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AEC ATOMIC WEAPON DATA
Summary
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HISTORY OF THE MK 6 BOMB (U)

(Including the TX/XW-13, Mk 18 and TX-20)

SC-M-67-726

Redacted Version

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Weapon Systems

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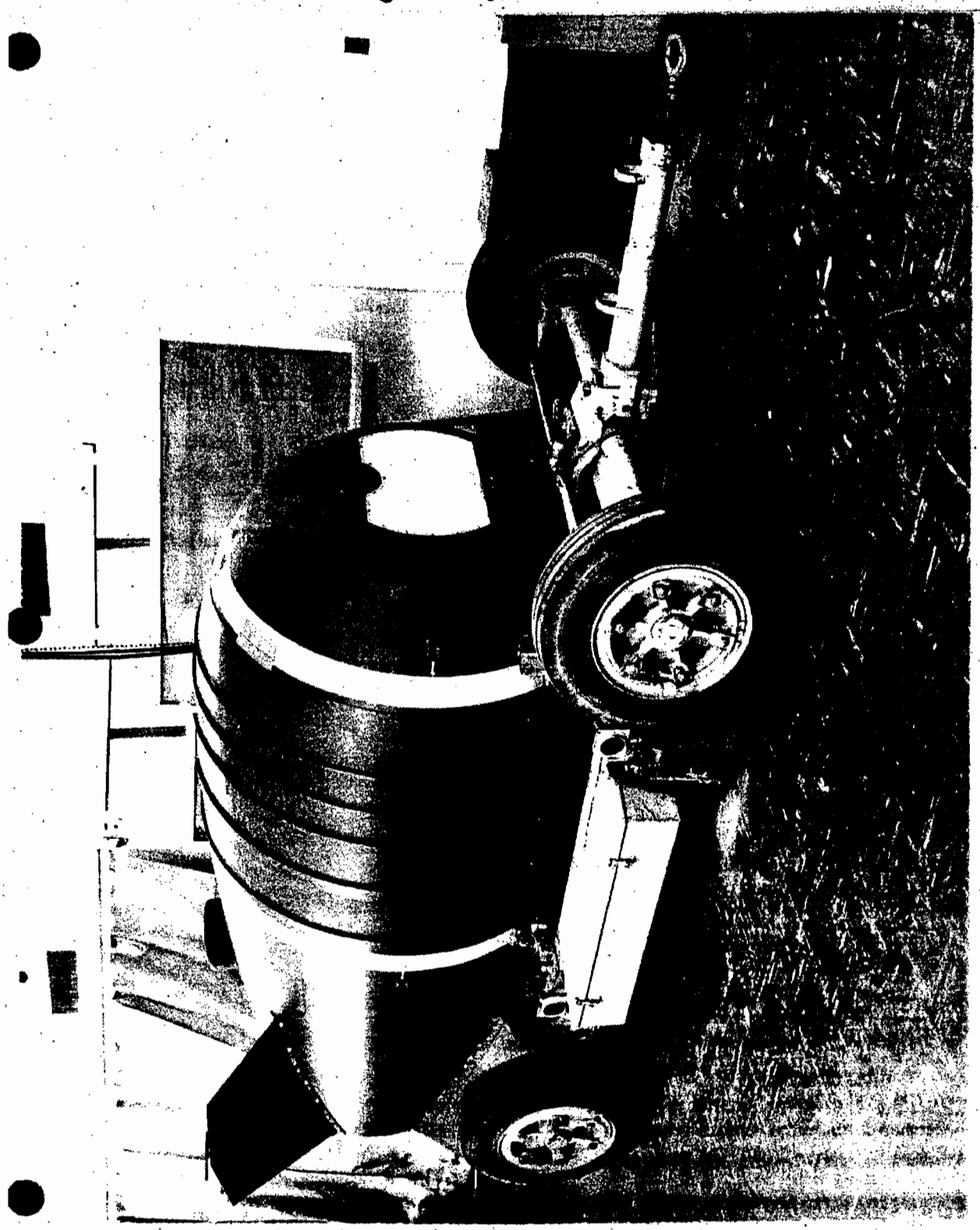

