United States Patent

[11] 3,623,045

[72] Inventor **Lawrence A. Ouellette**
Hackettstown, N.J.

[21] Appl. No. **91,895**
[22] Filed **Nov. 23, 1970**
[45] Patented **Nov. 23, 1971**
[73] Assignee **The United States of America as represented by the Secretary of the Army**

[54] INTERNAL GUN TUBE BALLISTICS LASER TELEMETER

8 Claims, 1 Drawing Fig.

[52] **U.S. Cl.** **340/190,** 250/199, 340/207
[51] **Int. Cl.** **G08c15/04,** G08c 19/12
[50] **Field of Search** 340/189, 190, 207; 250/199

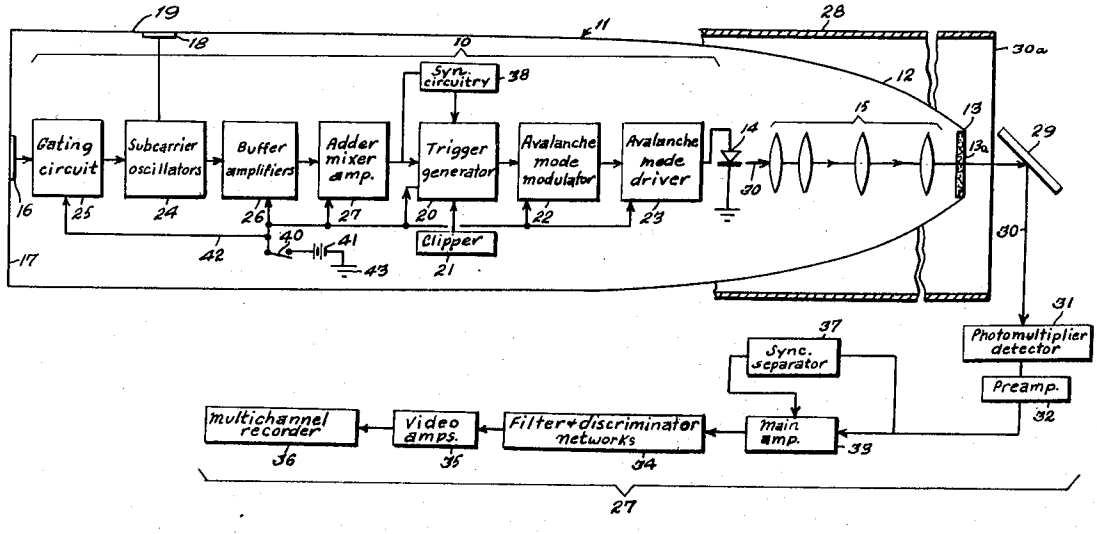
[56] **References Cited**

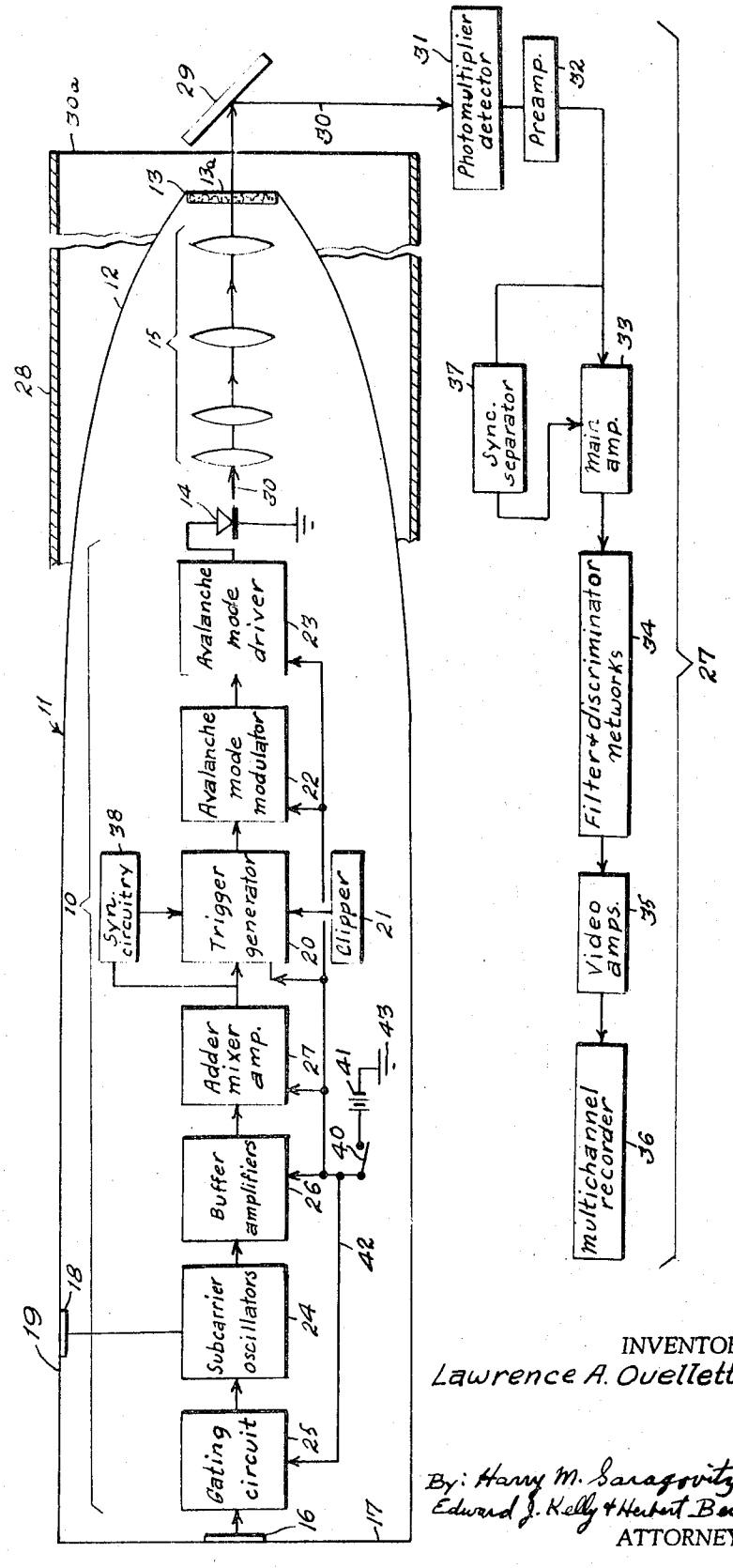
UNITED STATES PATENTS

2,884,624	4/1959	Dean	340/189
3,034,115	5/1962	Grantham	340/189
3,123,714	3/1964	Chope	250/199

Primary Examiner—Thomas B. Habecker
Attorneys—Harry M. Saragovitz, Edward J. Kelly and Herbert Berl

ABSTRACT: A laser telemeter affixed in the interior of a projectile whereby performance data may be obtained from the projectile body or its safing, arming and fuzing components during the time of actual high imparted shock and acceleration while the projectile is in transit in the gun tube. A RF oscillator which generates the carrier frequency is coupled to modulator means which converts the output of the generator to current pulses whereby the injection diode is current pulsed above the lasing threshold resulting in a constant train of light pulses being emitted therefrom. The light pulses pass through an opening in the nose of the projectile and then down the gun tube to the exterior thereof. Transducers affixed to various areas or components of the projectile respond to the performance of said areas or components to produce electrical signals which are coupled to and frequency modulate related RF subcarrier oscillators. The frequency modulated outputs of the subcarrier oscillators are superimposed on the output of the carrier oscillator. Thus, the light pulses are subsequently frequency modulated providing data indicative of the performance of said areas or components. The modulated light pulses are detected and processed by receiver means which include a photomultiplier, upon which the modulated light pulse impinge, coupled to electronic demodulating circuits and recorders.





