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Quick-Acting Electric Blasting Caps

Marcin NITA*, Radosław WARCHOŁ

Military Institute of Armament Technology
7 Prymasa Stefana Wyszyńskiego Str. , 05-220 Zielonka, Poland
** Corresponding author's e-mail address: marcinnita@gmail.com*

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Abstract. The paper presents the constructions of new, quick-acting electric blasting caps of WN-1 and WN-1A types, developed at the Military Institute of Armament Technology in Zielonka (Poland). These blasting caps have been characterized in terms of the materials used for their production and the applied explosives. The investigation results of selected blasting caps and their most important characteristics are given. Among other things, dependence between a response time of a blasting cap and a supply voltage was presented as well as influence of extreme temperatures on its reliability and response time was given. The investigations of the blasting caps and the results confirming their usefulness for initiating explosives charges were presented.
Keywords: armament, combat means, electric blasting caps, ignition delay, detonation

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1. INTRODUCTION

Contemporary designs of various combat means frequently must be precise and must characterize with a short response time. Such requirements are posed to the active defence systems, tandem shaped charge warheads or fuses of antiaircraft weapons. To fulfil these requirements, necessary are electronic and electric executive systems, among other things - various electric blasting caps.

At present, in Poland, there are carried-out investigations on some new constructions of such executive systems because, till now, widely used quick electrospark blasting cap of JED type (Fig. 1) has significant drawbacks. The most important drawback is its high sensitivity to electrostatic discharges. Simultaneously, for proper start working, the blasting cap needs the voltage of about 3 kV. It should be mentioned that JED blasting cap is not and never has been produced in Poland. However, low-voltage quick-acting blasting caps of M-100 type produced in the USA tend to be less accessible and their price is relatively high.

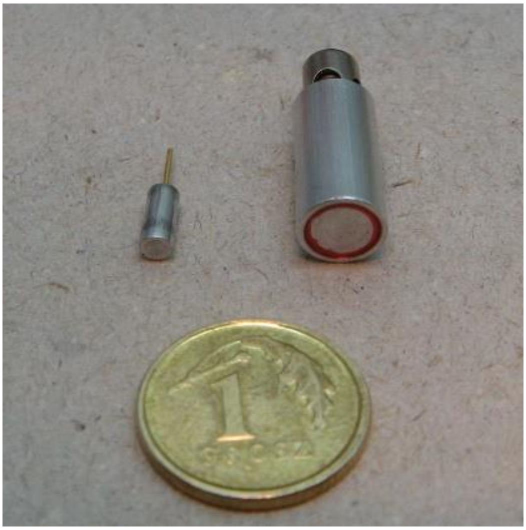

Fig. 1. Quick-acting electric blasting caps:
on the left side– M-100 type; on the right side– JED type

Thus, fully independence from foreign supplies of such significant elements as quick-acting electric blasting caps is justified.

The trials of blasting caps production, which began in Poland many years ago, were not successful. It was connected, among other things, with the failed process of elaboration of new synthesis of lead azide (II), that it was free from macromolecular compounds.

Preliminary investigations on the construction of new quick-acting electric blasting cap were carried out also by the Military Institute of Armament Technology (MIAT) in Zielonka (Poland).

The conclusions from these investigations showed that it is possible to simply develop a quick-acting electric blasting cap of Hot Bridge Wire (HBW) type. However, some problems, resulting from the choice and type of an assembly method of a resistive element and its substrate characterizing with the required mechanical strength and adequately low heat capacity had to be solved.

The currently applied methods of production of quick-acting electric blasting caps are based on the work of various automats and robots that ensure repeatability of the parameters of the manufactured products, simultaneously with high level of their reliability.

Report [1], related to resistance elements used in M-100 blasting caps, describes a complex process of their production. Among other things, Chemical Vapour Deposition (CVD) is applied in a production, what ensures precise production of layers of a conductor or isolator of a few μm thickness. Production of heating elements of adequately small dimensions makes possible to miniaturise the blasting caps.

Report [2], including information on the production of similar structures, even stronger pointed that implementation of the technology that is indispensable for production of quick-acting miniature electric blasting caps is a complex task requiring huge financial sources. It can be especially seen in the case of micro-detonators that need for correct operation low electric energy of the order of a few mJ.