Mk 6 Bomb on Trailer

(b)(1), (b)(3)

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Cross-Section of Mk 6 Mod 0 Bomb

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(b)(3)

(b)(1), (b)(3)

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(b)(1), (b)(3)

Other design improvements were also being considered. (b)(1), (b)(3)

The scheduling subcommittee of the Sandia Research and Development Board met July 6, 1949 and suggested that a proposed design-release date of February 1950 was overly optimistic and that the production design for the Abee radar could probably not be achieved until mid-1950, thus resulting in availability by the fall of the year. In addition, the ballistics of the lightweight case were proving troublesome, and further wind-tunnel tests and range drops were required. It was recommended that a production date of October 1, 1950 be established for the lightweight case and the new fuzing system.[3]

The schedule was further extended in a letter from the subcommittee to the Board, July 29, 1949, wherein it was proposed that the lightweight case be design-released in May 1950 and stockpiled by February 1, 1951; and that the new fuze be design-released July 1, 1950 and stockpiled by February 1, 1951.[4]

The lightweight case was discussed in the December 21, 1949 meeting of the Sandia Research and Development Board. It was noted that either the riveted or welded design would be selected in the next 3 months, and that the decision would be based on comparative weight, cost, and delivery factors. Consideration was, however, being given to authorizing simultaneous tooling for both types of cases, to save a few months in early production.[5]

The Armed Forces Special Weapons Project notified Sandia January 9, 1950 that improvements to the Mk 4 Bomb were accorded a high priority in the National Military Establishment. It was suggested that perhaps some weight might be pared from the high-explosive sphere case. (b)(1), (b)(3)

radars. (b)(3)

Height-of-burst settings would be adjustable in six steps before weapon assembly, and any one of the six settings could be selected by remote control from the strike aircraft before release. The ranges of these six steps would overlap each other.[16]

Some attention had previously been paid to the possibility of providing inflight insertion. Currently, it was necessary to manually extract two heavy blocks of high explosive, insert the nuclear capsule, replace the high explosive, and button up the assembly. This was tedious and time-consuming, and required that the strike aircraft fly at fairly low altitudes (and thereby at a high rate of fuel consumption) during the insertion process, as the aircraft bomb bays were not pressurized.

The Los Alamos Scientific Laboratory had notified the Division of Military Application that a suitable inflight insertion system could be developed by early 1949.[17] The Division had replied, July 14, 1948, that the Military would gain in safety and logistics if both insertion and extraction in flight could be provided. It was requested that these changes be incorporated as soon as possible.[18]

Los Alamos stated that nuclear efficiency could be improved by better timing of nuclear initiation and that this could be accomplished by use of an external neutron source. (b)(3)

Although this was highly desirable, the Board felt that it would be criticized if production of the Mk 6 was delayed, and suggested that this design revision be held in abeyance.[20]

to arm radars and might be used as primary fuzes if wider burst-height tolerances could be accepted. An improved pressure pickup system was being designed, and such fuzing systems as time of fall, time of flight, flight distance, contact, and pyrotechnic were all being investigated.[27]

The Division of Military Application notified Sandia Field Office, July 30, 1951, that about 20 percent of production Abee's currently being tested by the Air Force Special Weapons Center were failing due to various causes. It was noted that the Department of Defense had concluded that the Abee was not suitable and that baroswitches would have to be used to fire the Mk 6 Bomb.[28]

The problem was referred to Sandia, which replied, July 31, 1951, that recent Air Force experiments on the operation of the Abee motor timer had been conducted. This operation required that the radars be jammed, and the test was completed satisfactorily. Sandia had been informed that this test had been interpreted to mean that the bomb was extremely vulnerable to jamming. It was pointed out, too, that 4-N bombs had been used. Sandia felt that the Abee, as it existed, represented a distinct improvement over the Archie from both operational and reliability standpoints.[29]

Meanwhile the Mk 6 Mod 0 Bomb, which had been design-released May 15, 1951, achieved early production in July 1951.[30] The bomb was subsequently stockpiled, but not accepted for operational use by the Military.