INVENTOR,
Lawrence A. Ouellette

By: Harry M. Saragovitz,
Edward J. Kelly & Herbert Berl
ATTORNEYS.

INTERNAL GUN TUBE BALLISTICS LASER TELEMETER

The invention described herein may be manufactured, used, and licensed by or for the government for governmental purposes without the payment to me of any royalty thereon.

This invention relates to telemeters and more particularly to a laser telemeter contained in a projectile to be tested in an air gun or artillery piece whereby information is obtained from the projectile during its travel through the air gun or artillery piece.

Since the advent of artillery fired projectiles a need has existed for measuring the performance of a projectile and components contained therein while experiencing thousands of "G's" of imparted shock and acceleration forces in the gun tube. It is during this time that the projectile and fuzing components contained within it undergo their most severe stress environment during which the highest probability of failures occur. Without these data, the development of the projectile shell body and its fuzing components has been a long, tedious, hazardous and costly procedure. This condition results from the severe setback force in both systems, the confinement imposed by the gun tube which is a completely closed system for the air gun and from the byproducts of burning propellant for the artillery piece.

Though the air gun has been, and continues to be, a valuable tool in the evaluation of projectile safing and arming systems, it has been a no less frustrating tool in use. By its very nature as a closed system, the acquisition of performance data of projectile component during actual laboratory firing has been impossible, component evaluation therefore, in the past, has been restricted to a go-no-go type test.

A means of data acquisition which has met with a degree of success in artillery pieces is the hard wire telemetry consisting of fine strands of stainless steel wire electrically attached to the projectile components and brought out through the muzzle of the gun to external instrumentation. However, movement of the projectile through the gun tube particularly at high velocities causes bunching of the strands thereby presenting data acquisition problems. Another means of data acquisition is the radio frequency telemeter which has been used to transmit data after the projectile has exited the gun tube. However, such data are not available during the critical time of environmental extremes which occur during the in-bore transit time due to gun tube interference with the transmission of the RF beam.

The telemeter of the instant invention utilizes the semiconductor laser diode, injection diode, in combination with special electronic techniques and for the first time makes it possible to obtain data directly from a projectile shell body and its safing, arming and fuzing components during the time of actual high imparted shock and acceleration. The laser telemeter is installed in the projectile and the injection diode is current-pulsed above the lasing threshold. For every current pulse there is a lasing or light pulse emitted which is detected by a light detector. The component to be tested is connected to the telemeter through various forms of transducer means. Information on the behavior of a component, for example, closing of a switch, accelerometer output, time of component failure, setback effect on the projectile, stress on the peripheral surface of the projectile etc. is transmitted down the bore of the tube, air gun or artillery piece, on each light pulse. The receiver means consists of a photomultiplier in line with the transmitted frequency modulated pulses emanating from the gun tube coupled to electronic demodulating circuits and recorders.

Accordingly, a major object of the invention is a telemeter contained in a projectile whereby performance data of the projectile or components incorporated therein may be obtained directly during the time of actual high impared shock and acceleration.

Another object of the invention is a laser telemeter contained in a projectile for measuring the performance of a projectile or its components while experiencing thousands of G's of impared shock and acceleration forces during the confinement imposed by the gun tube and from byproducts of burning propellant for artillery pieces.

The novel features that are considered characteristic of the invention are set forth with particularity in the appended claims. The invention itself, however, both as to its organization and method of operation as well as additional objects and advantages thereof will be best understood from the following description taken in conjunction with the accompanying drawing in which

the sole FIGURE is a block diagram illustrating the invention.