Paper [3] presents description of the production process as well as of parameters of micro detonators, the resistance element of which is covered with aluminium layer thickness of 1.5 μm. Interesting is application as explosive material, highly sensitive to mechanical stimuli, nanopore copper azide, in amount of 0.93 mg.

The works performed at present by the MIAT are aimed at development of new quick-acting electric blasting cap that could be produced in Poland. It would allow to make the Polish weapon industry independent of these subassemblies' supply from foreign producers.

Currently, two variants of such quick-acting electric blasting cap are developed, made, and investigated.

2. SHORT CHARACTERISTIC OF BLASTING CAPS DEVELOPED BY MIAT

Significant differences between the blasting caps denoted as WN-1 and WN-1A, developed by MIAT, result from a kind of the used explosives. General characteristics of the first-generation blasting caps developed by MIAT and described in literature data of XM100 primer [4] are given in Table 1.

Table 1. Characteristics of the XM100, WN-1 and WN-1A blasting caps

Blasting cap type	**Response time/voltage µs/V**	**Notes**
XM100	4/100	Blasting cap replacing now M-100 primer
WN-1	8.0/150	Blasting cap with lead-free primary explosive
WN-1A	8.4/150	Equivalent of WN-1 blasting cap, containing lead azide

The parameters of WN-1 and WN-1A blasting caps are different than the blasting caps produced in highly developed countries, however, they can be sufficient for determined tasks. As an example, if anti-tank guided missile moves with velocity of 250 m/s, i.e., 0.25 mm/µs, after its impact to the target it will move further 2 mm before the blasting cap will be fully activated. Of course, such situation is in the case when, at the moment of impact to the target, the electric pulse of 150 V is applied to WN-1 blasting cap. Thus, the problem of possible delay in activation can be easily eliminated by equipment of a combat head in an element which will be deformed at the first phase in a controlled way.

The developed by MIAT, the WN-1 and WN-1A blasting caps, (Fig. 2.) are the blasting caps of HBW type. All they have the same body in form of aluminium cap of a diameter of 5.05+0.12 mm and a height of 7.00-0.15 mm. The blasting cap dimensions are the result of present trend to miniaturise the blasting caps of contemporary combat means and to reduce the amount of contained in them explosives to the accepted minimum.

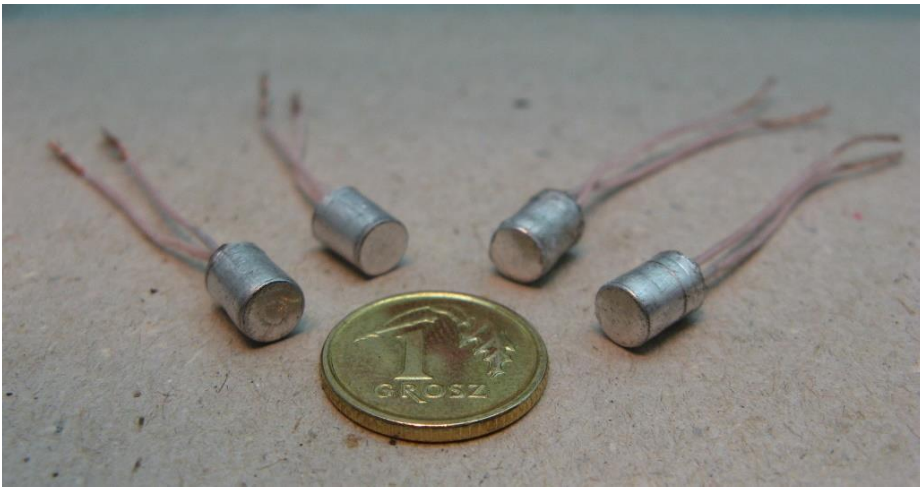

Fig. 2. Quick-acting electric blasting caps, developed and made by MIAT: WN-1 and WN-1A

The differences between the WN-1 and WN-1A blasting caps result from a kind of the used explosives. The WN-1 blasting cap can be classified to the family of the products containing the explosives that are not lead compounds. The WN-1A blasting cap is less friendly for environment because it based on lead azide (II).