Field Command notified Sandia August 1, 1951, that use of the Mk 4 baroswitch fuzing system, which was scheduled for use in the Mk 6, required an extremely complicated and arduous process. Theoretically, this system was accurate when precisely used but, under the most carefully controlled field conditions, this accuracy was halved. It was urged that an improved system be provided for the Mk 6 Bomb.[31]

The need for early introduction of this modified baroswitch sensing system was discussed in the August 8, 1951 meeting of the Sandia Weapons Development Board.

in accordance with current procedures.[33] To make matters worse, when these two units were again examined upon return from the test (this mission was aborted due to weather), they both failed to pass the standard assembly-type retest. This resulted in examination of a larger number of stockpiled Abee's, using stockpile testers and revised Sandia procedures. Results indicated that about half of these Abee's would fail to pass the test, and Sandia investigations confirmed these findings.[34]

The Sandia Weapons Development Board met September 26, 1951, and continued its appraisal of the Abee radar. It was pointed out that inconsistent results from tests conducted on the same radar at different locations were being reported, and it was suggested that the various pieces of test equipment be compared. It was noted that Abee drop tests had been conducted, and that some radar failures had been reported, but that no dud bombs had resulted. It was felt that, in the event of national emergency, the baroswitches could be used as primary fuzes, but the Military members of the Board stated that this expedient was unacceptable for other than the high-burst option of the Mk 6.

Sandia assigned an overriding priority to the problem, and formed a task group of the most highly qualified Sandia and contractor personnel to investigate all phases of the problem. This group was to issue a formal report of its findings by November 1, 1951.[35] The program was named the GF (for Grouped Forces, code-named Greenfruit) Task Group. The GF task was to conduct a complete evaluation of the Abee, recommend measures to correct existing deficiencies, and implement the necessary corrective measures.[36]

Early investigation by the GF Group discovered that a delay in the transmitter/receiver keep-alive circuit allowed a large transmitted signal breakthrough for the first 200 transmitted pulses and that this caused excessive crystal burnout. This was corrected by a minor wiring change in the unit which provided advance arming of the keep-alive electrode.

The transmitter tube was found to have a slow leak which was traced to a defective ceramic cathode seal and was replaced by an improved arch glass design.[37] The lack of correlation between production-line tests of the Abee and subsequent testing in the field, involved the use of different testing devices which contributed to the problem, and action was taken to revise these tester designs.

It was found that the transmitter/receiver tube was subject to frequent breakage, aggravated by temperature cycling of the tubes in their mounts. Detailed examination showed that high stresses were created and the tube mountings were redesigned. Failure of the ballast tubes was traced to faulty mechanical support of the tube filament. A rigid system of inspection was instituted and tube redesign was started.

Unstable ranging and relay chatter was reported which caused reduced ranging accuracy. A circuit change was made, providing parasitic suppressors to the range deck.[38] The final GF evaluation report, issued in late 1951, recommended that the revised Abee be released to stockpile. Acceptable quality had been achieved, together with good fuzing accuracy at attitude angles up to 28 degrees from the vertical.[39]

Sandia presented Report SC2319(TR), Engineering Evaluation of the Design of the Mk 6 Mod 0 Weapon, to the April 16, 1952 meeting of the Sandia Weapons Development Board. The Board felt that no formal action was necessary. It was pointed out that the Mk 6 Mod 0 would soon cease to exist, as parts were already being procured for the Mk 6 Mod 2 Bomb.[40]

The report was published August 15, 1952. The Mk 6 Mod 0 Bomb was 61 inches in diameter, 128 inches long, and weighed 8500 pounds. It was suspended by a single lug from the internal bomb bays of the B-29, B-36, B-47, B-50, B-52, AJ, A2J and A3D aircraft. (b)(1), (b)(3)

The manual insertion mechanism was the same as that used in the Mk 4 Bomb.

