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THE DEVELOPMENT OF NUCLEAR WEAPONS: A HISTORICAL AND SCIENTIFIC ASPECTS

1. Introduction

Nuclear weapons development may be traced back to 1896, when Henri Becquerel revealed the discovery or finding of radioactivity to the Academy of Sciences in Paris after discovering the radioactive properties of uranium [1]. Rutherford and Soddy defined their hypothesis of radioactivity in 1902 as a spontaneous disintegration of the radioactive element due to particle expulsion, resulting in the formation of new elements. Rutherford later demonstrated, with the help of James Chadwick, that any light atom could be dissolved when struck by alpha particles. In Rutherford's group, John Cockroft and Ernest Walton invented the technique for producing accelerated particle beams for atom disintegration [2]. The main fundamentals of nuclear explosives operation are, nuclear reaction, nuclear fission, nuclear fusion, chain reaction, and critical mass. Nuclear weapons are explosive devices that derives its destructive force from nuclear reactions (fission or fusion). Detonators, chemical explosives, and unique nuclear material make up nuclear weapons, which are controlled by arming, fuzing, firing, and safety systems. Bombs, ballistic missiles, and cruise missiles are all examples of nuclear weapons [3].

2. How nuclear weapons work

2.1. Gun-assembled fission device

Two half subcritical components of a supercritical assembly of fissile material are inserted at either end of a gun barrel in a gun-assembled weapon. One of the sections contains an explosive propellant charge behind it, similar to what would be used in a conventional gun. When the propellant is discharged, one of the halves travels down the barrel and collides with the other, generating a supercritical mass. A source of neutrons is introduced to the supercritical assembly at the ideal time to start an exponentially growing chain reaction that results in a nuclear explosion. An example of this type of weapon is shown below (fig.1).

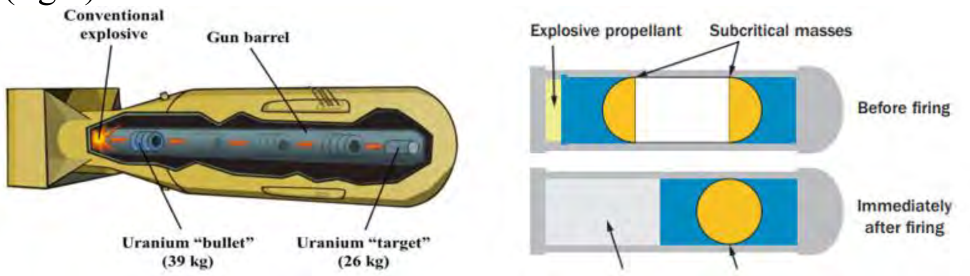

Fig. 1. A Gun-Type Bomb 3D cut-away with schematic diagram

2.2. Implosion-assembled fission device

In this type of device, a plutonium subcritical sphere is surrounded by a high explosive sphere as shown in figure 2. A layer of explosive lenses covers the surface of the high explosive, creating a spherically shaped, inwardly directed shockwave that precisely detonates the high explosive sphere's outer surface. This causes an internally directed chemical explosive detonation, which forces the subcritical sphere of plutonium to implode. The implosion compresses the plutonium, causing the atoms to close in on each other, causing the plutonium to reach supercriticality. A neutron source is introduced to the now supercritical assembly at the appropriate time to start an exponentially growing fission chain reaction, resulting in a nuclear explosion [4].

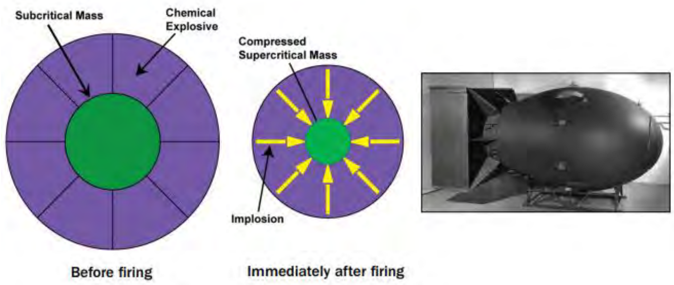

Fig. 2. Schematic of implosion-assembled critical mass with photo of Fat Man bomb

