate additionally receives a CRYSTAL_IN signal applied thereto for maintaining a stable clock to counters of the PAL, and a resulting output signal is provided by the second D flip-flop. A second independent N-bit counter outputs a count. A second delay generation logic block receives the output of the second N-bit counter, and outputs a high pulse signal upon lapse of a
predetermined count. A third D flip-flop receives the output pulse signal from the second delay generation logic, and additionally has a constant voltage applied to it's D input and a resulting latched output signal, wherein a rising edge of an output generated by the third D flip-flop identifies an end of the camera activation window. An exclusive OR gate receives outputs from each of the second D flip-flop and the third D flip-flop, the exclusive OR gate producing a high pulse from the time delayed trig out goes high to the time second delay goes high, an output of the exclusive OR gate passing through an inverter to generate the desired low pulse. This output signal is buffered via a separate non-inverting buffer (whose open collector is pulled up to 5VDC) and then sent to the strobe light trigger.

Illumination is controlled by the control circuitry at the exact moment the projectile passes the lens of the camera.

BRIEF DESCRIPTION OF THE DRAWINGS

The appended claims particularly point out and distinctly claim the subject matter of this invention. The various objects, advantages and novel features of this invention will be more fully apparent from a reading of the following detailed description in conjunction with the accompanying drawings in which like reference numerals refer to like parts, and in which:
FIG. 1 is a plan view of a first preferred embodiment of the present invention; FIG. 2 is a diagrammatic view of the circuitry used in the preferred embodiment of the invention; and FIG. 3 is a timing diagram of the preferred embodiment of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

In general, the present invention is directed to a control circuitry for controlling an underwater strobe light for the purpose of taking underwater photographs of a high speed projectile tested in the Adaptable High Speed Underwater Munition (AHSUM) project. The control circuitry essentially senses when the projectile has passed through a break screen or sensing coil and turns on a strobe light at the exact time the projectile is passing through a 35mm camera field of view. The camera's shutter is opened approximately 200msec prior to the shot and closes immediately after the picture has been taken (film has been exposed by strobe light pulse of light).

The Adaptable High Speed Underwater Munition (AHSUM) project needed a method to obtain photographs of underwater projectiles during the course of their test series. The test apparatus is shown in FIG. 1. In FIG. 1, there is shown a plurality of sensing devices 10 all spaced a predetermined distance D apart. These sensing
devices 10 can be either sensing coils or break screens. Each
sensing device 10 is mounted to a steel plate 12 having an
opening formed therein for passage of a projectile 14
there through as discharged from a gun 30. The opening may be
of any shape suitable for a clean passage of the projectile
14, however, a circular opening was utilized in the actual
device. The steel plate 12 is not only used as a fastening
surface for the sensing device 10, but as a barricade to
protect the surrounding facility and personnel in the event
the projectile 14 strays off course.

The sensing device 10 may be further constructed as a
break screen having clear plastic sheets or film 16, similar
to a transparency. A continuous resistive trace 18 winds its
way back and forth from one side of the film 16 to the other
and is sandwiched between two of the sheets of film 16. It is
understood that alternative forms of capture may be used in
connection with one or more of the sheets of film 16, and such
modifications are intended to be included within the scope of
the invention. Both ends of the resistive trace 18 are
connected to the input of a control circuitry described in
detail in co-pending application entitled Underwater High
Speed Projectile Break Screen Based Speed Sensing Circuit for
the Adaptable High Speed Underwater Munition (AHSUM) Project.

Referring further to FIG. 1, there is additionally shown
a camera 20 opposed to a source of illumination such as a
strobe light 22. While a strobe light 22 is used for the purposes of illustration, it should be understood that this does not preclude other appropriate sources of illumination should they be suitable for use in the present invention.

