THE GRAPHITE BOMB: AN OVERVIEW OF ITS BASIC MILITARY APPLICATIONS

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Abstract: *It is well-known that, high-power electromagnetic pulse generation techniques and high-power microwave (HPM) technologies have matured to the point where practical electromagnetic bombs (in fact, E-bombs) are becoming technically feasible, with new applications in non-nuclear confrontations. This paper presents in a short form some theoretical considerations about the technology base and applications of the electromagnetic bombs.*

Keywords: *soft bomb, graphite bomb, carbon filaments, BLU-114/B*

1. INTRODUCTION

Graphite bomb (also, known as the *soft bomb*) is a non-lethal weapon which is used for shutting down the power supply systems of the enemy. The working mechanism of the graphite bomb is relatively simple and is based on making suspensions of air/clouds of carbon filament chemically treated extremely fine over the electrical components, causing short circuits and electrical discharges within the infrastructure of electricity supply (in especially on the power plants, transformer stations, air transportation facilities of electrical power etc.). In addition, the effective use of this unconventional electronic attack system is based on *critical points* identification and disruption philosophy. Carbon filaments used inside of graphite bombs are very small and may give rise to dense clouds, with a long persistence. Also, the name of *soft bomb* it comes from that its basic destructive effects are centered only on the electricity supply facilities, with minimal risk of occurrence of some collateral damage and particularly over the human staff [1-3].

In other news, the effect of the graphite bomb is only over the equipment and facilities of uninsulated power supply. Figure 1 shows the effects of graffiti bombs launched by US Air Force, on 22 March 2003 on a 400 kV Transformer Station in the Electrical Power in Nasiriyya, which caused the power shortage in the city for 30 days [4].

Fig.1 The 400 kV Electrical Power Transformer Station bombed by U.S. Air Force in Nasiriyya on March 22, 2003, with a carbon fiber bomb (Source: R. E. Brigety, Human Rights Watch, 2003, [4])

2. BASIC MILITARY APPLICATIONS OF THE GRAPHITE BOMBS

Graphite bomb was used against Iraq in the first Gulf War (1990-1991), neutralizing about 85% of this country facilities supply electricity. Also, the graphite bomb (composed of submunitions BLU-114/B, produced by USA) was used widely in the NATO military intervention in former Yugoslavia (1999), where its effect consisted in disabling of more than 70% national grid electricity supply.

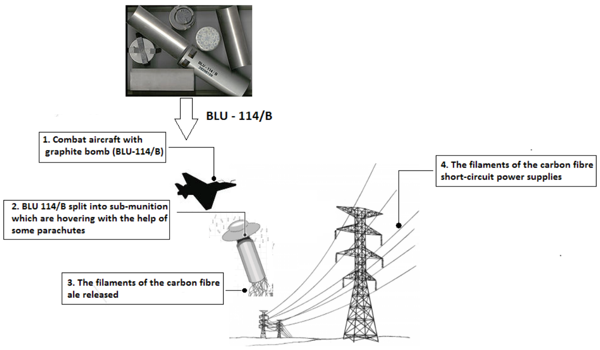

Fig. 2 The mode of action of graphite bomb

Although initially in less than 24 hours, the Serbs have managed to restore their electrical systems operability, however, repeated use of the graphite bomb by alliance thwarted almost any further effort in this direction.

In the final phase of this intervention, NATO air forces used mostly standard carrier vectors (e.g., bombs, missiles etc.) to transport and detonation of the munitions in the area of interest of the graphite bomb.

In addition, for an accurate understanding of the multiple implications (economic, social, etc.) and respectively, the effective conditions of use in a military conflict of a graphite bomb, it is very useful a summary of the main features of a modern system of electrical energy distribution.

It should be remembered first that any modern network of power supply has a high-degree of complexity and, respectively, a wide-range of distribution and therefore the decommissioning of its elements vital involves subsequently a technological effort and substantial financial for a long time. It should also be remembered that, any system of power supply will contain in its architecture the following basic elements: the generator of electricity, the electricity transmission system (incorporating in its structure the high-power transformers, losses into transmission lines which are reasonable if the line voltage is very high, typically up to 400 kV) and the electricity distribution system to the users, industrial and domestic use (i.e., this system consists mainly by the primary distribution subsystem providing voltages between 2.4 and 35 kV and respectively, secondary distribution subsystem providing voltages between 110/220 and 600 V). Theoretically, any of these sub-components may represent a potential target for an attack based on graphite bombs.