Referring to the drawing, reference number **10** generally indicates the laser transmitter of the telemeter of the invention. The components of transmitter **10** consist of solid state elements and related circuitry assembled to comprise a package adapted to fit within projectile **11** adjacent nose **12** thereof which is provided with an opening **13** in which is affixed an optical protective window **13***a*. The semiconductor laser or injection diode **14** is oriented so that the light pulses radiating therefrom are transmitted through opening **13** and subsequently down the tube of the artillery piece or air gun to the exterior thereof while the projectile is in transit in the tube. Intermediate to the laser diode **14** and opening **13** there is affixed in nose **12** an optical system **15** for collimating and focusing the coherent laser beam. Transistor RF trigger generator **20** which is employed to generate the carrier frequency of the laser telemeter is a sine wave generator provided with a clipper circuit **21** which clips both the positive and negative peaks of the generated sine wave to 70.7 percent. The output of generator **20** is coupled to transistor avalanche mode modulator **23** which in response thereto produces a fast rise time, short-duration pulse which subsequently drives laser diode **14** to a lasing or coherent light output. In order to assure operation of laser diode **14** beyond its threshold current level an avalanche mode driver **23** is coupled between the avalanche modulator **22** and laser diode **14**.

In order to obtain a measure of, for example, the setback force which the projectile experiences when fired in an artillery piece, a transducer **16** which may be a piezoelectric device may be affixed in the base **17** of the projectile **11**. Similarly, a transducer **18** may be affixed in wall **19** of the projectile to obtain a measure of the peripheral stress. Although transducers **17** and **18** represent but two sources for obtaining data, it is to be understood that 18 such means have been employed involving as many channels in the telemeter of the invention. Transducer **18** is coupled directly to one of the RF subcarrier oscillators **24** while transducer **16** is coupled through gating circuit **25**, employed to conserve battery power, which in response to a signal therefrom activates the subcarrier oscillators **24** and also applies said signal to another one of the subcarrier oscillators whereby it is frequency modulated, the frequency deviation thus obtained being a measure of the setback force. Transducer **18** responding to the peripheral stress to which the projectile is subjected produces a signal which frequency modulates the carrier frequency of the related subcarrier oscillator, the frequency deviation of the said carrier frequency or center frequency being indicative of the peripheral stress. Each of the subcarrier oscillators **24**, each of a different center frequency, is coupled to a respective buffer amplifier of buffer amplifiers **26**. The frequency modulated outputs of buffer amplifiers **26** are added and mixed in adder and mixer amplifier **27**. The output of adder and mixer amplifier **27** is applied to the input of trigger generator **20** which is provided with a synchronizing circuit **38** coupled thereacross whereby the amplified outputs of the frequency modulated subcarrier oscillators are superimposed on the clipped sine wave output of trigger generator **20**.

In either the air gun or artillery piece when the projectile is in transit in the gun tube **28** the modulated laser beam **30** containing data relative to the performance of the projectile or related components is transmitted through the bore **30***a* of the gun tube **28** to the exterior thereof. When the artillery piece is employed, a mirror **29** aligned with the bore of the gun tube in

spaced relationship to the muzzle reflects the modulated laser beam 30 to a photomultiplier detector 31. The air gun is provided with an apertured cap having an optional window affixed therein at its muzzle or exit end which permits passage of the laser beam therethrough and the positioning of photomultiplier 31 adjacent to and in alignment with the aperture. Photomultiplier 31 is provided with a preamplifier 32 coupled to main amplifier 33 which has coupled thereacross a multivibrator sync-separator 37. The output of main amplifier 33 is coupled to filter and discriminator networks 34 which are inturn coupled to related video amplifiers 35 having their outputs coupled to respective channels of multichannel recorder 36.