The Mk 6 Mod 0 had two interchangeable, lightweight, aluminum-alloy ballistic cases, one of welded and the other of riveted construction. The bomb was provided with improved barometric pressure sensing and dynamic stability by spoiler bands placed around the central portion of the ballistic case. The Abee radar fuze incorporated a remotely controlled range-setting feature plus circuit refinements that made the bomb more resistant to enemy countermeasures. (b)(1), (b)(3)

Mk 6 Mod 1 Bomb

The Mk 6 Mod 0 was the start of a development effort which was to continue for several years. Technological advances were breaking through on all fronts, both nuclear and nonnuclear, and including the carriers of the bomb. One of

the early changes provided optional use of the Albert radar as an alternate to the Abee radar.

The Albert radar had been started into development, and it had been hoped that units would be available by July 1950. However, the device proved difficult to design and fabricate, and its operational details were not firmed up until mid-1951, when it emerged as a device using different radiated frequencies than the Abee and providing higher transmitted power. (b)(1), (b)(3)

Use of the Albert required a different bomb antenna, and a new nose plate was developed for use with either Abee or Albert. This nose plate incorporated horn-type antennas for the Albert, while a discone antenna was used with the Abee.

Sandia notified the Albert development contractor that a GF-type program should be established to evaluate radar quality prior to production and to provide any steps necessary to achieve a fully satisfactory unit for military use. Thus a program called 3-E (for MC-3 Evaluation) was established in late 1951.[42]

The Albert was designed-released in February 1952 and assembly of units was started. It had been hoped that the 3-E Group could issue a formal report by September 1952, but discrepancies were revealed by the investigation. These problems concerned sensitivity, compatibility, vacuum-tube difficulties, and some mechanical troubles. (b)(1), (b)(3)

It had been discovered that full ranging capability within 10 seconds after application of inverter power was not guaranteed, even with preconditioning.[43]

weapon development was recognized. The Navy was prepared to accept the improved manual inflight insertion system.[47]

Thus, incorporation of the change into stockpile was urged, and schedules were established calling for first delivery in January 1952.[48] (b)(3)

For ease in assembly, the horn antennas were installed on the sphere case rather than on the nose plate as in the previous models, and this eliminated the need for connecting the antenna cables during reassembly of the nose plate after nuclear insertion. The Mk 6 Mod 2 Bomb entered stockpile in January 1952.

Report SC2484(TR), Engineering Evaluation of the Mk 6 Mod 3 Bomb, was dated November 17, 1952, but the report also covered the Mod 2. (b)(3)

Mk 6 Mod 3 Bomb

Drop tests of the Mk 6 Mod 2 configuration brought unexpected results. It was found that the radars were firing prematurely, as soon as they were armed by the baroswitches. When weapons were tested in the laboratory, the same thing happened, and investigation disclosed that the radars were "ringing" off the nose cavity of the bomb itself.

It was found that a quarter-inch clearance between the horn antenna and the nose plate of the bomb permitted radio leakage into the cavity between the nose plate and the rest of the bomb. The microwave signal reflected back and forth within this cavity, and then leaked back into the antenna and fired the radar relays.[50]

There were several possible solutions, such as adding absorbent material to the bomb nose or making the nose of plastic material, but the simplest one was to revert to the original configuration by installing the antennas on the nose plate rather than the sphere case. This meant that the antenna cables had to be disconnected for removal of the nose plate and reconnected in flight after nuclear insertion, but this was not considered to be a serious problem and the change was quickly made.[51]

The altered weapon became the Mk 6 Mod 3, which entered stockpile in July 1952.[52] By November of that year, all Mk 6's had been converted to the Mod 3 configuration.