However, finally, the unit cost of the WN-1A blasting caps production is lower than WN-1 primers of about 50%.

Both types of the above-mentioned blasting caps are equipped with electric terminal made of isolated copper conductors of 30-mm length. These conductors and resistance element of the resistance lower than 0.2 Ω (Table 2) is isolated from its casing.

Table 2. Operating voltage, resistance, and mass of blasting caps

Type of blasting cap	**Standard operating voltage, V**	**Average mass of blasting cap, mg**	**Resistance of resistor, mΩ**
WN-1, WN-1A	50-210*	356	183

* Higher voltages were not applied.

Total mass of explosives, contained in blasting caps, was 100 mg. The blasting caps had flat bottoms – it may turn out to be significant at the stage of implementation.

3. BASIC PARAMETERS OF BLASTING CAPS. INVESTIGATIONS AND THEIR RESULTS

This section of the paper presents the most important, from applicability point of view, parameters of the WN-1 and WN-1A blasting caps.

3.1. Time response of blasting caps

The most important parameter of the quick-acting electric blasting caps, despite their high reliability and efficiency of operation is time of response. This time corresponds to the interval, calculated since the moment of current pulse application to the blasting cap till the moment of recording, by the detector, the reaction signal of blasting cap. The most popular detectors used for such investigations are photodiodes and piezoelectric converters. Of course, both the supply source of blasting caps, switch, as well as detector should have adequate characteristics in order not to falsify the measuring results. For example, the response time of blasting caps is affected by, e.g., the shape of a supply pulse that should be possibly steep in this situation.

Investigations of response times of various explosive systems are carried-out at MIAT on the special test bench, which is shown in Fig. 3.

This test bench consists of the capacitor C of low resistance and capacity 100 μF, charged by the resistor R of the resistance 10 kΩ by means of the controlled power supply

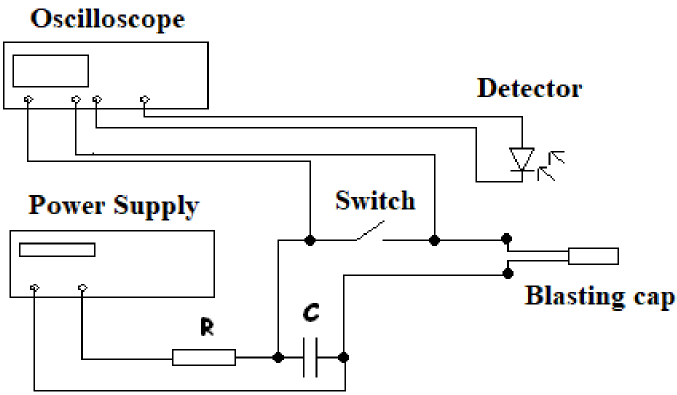

Fig. 3. Scheme of the stand for investigation of response times of WN-1 and WN-1A primers

Discharge of the capacitor by means of a resistance bridge of the blasting cap is made by means of triac of BTB12 type denoted for simplicity in Fig. 3 as a mechanical key.

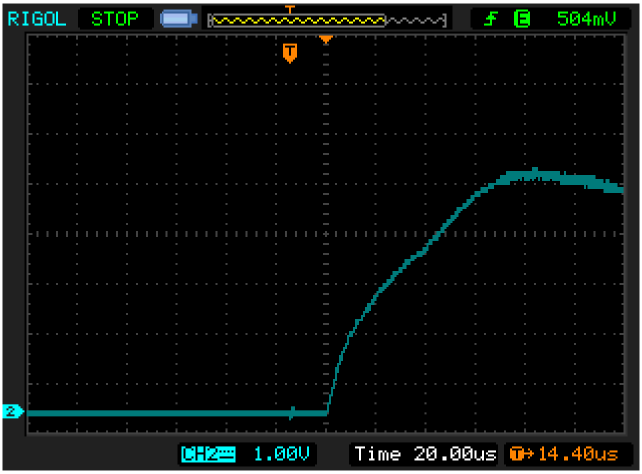

Fig. 4. The oscillogram obtained during investigation of WN-1 blasting cap

The moment of blasting cap activation is observed by a photodiode, operating within the range visible light and connected with the digital oscilloscope RIGOL DS1052E. The trigger input of the digital oscilloscope is connected with the triac's gate, what ensures synchronization of the whole system. Exemplary oscillogram from the measurement of the response time of the WN-1 blasting cap with a visible signal, generated by photodiode, is shown in Fig. 4.