In the special literature (e.g., documents prepared by NERC/*North American Electric Reliability Council* etc.), the concept used in the moment when a facility or electricity supply system, as a its whole, suffers damage (or collapse) is called generic *blackout* (shutdown or blindness). In fact, the blackout is a condition which is satisfied when a significant part or the entire electrical network is damaged. Any module containing connections to the high-voltage network and that cannot support a reasonable level disturbances is a significant candidate for the blackout (and of course, for the action of graphite bombs). In addition, in some military documents, the graphite bomb is also called blackout bomb. Generally, the blackout condition can be the result of the occurrence of industrial dynamic instabilities (e.g., changing nominal parameters of the operating power generators, the occurrence of the short circuits due to the heat effect or to adverse weather conditions, etc.) or after their artificial induction.

Naturally, in the architecture of any modern power supply system, the critical subsystems for operation are either protected or redundant (forming so-called system of auxiliary power supply) and respectively, exists the possibility to isolate and route the damaged sections. Therefore, a proper attack initiated with the graphite bombs must cover up these subsystems. Consequently, for a maximal effectiveness of the action of such type of bombs, a detailed knowledge of the system architecture of the targeted power supply, concomitantly with a correct identification of its critical points in operation is also necessary.

Like in the conflict from the former Yugoslavia, to prevent the enemy to pass effective actions to restore its power supply system, it must be known or intuit their effective procedures of action in this situation. Consequently, after the removing of the major defects, it is possible to follow two strategies in order to restore the functionality of the energy system: the first strategy, called *all open* follows that all facilities affected and recovered after the attack to be made operational and respectively, the second one, called *operation control* follows to restore the working only of those components which are essential for its revitalization process [5].

3. SOME TECHNICAL CONSIDERATIONS ABOUT GRAPHITE BOMBS

As before mentioned, the combat load of these bombs is based on the massive use of the graphite. As it is already known, the carbon is a nonmetal chemical element in group 4, which is found in nature in two allotropic states: diamond and respectively, graphite.

The graphite contains a special type of atomic network called *atomic layered network* which is represented by a hexagonal atomic network composed by parallel planes of carbon atoms. The hardness of the graphite is by ten times lower than of the diamond one (1 on the Mohs scale), with a density of 2.262 g/cm^2.

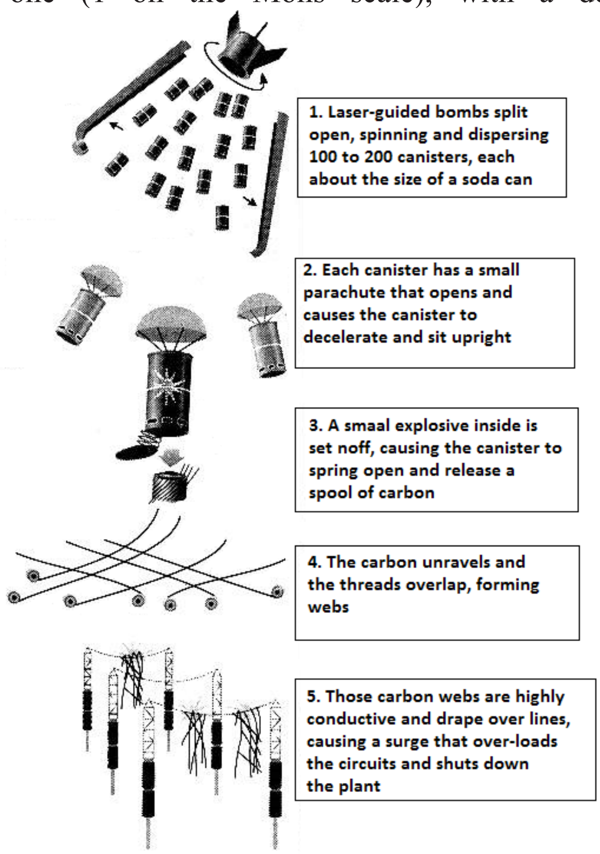

Fig. 3 The mechanism of action of the graphite bomb (schematic)
(Source: W. M. Arkin, *Aviation Week and Space Technology*, [6])

Also, the graphite is an excellent conductor of heat and power (i.e., these properties are generated by the presence into graphite of the chemical *pi* links, and in which the electrons are moving free between the carbon atoms through the overlapping orbits *2p*) and generally, its physical properties (including its electrical conductivity) are determined by the atomic structure resulting from the specific application of some chemical treatments. Also, the graphite may not be molten and for a temperature more than 35000 ^{0}C, it directly forms the vapor carbon atoms. In addition, graphite has a low reactivity and practically, does not chemically interact with any other substance.

