Optical Pulse-Ranging with the Nanolite

In the following I should like to report about some preliminary tests which demonstrate that a noncoherent high-power but low-energy nanosecond spark[1] known as the "Nanolite" successfully can be used as the source for short-distance pulse ranging of high-repetition rate suggesting range accuracies of several cm. There is promise that such a device can be utilized in a simple and lightweight practical apparatus.

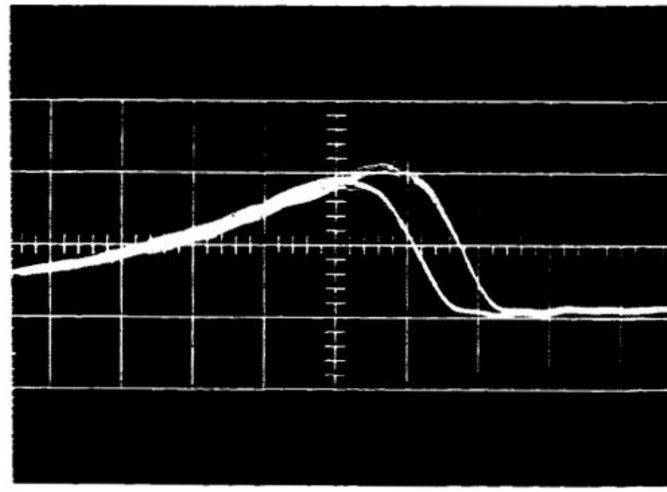

Fig. 1. Signals from a ~70 percent reflection, 55×75 cm target at 20 and 20.9 m distances—Tektronix 585 Scope, time scale: 10 ns/cm—40 successive shots superimposed.

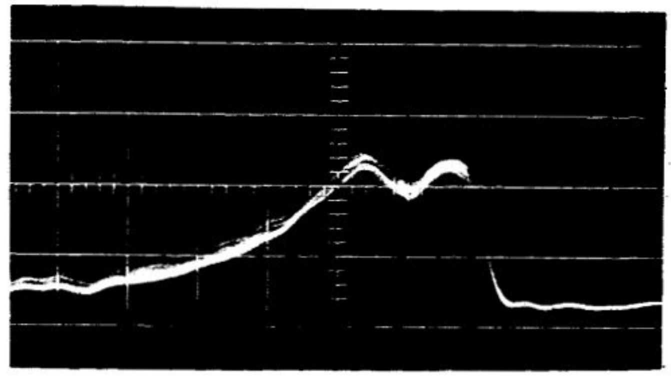

Fig. 2. Signal differentiation from 2 separate standard targets in 20 and 22 m distance and 1 m separated sidewards—30 shots superimposed.

Experimental Data

The nanolite represents a spark gap integrated into a coaxial capacitor.[1] The complete source including capacitor may weigh as little as approximately 100 g when a plastic line is utilized for the capacitor. The gap may be operated free firing without a trigger in air up to short-burst repetition rates of approximately 10 000 pps with a time jitter of successive firing which is within approximately 3 ms,[2] assuming polished electrodes. A time jitter of considerably less than 1 ns may be obtained in a single-shot operation.[3]

The *distance* of the target was determined from the time delay of the reflected light pulse; it was observed by means of a Tektronix Scope 585 (risetime 4 ns) which does not take full advantage of the 2 to 7 nsec risetime of various nanolites. Photomultipliers 7746A, S11 response (3, 5 ns rise) and the UV sensitive 1P28, S5 response (3 ns rise) were placed sidewards to the source at a distance of 1 m; no optical system for the Photomultipler was used.

The electric pick-up at the opposite end of the coaxial line of the nanolite provides the trigger pulse[1] for the timing device. The image of the source using a 17 cm diameter reflector was focused on $a\sim70$ percent reflectance target, 55×75 cm in size, at distances from 5 to 75 m. Tests were performed at night and in bright sunlight.

Results

The range accuracy is demonstrated in Fig. 1. The 7746 Photomultiplier was operated at 1000 V and the scope amplification was 0.51 V/cm. The operational data of the source in Fig. 1 were breakdown voltage $U=4.0$ kV, $C=3.6$ nF and energy per pulse $K=2.9\times10^{-2}$ J; maximum current was approximately 4000 A after 7 ns from the beginning of the breakdown. Note the extremely small amount of time jitter in the rise of the reflected signals. The time difference of the two target positions having a range difference of $\Delta r=90$ cm reads exactly 6 ns, which in return equals:

$$\Delta^r = \frac{6\times10^{-9}\text{ sec}\times 3\times10^{+10}\text{ cm/sec}}{2} = 90\text{ cm}.$$

The accuracy is assumed to be better than the trace-width which equals approximately 0.5 ns. This means, that the observed range is accurate better than approximately ±3.5 cm. It appears that present limiting factors for the accuracy of observation are insufficient time resolution and time jitter of the scope, also inadequate focusing of the scope beam.

The signal in Fig. 1 was reduced by means of neutral optical filters and at night time was above the noise level by a factor of approximately 8×10^4. This noise presently results largely from cross talk from the outgoing light pulse. Background lights from the airstrip did contribute to a small fraction only.

Signal differentiation as observed within the same scope trace is demonstrated in Fig. 2. Operational data of this particular source were $U=4.1$ kV, $C=0.615$ nF, current rise ~2 ns.

Summary and Discussion

Accuracies of range within a few cm were demonstrated with targets at 10–75 m distances. Several small size targets may be recognized within the same scope trace. The preliminary apparatus was crude. The source, its operation and power supply are simple and extremely lightweight. Short-burst repetition rates $\sim10^4$ pps are possible.

The wide band of spectral emission[4] of the noncoherent nanolite can be utilized fully during *night time* ranging only. Here ranges exceeding several km may be calculated from the observed signal-to-

Manuscript received September 6, 1966.

[1] Heinz Fischer, *J. Opt. Soc. Am.*, vol. 51, p. 543, 1961; see also "Nanosecond pulses of very low impedance." *Proc. IEEE*, vol. 53, pp. 545–546, May 1965.

[2] Heinz Fischer and A. Fritzsche, *Appl. Optics*, vol. 3, p. 1235, 1964.

[3] Heinz Fischer and C. C. Gallagher, *Appl. Optics*, vol. 4, p. 1151, 1965.

[4] Heinz Fischer and W. B. Rueppel, *Appl. Optics*, vol. 3, p. 769, 1964.

noise ratio, which may be increased by a large factor by integration of the photomultiplier into an adequate optical system. A sunblind UV-filter by Thin Film Products, Inc., Cambridge, Mass., did reduce the light signal by a factor of 170. During bright *daylight*, ranges exceeding several 100 m are expected with a properly shielded photomultiplier.

Acknowledgment

C. C. Gallagher performed the experiments, P. C. Tandy assisted.

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