In operation, the laser telemeter 10 is affixed in the projectile as aforedescribed and the projectile propelled in the gun tube which is accomplished in the case of the artillery piece by means of an explosive propellant and in the air gun by means of air under pressure admitted at the breech end thereof. Battery 41 is a power source for the various electronic units of telemeter 10 and is connected with said units through common circuit 43 and conductor means 42 through manual switch means 40 in series with the battery and conductor means. Trigger generator 20 is activated by the manual switch means 40 prior to inserting telemeter 10 in the projectile. Considering for the moment the time during which the projectile experiences the setback force, transducer 16 generates an electrical signal in response thereto which is coupled to gating circuit 25 which utilizes the signal to turn on subcarrier oscillators 24 and also applies the signal to the input of one of the subcarrier oscillators whereby its frequency is caused to shift above or below its center frequency, i.e., 5,400 cycles ± 7.5 percent by some value determined by the polarity and amplitude of said electrical signal. Various other areas or components of the projectile or other items under such test are coupled directly to related subcarrier oscillators 24 through respective transducer means which generate electrical signals in response to stress or malfunctioning of the areas or components whereby the related subcarrier oscillators are also frequency modulated. Depending upon the complexity of item under test there may be as many as 18 input channels to subcarrier oscillators 24. The output of each subcarrier oscillator is coupled to the input of its related buffer amplifier of buffer amplifiers 26 the outputs of which are coupled to adder and mixer amplifier 27 whose output is coupled to trigger generator 20 which in combination with clipper circuit 21 produces a clipped sine wave as the carrier frequency of the laser telemeter. Synchronizing circuit 38 superimposes the subcarrier oscillators frequencies upon the clipped sine wave. The resultant output signal from generator 20, consisting of the clipped sine wave with the complex wave superimposed, is coupled to the transistor avalanche mode modulator 22 which in response to said resultant output signal produces fast rise time, short-duration pulses which subsequently drive laser diode 14 to a lasing or coherent light output. To achieve greater driving currents beyond threshold operation of laser diode 14, the transistor avalanche mode driver 23 is coupled between the output of avalanche mode modulator 22 and laser diode 14. When the avalanche mode driver is driven on by the avalanche mode modulator, amplified current pulses flow in the output thereof supplying a three to four times threshold forward bias to laser diode 14 which in turn produces a highly coherent light wave containing the trigger generator frequency, the syncircuit frequency and all frequencies of the subcarrier oscillators. The resultant coherent light output of laser diode 14 is collimated and focused by lens system 15 and projected down the gun tube 28 while the projectile is in transit therein to the optical detector, photomultiplier 31, the electrical response of which is amplified by preamplifier 32 and further amplified by main amplifier 33 which has a multivibrator sync-separator 37 coupled thereacross whereby the synchronizing signal generated by sync-circuit 38 is removed. The output of amplifier 33 consisting of the carrier frequency generated by generator 20 and the subcarrier signals generated by subcarrier oscillators 24 is coupled to the filter and discriminator networks 34 wherein the carrier frequency is filtered out and the subcarrier oscillators frequencies are passed to the outputs thereof which are coupled to respective channels of multichannel recorder 36 through respective video amplifiers 35.

What is claimed is:

1. A semiconductor laser telemeter affixed in the interior of a projectile for obtaining data relating to the performance of the projectile and components while in transit in a gun tube comprising in combination:

a hollow projectile provided with an aperture in the nose thereof,

a semiconductor laser diode affixed in the projectile adjacent the aperture,

means for generating a carrier signal for the telemeter,

means coupling the semiconductor laser diode with the means for generating a carrier signal whereby the semiconductor laser diode is pulsed and emits light pulses at the frequency of the carrier signal,

means for generating subcarrier frequencies,

means affixed to selected parts of the projectile responsive to the performance of said parts to produce electrical signals which are coupled to and frequency modulate the subcarrier frequency of respective means for generating subcarrier frequencies whereby the frequency deviations thus obtained are indicative of the performance of said parts,

means coupling the frequency modulated outputs of the means for generating subcarrier frequencies to the means for generating a carrier signal,

means for superimposing said frequency modulated outputs on said carrier signal providing a resultant output which is coupled through the means coupling the semiconductor laser diode with the means for generating a carrier signal whereby the light pulses of the semiconductor laser diode are modulated in accordance with the performance of said parts,

optical means affixed in said projectile intermediate the aperture and semiconductor laser diode whereby the modulated light pulses comprising the laser beam are collimated and focused down the gun tube to the exterior thereof during transit of the projectile in said tube,

receiver means external of the gun tube for receiving, demodulating and recording said modulated light pulses.