Next, the intrinsic working mechanism of the graphite bombs action will synthetically described. Taking into account the suggestive scenario illustrated in Figure 2, the basic key-stages of its internal mechanism are the following (see Figure 3).

1) The overhead of the target of interest is accomplished breaking the carrier vector (e.g., a laser-guided bombs etc.) and using a spin moving, the dispersion of the submunitions components takes place (e.g., 100 up to 200 submunitions), the size of each submunitions being by *cm* order;

2) Each component submunitions have attached a small parachute allowing a decreasing of its fall rate, while ensuring its vertical positioning;

3) A small internal explosion in each submunitions assures its breaking and respectively, releasing a coil (reel) of carbon filaments;

4) The carbon filaments because of the movement of the printed coil are released and form overlapping spider webs like a network (*webs*);

5) These carbon filament nets are highly conductive and overlapping over power lines, having as effect the voltage peaks which are overloading electrical circuits and thus, leads to deactivation of the power supply.

Generally, having as starting point the strict confidentiality of the documents related to the technology used in the design and development of the graphite bombs, the access to the relevant information in this field is more difficult. However, because such systems have been already used with a maximal efficiency in the context of recent armed conflict (former Yugoslavia or Iraq) and the public interest in this area is still risen, in the literature are synthetically indicated an important number of useful references about this weapon system. Consequently, some significant remarks and technological details related to graphite bombs can thus be made.

4. SOME CONSTRUCTIVE EXAMPLES

US Army have in service the weapons system *Blackout Bomb* CBU-94 which is composed by specific submunitions BLU-114/B for attacking electricity supply infrastructure belonging to a potential enemy. Although some few technical details about this classified weapon system are known, its operation mechanism can be summarized by dispersion of its submunitions containing a significant amount of carbon filament chemically treated, and whose action on a power supply system may lead to short circuits into some sensitive equipment components (e.g., transformers or switching power stations). The use of submunitions BLU-114/B is limited to action on power supply facilities with minimal risk of occurrence of collateral damage (hence the name of soft bomb).

By the detonation of these submunitions over the selected targets, a large number of fine carbon filaments are dispersed in the air, each one having a thickness of the order of several hundredths *cm*. Also, these filaments can float into atmosphere and forms dense clouds with a significant persistence. Next, the filaments of carbon fiber dispersed by the BLU-114/B submunitions come into direct contact with the power transformers and other high-voltage equipments. These can provide short circuits and often, an arcing current flowing through the fiber is generated and finally as result, the fiber is subsequently vaporized. Graphite, which is an excellent conductor of electricity, it is probably covered in this case with other materials that enhance this effect. In the area where the electric field is the strongest, this can initiate a download and electrons form rapidly a channel of ionization that will conduct the electricity.

This causes an instantaneous local melting of a certain quantity of material from the surface of the two conductors. If the current has enough intensity, this arc can cause major faults or even, a fire. This fire can be also started in overheated equipments or conductors by a current oversize. In addition, the electrical arcs with very high-energy can cause even a mechanical explosion of the electrical equipments by their action.

Although the most important part of the specific technical details are classified and Pentagon declined intention to provide any information about this submunitions, its cost price is probably somewhere in the hundreds of thousands of dollars.

The relative simplicity of the concept and respectively, the potential use inside of its structure of the components from other munitions leading to relatively low production costs.

In other news, if we consider the overall design of the CBU-94 weapon system, the central element of attraction is represented by submunitions BLU-117/B and less by the submunitions dispensing system [1, 2, 7].