3. Historical developments of nuclear weapons in USA, USSR, UK, France, and China

3.1. Nuclear programs of USA

After the start of World War II, Albert Einstein wrote a letter to Franklin D. Roosevelt, warning him of recent nuclear findings and the prospect of building an extremely powerful bomb using uranium. The USA President Franklin Roosevelt paid a great attention to the Albert's letter and in 1939 S-1 Uranium Committee was established. Enrico Fermi constructs the first atomic pile in Chicago, and for the first time, he is able to control the fission of uranium atoms in a chain reaction [5]. On December 28, 1942, President Franklyn Roosevelt authorized the construction of full-scale plants to generate both Uranium-235 and Plutonium-239, following the successful demonstration of the controlled chain reaction. The Manhattan Project is secretly launched with an ultimate goal of building an atomic weapon by making a uranium-based bomb and a plutonium-based bomb. Reactor Chicago Pile - 1 (Chicago, 1942) was the world's first nuclear reactor supervised by Enrico Fermi to be built with the main goal of achieving controlled self-sustaining nuclear chain reaction. In 1943, Reactor X-10 was constructed to produce the first significant amounts of plutonium for research. In 1943, enrichment plants were constructed, which included the Y-12 plant (electromagnetic uranium enrichment plant) and the K-25 plant (gaseous diffusion uranium enrichment plant).

At the end of 1944 and the beginning of 1945, scientists devised two sorts of explosives, one for uranium and the other for plutonium. "Gun" and "implosion" were the names given to the two types of explosives based on their triggering mechanisms. On July 16, 1945, USA tested its first nuclear bomb in the desert of Alamogordo, New Mexico. The name of the bomb was the trinity bomb [6]. The development of engineering education is an integral part of the formation and development of the intellectual potential of the modern engineer in all industries [7].

3.2. Nuclear programs of USSR

Secret works in the West on the creation of nuclear weapons played a key role in the development of weapons in USSR. Theodore Hall, Klaus Fuchs, and David Greenglass were the three spies who worked at Los Alamos who shared information to USSR. None of them had to be persuaded to give information. Klaus Fuchs on the basis of his own political opinion and being aware of the danger of a possible US nuclear monopoly, informed USSR about the work on the creation of nuclear weapons and gave information on its design. Theodore Hall, an American physicist who was later fired, gave the USSR a scheme for an implosion-type nuclear weapon as well as a description of the processes to extract plutonium. All the three spies were the participants of Manhattan project [8]. Before 1945, there was limited research on the USSR's military situation. The USSR didn't believe in the creation of nuclear weapons in the USA until they tested it in 1945. This led to the establishment of a special committee which was mandated to build the first research reactor, build a reactor for large-scale Pu production, develop equipment for gaseous diffusion and electromagnetic uranium enrichment, and choose a site for a plant for assembling nuclear weapons. In 1946, reactor F-1 was built. The main goals were to achieve controlled, self-sustaining nuclear chain reaction, plutonium production for research, and estimate the parameters of an industrial reactor. Industrial reactor A was the USSR's first nuclear reactor for large-scale plutonium production to be built in 1948. Radiochemical Plant B was the USSRs first spent nuclear fuel reprocessing plant and was built in Ozyorsk in the year 1948 with the main goal of extracting plutonium from spent nuclear fuel. In 1949, Nuclear Weapons Plant C was constructed for production of nuclear weapons. The same year, RDS-1 reactor was made. The testing site for the newly created bomb was chosen in the Semipalatinsk region of Kazakhstan. At 7 a.m. sharp on August 29th, 1949, USSR tested its first atomic bomb [9].