Response times of particular types of blasting caps were investigated for various supply voltages. The results of these measurements are shown in Fig. 5.

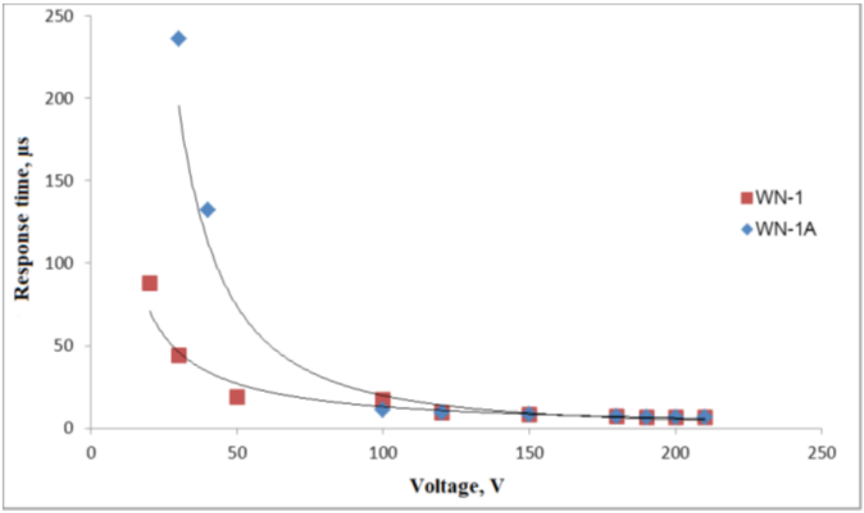

Fig. 5. Characteristics of WN-1 and WN-1A blasting caps

3.2. Dependence between time response of blasting caps and their temperature

Application of newly developed blasting caps is possible only if these blasting caps operate correctly within the assumed range of temperatures. The temperature range for various combat means is the most frequently between – 40ºC and + 50ºC. The next step was measurement of blasting caps response time in dependence on their temperature. The blasting caps were tested after conditioning during 1 hour at the temperatures – 40ºC, + 20ºC, and + 60ºC. The supply voltage was 190 V. The measurement results are presented in Fig. 6.

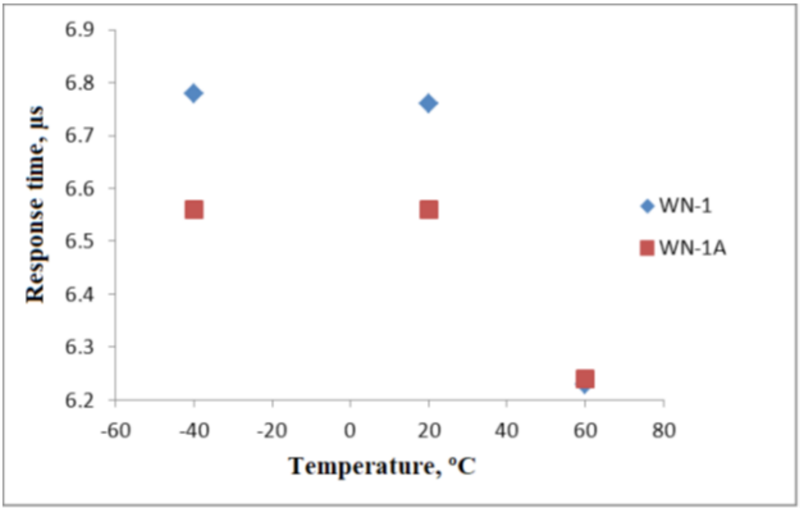

Fig. 6. Influence of temperature on blasting caps response time

3.3. Investigations of scatter of blasting caps response time

The subsequent investigation was focused on estimation of scatter of the blasting caps response times in the case of one, chosen value of supply voltage. All the tests were performed applying 200 V because then the response times are practically constant and equal to about 6.4 µs. 15 blasting caps of each kind were used for the tests. On the basis of the obtained results, for the above-mentioned assumptions, average value of the response time was calculated and its standard deviations (Table 3).