2. The invention in accordance with claim 1 wherein said means for generating a carrier signal is an RF sine wave oscillator provided with clipping means whereby the positive and negative peaks of the sine wave output thereof are clipped to 70.7 percent portion of the wave.

3. The invention in accordance with claim 1 wherein said means for coupling the semiconductor laser diode with the means for generating a carrier signal comprises a transistor modulator operated in the avalanche mode having its input coupled to the output of the means for generating a carrier signal and its output coupled to a transistor driver operated in the avalanche mode with the output thereof coupled to the semiconductor laser diode whereby the output of the means for generating a carrier signal is applied to said diode in the form of a positive pulse of a value in excess of the threshold forward bias of said diode.

4. The invention in accordance with claim 1 wherein said means for generating subcarrier frequencies comprise a multiplicity of subcarrier RF oscillators, each said subcarrier oscillator operating on a different center frequency, and each said subcarrier oscillator coupled to respective means affixed to selected parts of the projectile, each said respective means comprising a transducer.

5. The invention in accordance with claim 4 wherein each said subcarrier oscillator is provided with a buffer amplifier having its input coupled to the output of said subcarrier oscillator.

6. The invention in accordance with claim 5 wherein said means for coupling the frequency modulated outputs of the means for generating subcarrier frequencies to the means for generating a carrier signal comprises an adder and mixer amplifier coupled between the outputs of the buffer amplifiers and the input of the means for generating a carrier signal.

7. The invention disclosure in accordance with claim 5 wherein said means for superimposing said frequency modulated outputs on said carrier signal comprises a synchronizing circuit coupled across the means for generating a carrier signal whereby said frequency modulated outputs are superimposed on the clipped sine wave output of said means for generating a carrier signal. The invention in accordance with claim 7 wherein said receiver means comprises a photomultiplier tube positionable in the path of the modulated light pulses whereby said light pulses are converted to electrical signals, an amplifier coupled to said electrical signals for amplification thereof, a multivibrator sync-separator coupled across said amplifier whereby the sync-signals generated by said synchronizing circuit are removed from said electrical signals, filter and discriminator networks coupled between the output of said amplifier and the inputs of video amplifiers wherein the carrier signal as represented in said electrical signals is filtered out and each of said frequency modulated outputs as represented in said electrical signals is passed through respective networks filter networks thereof, and means coupling the outputs of said filter networks to respective channels of a multichannel recorder to provide data thereon from which the performance of the projectile and components is evaluated.

* * * * *

PO-1050
(5/69)

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,623,045 Dated November 23, 1971

Inventor(s) Lawrence A. Ouellette

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

At the end of the patent add the following claim:

8. The invention in accordance with claim 7 wherein said receiver means comprises a photomultiplier tube positionable in the path of the modulated light pulses whereby said light pulses are converted to electrical signals, an amplifier coupled to said electrical signals for amplification thereof, a multivibrator sync-separator coupled across said amplifier whereby the sync-signals generated by said synchronizing circuit are removed from said electrical signals, filter and discriminator networks coupled between the output of said amplifier and the inputs of video amplifiers wherein the carrier signal as represented in said electrical signals is filtered out and each of said frequency modulated outputs as represented in said electrical signals is passed through respective networks filter networks thereof, an means coupling the outputs of said filter networks to respective channels of a multi-channel recorder to provide data thereon from which the performance of the projectile and components is evaluated.

Signed and sealed this 25th day of April 1972.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR.
Attesting Officer

ROBERT GOTTSCHALK
Commissioner of Patents