3.3. Nuclear programs of United Kingdom

In the summer of 1939, Otto Frisch, an Austrian Jew and theoretical physicist, moved to England from Germany and established at the University of Birmingham where they focused their research on the topic of whether nuclear fission might be used to create an explosion. Their research led to the historic memoranda that an atomic bomb could be made with a relatively modest quantity of refined U235, and that such a quantity could be made once the appropriate industrial-scale machinery was created. Oliphant encouraged them to write down their ideas after they discussed them with him. The British government organized a committee (M.A.U.D. committee) to analyze the military consequences of their memoranda, which Oliphant delivered to them. The Committee produced a two-part report, which Chadwick wrote up in July 1941. In September 1941, the Committee concluded that "all conceivable means should be taken to carry on with the task" of developing the uranium bomb. Tube Alloys was the name given to the project. The entire project was to be carried out in UK [10]. In 1947, UK made a final decision to create a nuclear weapon. The UK scientists followed the plutonium way, using their experience from the Manhattan Project, as most of them participated in the project. On July 3, 1948, Britain's first nuclear reactor, led by Sir John Crockcroft, reached criticality. Sites for the manufacturing of plutonium and highly enriched uranium were also built. UK chose the Monte Bello Islands off Australia's west coast to test its nuclear weapon. Britain's first atomic weapon, code-named "Hurricane," exploded on October 3, 1952. Churchill determined in 1954 that Britain should proceed with the development of hydrogen bombs. The first successful hydrogen bomb was exploded over Christmas Island in the Pacific on November 8, 1957 [11].

3.4. Nuclear programs of France

Plans to construct nuclear weapons in France started after the Suez crisis between 1956 and 1957. Egypt nationalized the Suez Canal in July 1956, causing a crisis. Despite intense diplomacy, war broke out shortly after. The United Kingdom and France joined Israel in a coalition against Egypt, with the goal of seizing Sinai and the Suez Canal, as well as toppling Egypt's government. Because of intense international criticism and pressure from USSR and USA, the United Kingdom and France halted their operations in Egypt [12]. After this encounter, France realized that, for them to participate effectively in international affairs, they must acquire a nuclear weapon. Between 1957 and 1960, the military applications division was established, the French Nuclear Forces Program was approved, and two nuclear submarine projects were approved. The atomic choice of France was more about the rivalry between allies than a threat from enemies. Possessing a nuclear weapon provided an edge over Germany as well as extra pressure points against the United States. De Gaulle fixed the date for the first nuclear detonation in the first three months of 1960 on July 22, 1958. On February 13, 1960, detonated an atomic bomb in Algeria which was then a French colony [13]. The first French nuclear submarine was built only in 1969.

3.5. Nuclear programs of China

Following the Korean War, China began to investigate the military possibilities of nuclear power. The Soviet Union provided the majority of the technological know-how for weaponizing nuclear power. In fact, the Soviet Union provided China with not only nuclear physicians, but also all of the necessary tools and materials to build nuclear weapons. Most of the study was done in secret by the National Institute of Physics and Atomic Energy in Beijing, China. In 1959, ties between China and the Soviet Union deteriorated slightly as a result of Nikita Khrushchev's decision to stop supplying China with nuclear-weapons-related materials and scientists. This decision is thought to have been made by Khrushchev because not only did the Soviet Union require as many resources as possible, but they also wanted to ensure that China would not use this technology against them, thereby extending the time it would take China to develop their first nuclear weapon by at least three years. In 1960 all USSR specialists left China. To China this was a top-priority project. China went ahead and completed construction of nuclear industry objects that included uranium enrichment plants (gaseous diffusion), nuclear fuel fabrication plants, and nuclear weapons plant test sites (which were proposed by the USSR's scientists). They tested their first nuclear weapon on 16th October 1960 [14].

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AIR CIRCULATION MECHANISMS FOR SOLAR DRYER

Introduction

Drying is very important process usable for agricultural and industrial products. The process of eliminating moisture from items is known as drying. Bacterial growth in products is reduced when they are dried. Drying is a straightforward procedure for eliminating excess moisture from agricultural or industrial products [1]. It is the earliest way of preserving food. Most agricultural goods have a greater moisture content, ranging from 25 to 80 percent, although most agricultural products have a moisture content of approximately 70 percent. This moisture level is substantially greater than what is necessary for long-term storage. Bacterial and fungal development in the crops is accelerated due to the high moisture content. Bacteria and enzymes may degrade foods and diminish their nutritional value. The influence of bacteria, enzymes, and yeasts is slowed by decreasing the moisture content of crops to a given level. The solar dryer is a gadget that uses sun energy to dry products effectively. The air flow in the drying chamber is used to classify solar dryers. Natural circulation and forced circulation are the two main classifications. Air drying is the most common method of preserving food crops for lengthy periods