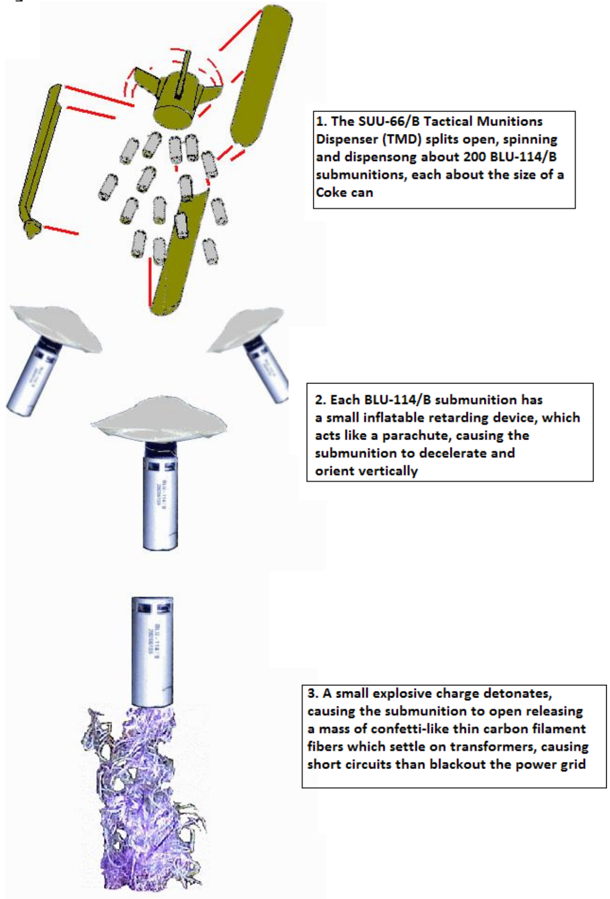

Fig. 4 Mode of presentation of the operation of the BLU-114 / B
(Source: global security, [7])

The first effective use of the submunitions BLU-114/B was for attacking the infrastructure of the power supply belonging to Serbia, where the carrier-vector was based on the airplane F-117 and the dispensing system by the SUU-66/B (i.e., lens ammunition tactical TMD), normally associated with carrier system CBU-97/CBU-105 SFW.

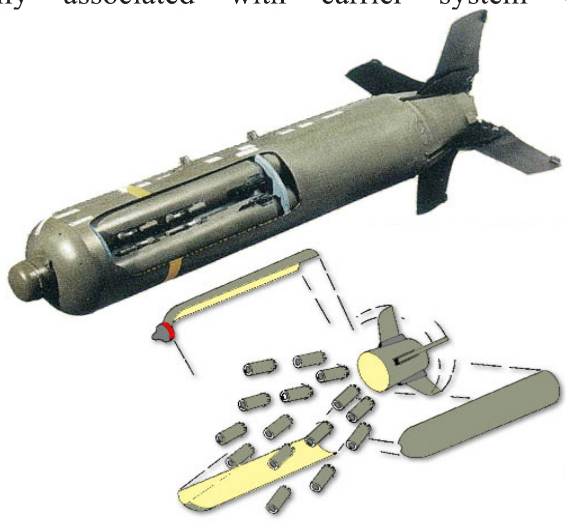

Fig. 5 The carrier system CBU-97
(Source: defense industry daily, [8])

Typically, the circular error assigned to these unguided systems is by order of tens of meters. In the future, by incorporating in the architecture of the next generation of graphite bombs of the advanced guided kits having a high-precision as JDAM (*Joint Direct Attack Monition*) or JSOW (*Joint Standoff Weapon*), the precision and destroying efficacy of these weapon systems will be highly increased [8].

Fig. 6 Examples of CBU-97 weapon system images from the former Yugoslavia conflict (Source: global security, [7])

CONCLUSIONS

The first important remark that can be obtained from the analysis of these military conflicts is that related to the very favorable ratio between the price cost assigned to the current power supply facilities destroyed and respectively, the actual price cost of the graphite bombs. Consequently, the use of such unconventional weapons becomes extremely profitable. Also, can be noted the huge damages, human losses virtually minimal, and a devastating demoralizing effect against the attacked nations etc.

Another important remark is concerning to the fact that, an important number of generations of graphite bombs was developed by the US military. Consequently, starting from the specific ammunitions based on Tomahawk kits and used in the early days of Operation Desert Storm (1991), continuing with the submunitions BLU-114/B massive used in the conflict from the former Yugoslavia (1999) and Iraq (2003) and ending with the next generation of graphite weapons based on the exploiting of the carrier-vector having a high precision like AGM-154 D JSOW, it can conclude that the interest in development of this type of unconventional electronic attack systems remains very high (e.g., given by the relatively low price cost compared to the efficiency of its use and respectively, the membership to the class of software system bombs). Finally, all these important advantages of the graphite bombs will explain the increased human and financial resources which will be allocated in the next period of time.

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