It is not possible to operate camera 20 manually and capture the desired photographs of the projectile 14 passing by at a high speed. Therefore, a system was required to automatically operate the camera 20. Since the shutter of the camera 20 cannot operate quickly enough to take a picture of the projectile 14 passing by at high speed, an alternate approach is devised. The camera 20 is located in an opaque enclosure 24 through which the projectile 14 will traverse. This enclosure 24 is preferably constructed from black plastic sheeting material. A computer 26 is joined to control camera 20 and gun 30. The computer 26 opens the shutter of the camera 20 approximately 200 msec prior to launching the projectile 14. The computer 26 closes the shutter 700 msec later, well after the projectile 14 has run its course. The strobe light 22 is also located in the enclosure 24 and is pulsed on for a predetermined time (typically 3 usec) when the projectile 14 passes to expose the camera's film, taking a picture of the projectile 14. The control circuitry (FIG. 2) of the strobe light 22 is activated when the projectile 14 passes through the sensing device 10 located immediately up-range of the camera 20. A time delay must be incorporated to
compensate for the time required for the projectile to reach
the camera equipment after passing through the break screen or
voltage sense coil.

The remaining invention disclosure in relation to FIG. 2
and FIG. 3 describes the control circuitry 28 that receives
the sensor device 10 information and then creates the
appropriate timed trigger signal to control the underwater
strobe light 22. The selected illumination or strobe light 22
used during the AHSUM testing requires a low input pulse, of
specific duration, at the exact moment the projectile is
passing by the lens of the underwater camera 20. The control
circuitry 28 receives the input trigger information either as
an open circuit from a break screen sensor or as a voltage
spike from a sensing coil which detects the presence of a
magnetic projectile 14 passing through it. This signal is
sent to a sensor conditioning circuit 29 that outputs a
logical high (5V) referenced as TRIGGER_IN 31 pulse. The
TRIGGER_IN signal 31 is sent to the input of a programmable
array logic (PAL) device (FIG. 2) which contains the
circuitry.

The PAL contains discrete logic devices that can be
programmed and reconfigured. The waveforms produced by the
control circuitry in order to properly control the strobe
light are depicted in FIG. 3.
Referring now in detail to FIG. 2, the circuitry programmed in
the PAL is shown therein. All discrete logic labels are used
in the description strictly for explanation purposes. The
signal and component labels match those appearing in the
following figures.

Control circuitry 28 is implemented using logic circuitry
having an asserted or logical high value of 5 volts and a non-
assembled or logical low value of 0 volts.

The TRIGGER_IN input signal from one sensing device 10 is
sent to the clock input of a first D-flip-flop 32 that is
programmed internally in the PAL. The D-input of the first
flip-flop 32 is permanently connected to a logical high (5V)
source. The purpose of the first flip-flop 32 is to provide a
latched logical signal when a projectile passes through the
coil or break screen while preventing the output of the
circuit from changing in the event of voltage fluctuations at
the input. The output of the first flip-flop 32 is labeled as
TRIGGER_IN_LATCHED 33.

This signal of TRIGGER_IN_LATCHED 33 is sent to a two-
input AND gate labeled 34. The other input of the AND gate 34
is a 1 MHz square wave generated by a quartz crystal based
oscillator 35 and is labeled CRYSTAL_IN 37.

The main purpose of CRYSTAL_IN signal 37 is to provide a
stable clock input to the counters programmed in the PAL.

This AND gate 34 acts as a switch which allows the CRYSTAL_IN
37 signal through, only when the TRIGGER_IN_LATCHED signal 33
is high. The output of the AND gate 34 is sent to the clock
input of N-Bit Counter 36. The size in bits of the counter 36
(clocked at a 1 MHz or 1μsec rate) depends on the sum of: 1)
the length of time delay required between the initial
triggering of the control circuitry by the sensor device 10
and the time the first image is desired; and 2) the time the
camera 20 is to acquire images.

The output of the N-Bit Counter 36 is sent to the first
Delay Generation Logic section 38. The first delay generation
logic section 38 contains logic that utilizes one of ten user
selectable preprogrammed delay times. The delay time selected
is actually the number of counter transitions that must occur
before allowing the output of this logic section to assert
itself. From zero, the counter 36 starts incrementing once
the clock input from oscillator 35 is enabled via the first
AND gate 34. Once the N-Bit Counter 36 reaches the time delay
value selected by the user, a high pulse is output from the
first delay generation logic 38 and fed into the clock input
of a second D flip-flop 40.

Once again the D-input of the flip-flop 40 is permanently
connected to a logical high source. Therefore, the first
delay generation logic 38 output will latch an output signal
of the second flip-flop 40 high until reset. The second flip-
flop output is labeled DELAYED_TRIG_OUT 41. The rising edge
of DELAYED_TRIG_OUT 41 signifies the beginning of the camera activation window. The next step in the control circuitry is to create an additional delay signal.