Table 3. Average response time of WN-1 and WN-1A blasting caps and standard deviation from average value

Type of blasting cap	Average response time at 200 V	Standard deviation
WN-1	6.413 µs	0.0499 µs
WN-1A	6.413 µs	0.266 µs

3.4. Investigations of initiation ability

The basic task of each quick-acting electric blasting cap is initiation of a detonation process in the subsequent elements of a fire chain in which the blasting cap is situated. This capability of the WN-1 andWN-1A blasting caps was investigated in two ways. In the first test, capability of blasting caps for puncturing the lead plates of the thickness of2 mm was checked.

In each case, the hole created after the detonation of the blasting cap, located at the plate, had a diameter of about 6.1-7 mm. Lead plates were supported with steel ring during investigations.

At the next stage, the blasting caps capability for initiation of detonation was checked in the pressed charges made of tetryl (2,4,6-Trinitrophenylmethylnitramine) and PBX-N5 (explosive consisting of 95% of octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine (HMX) and 5% of Viton). A role of witnesses was fulfilled by using the steel cases with the initiated charges inside. In each of ten investigated systems, the total detonation has occurred resulting in complete fragmentation of the steel cases.

3.5. Waterproof tests of primers

The last test was focused on waterproof tests of blasting caps. This test relied on blasting caps immersion in water of room temperature under the depth of 1 m. Next, after 1 hour, the blasting caps were taken out from water and next their responses time were tested. Both, for WN-1 and WN-1A blasting caps, response time was not longer than the value of standard deviation.

4. SUMMARY AND CONCLUSIONS

The two types of quick-acting electric blasting caps designed to contemporary precise combat means have been performed and investigated. These blasting caps named WN-1 and WN-1A include different explosives. Within some range, their time characteristics are also different.

The WN-1A blasting cap, at the voltage value below 100 V has the response time two times longer than the WN-1 blasting cap. At 200 V, time response of both blasting caps is the same and equals about 6.4 μs. Some temperature influence on time response of both types of blasting caps can be observed. The most noticeable is shorting the time response after exceeding + 20ºC. Total reduction of time response of WN-1 type blasting caps within the temperature range from –40ºC to + 60ºC amounts about 8%. For WN-1A blasting cap, it is about 5%.

The scatters of response times of both types of blasting caps at 200 V are different. For the WN-1 blasting caps, the scatters do not exceed 2% and for WN1A 9%. Thus, it can be stated, with full responsibility, that WN-1 blasting caps are relatively precise initiators.

Finally, investigations of both types of blasting caps showed that despite they include a small amount of explosive, they can efficiently initiate detonation of the pressed (compact) charges made of tetryl and PBX-N5. Thus, it can be stated that up to now, the obtained parameters for WN-1 and WN-1A blasting caps are satisfactory ones.

Possible improvement in the presented constructions should concern the decrease in the voltage value, at which the blasting caps operate not longer than 10 μs.

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Szybkodziałające elektryczne spłonki pobudzające

Marcin NITA, Radosław WARCHOŁ

Wojskowy Instytut Techniczny Uzbrojenia
ul. Prymasa Stefana Wyszyńskiego 7 , 05-220 Zielonka

Streszczenie. W artykule zaprezentowano konstrukcje nowych, szybkodziałających elektrycznych spłonek pobudzających typu WN-1 i WN-1A, opracowanych i wykonywanych w Wojskowym Instytucie Technicznym Uzbrojenia w Zielonce. Spłonki te scharakteryzowano pod względem użytych do ich wykonania materiałów konstrukcyjnych i wybuchowych. Zaprezentowano wyniki wybranych badań spłonek oraz ich najistotniejsze charakterystyki. Przedstawiono między innymi zależności czasu zadziałania spłonek od napięcia zasilania, jak również wpływ skrajnych temperatur na niezawodność i czas zadziałania. Wykonano i zaprezentowano wyniki badań potwierdzających przydatność spłonek do pobudzania ładunków kruszących materiałów wybuchowych.
Słowa kluczowe: uzbrojenie, środki bojowe, elektryczne spłonki pobudzające, detonacja