The DELAYED_TRIG_OUT signal is provided as input to a second two-input AND gate 42 programmed in the PAL. The other input of the AND gate 42 is joined to receive the CRYSTAL_IN signal from oscillator 35. The output of the AND gate 42 is sent to the clock input of an independent second N-Bit Counter 44. The size in bits of the second N-Bit Counter 44 depends upon the maximum possible length of the activation window required by the strobe light 22. The N-Bit output of this counter 44 is joined to a second delay generation logic 46. As in the first delay generation logic, this section contains logic that utilizes one of ten user selectable preprogrammed delay times. The delay time selected is actually the number of counter transitions that must occur before allowing the output of this logic 46 to be asserted. The counter 44 starts at zero and will only start incrementing once the CRYSTAL_IN signal is enabled via the second AND gate 42.

Once the N-Bit Counter 44 reaches the time delay value selected by the user, a high pulse is output from the second delay generation logic 46 and provided to the clock input of a third D-flip-flop 48. Once again the D-input of the flip-flop 48 is permanently connected to a logical high source.

Therefore, the assertion of the second delay generation logic...
46 output will latch the output of the flip-flop 48 to a high
signal until reset. The latched signal is labeled
SECOND_DELAY. The rising edge of the SECOND_DELAY signifies
the end of the camera activation window.

The DELAYED_TRIG_OUT from the second D-flip-flop 40 and
SECOND_DELAY from the third D-flip-flop 48 are fed to the two
inputs of an exclusive-OR gate 50 which produces a high pulse
(activation window) which is high from the time the
DELAYED_TRIG_OUT goes high to the time the SECOND_DELAY goes
high. The output of the exclusive-OR gate 50 is in turn
passed through an inverter 52 to generate the desired low
pulse. This output signal, labeled DELAYED_TRIGGER_OUT_PULSE,
is buffered by non-inverting buffer 54 and then sent to the
trigger of the strobe light 22.

When programmed correctly, the strobe light 22 will be
turned on by the control circuitry at the exact moment the
projectile 14 passes the lens of the camera 20.

As stated above, the camera 20 has its shutter opened
just prior to firing the projectile 14. Thus, the flash of
the strobe light 22 provides the high intensity light source
required to expose the camera's film, and thereby produce the
projectile photograph.

The above circuitry provides an accurate and inexpensive
method to control an underwater strobe light for photographic
imaging purposes. The circuitry is programmable which
provides flexibility and greatly minimizes the need for circuit modifications as test requirements and conditions (i.e., projectile speed) vary.

Finally, it is anticipated that the invention herein will have far reaching applications other than those of underwater projectile testing projects.

This invention has been disclosed in terms of certain embodiments. It will be apparent that many modifications can be made to the disclosed apparatus without departing from the invention. Therefore, it is the intent to cover all such variations and modifications as come within the true spirit and scope of this invention.
ABSTRACT OF THE DISCLOSURE

A device for controlling a strobe light in underwater high speed photography in a first aspect includes a plurality of spaced break screen or sense coil members, a projectile for launch through the series of break screen or sense coil members, a camera having a shutter opened at a predetermined timing prior to release of the projectile and closing at a predetermined timing subsequent to release of the projectile, and a strobe light opposed to the camera for illumination at a time when the projectile passes in front of the camera. A trigger device, such as a break screen or sense coil, is positioned immediately up-range of the camera. With a time delay programmed into a Programmable Array Logic (PAL), a control circuit receives the trigger information and creates a timed signal to control the illumination of the strobe light.

In accordance with another aspect of this invention, the control circuitry includes discrete logic devices programmed such that illumination is controlled by the control circuitry at the exact moment the projectile passes the lens of the camera.
FIG. 3

TRIGGER_IN_LATCHED

DELAY_LOGIC

DELAYED_TRIG_OUT

FIRST DELAY

SECOND DELAY

SECOND DELAY

DELAY_TRIG_OUT

:+: SECOND_DELAY

DELAY_TRIG_OUT

:+: SECOND_DELAY

ENABLE PULSE

BREAK SCREEN/COIL VOLTAGE