Mk 6 Mod 4 Bomb

This change added a warmup cable. This cable permitted application of 28-volt direct current from an external power source to operate the heaters in the radars and battery cases. It was found that after the weapon had been stored at low temperatures, preheating of these components was necessary to ensure that they would perform properly during checkout tests. After the bomb had been loaded into the strike aircraft, the heaters could be operated through the aircraft pullout cable, using aircraft power. The Mk 6 Mod 4 entered stockpile in November 1952.[53]

Mk 6 Mod 5 Bomb

The Mod 5 incorporated a baroswitch fuze. The Military had for some time advocated replacement of the radars with an all-barometric fuzing system.[54] Their reasons were based not only on the difficulties which had been experienced with

The design also used nickel-cadmium batteries or Mk 2 Power Supply. These batteries replaced a lead-acid design and provided greatly improved operational readiness, since they could be charged in less time and be stored in the charged condition for longer periods. The Mk 6 Mod 5 Bomb entered stockpile in May 1953.

Mk 6 Mod 6 Bomb

The broad objectives of the Mod 6 were to provide contact fuzing and a Mach-insensitive barometric sensing system. This latter system was one which the Military had been requesting for some time.[60] It would provide the correct atmospheric pressure to the baroswitches regardless of the rate of fall of the weapon. Corrections to baroswitch settings were required to compensate for the varying effect of air flow past baroswitch ports at different Mach numbers. Making this correction was troublesome as it involved use of complicated tables incorporating the latest meteorological data, estimating the speed of weapon fall at the altitude at which the baroswitches were to close, and accurately controlling the speed and altitude of the strike aircraft at the time of drop. These problems were discussed at the August 8, 1951 meeting of the Sandia Weapons Development Board, and a formal recommendation was made that development emphasis be continued on a Mach-insensitive design.[32]

The emphasis was applied, but solutions to the problem were found to be quite elusive.[61] Early experiments with drag cones and trailing probes showed some promise. These devices placed the pressure pickup far enough behind the falling bomb to be relatively free of the effect of air flowing past it.

The drag cone showed especially good statistical reliability when the pressure orifices were located at the end of an 18-foot length of flexible hose attached to the bomb tail plate. This proved to be a difficult mechanical installation, however, as the buffeting effect of the air exerted forces on the hose which exceeded the breaking strength of the material, even when stainless-steel hose was tested. Deployment of the device as the bomb fell away from the carrying

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Sandia presented Report SC3271(TR), Design Description and Status Report of the Station 124 Pressure Sensing System for the TX-6-X4 Weapon, to the March 31, 1954 meeting of the Special Weapons Development Board. This report described the pressure-sensing system, discussed its capabilities, and summarized the test results. It appeared possible to use a single pressure offset when determining the baroswitch setting, and accept some degradation for those few burst heights (about 2 percent) which would be made at speeds higher than Mach 0.9.[68]

Sandia presented Report SC2540(TR), Engineering Evaluation of the Mk 6 Mod 6 Bomb with Mk 13 Mod 0 Fuze, to the January 12, 1955 meeting of the Special Weapons Development Board. Basic changes included the Mach-insensitive pressure-sensing system and a contact fuze. Contact-fuze tests had included 75-millimeter gun firings to simulate a spike impact, and sled tests to measure sensitivity of the system to rain impact. The Mk 6 Mod 6 entered stockpile in January 1955, and all previous modifications were converted to this design.

Stability of the bomb was satisfactory, except for drops made from B-47 aircraft at low altitudes and high speeds. In these cases the weapon pitched considerably upon release, due to the aerodynamics of the airplane and the bomb. This particular delivery required that bombing-table corrections be made to achieve the desired ballistic accuracy. All components and systems operated satisfactorily during fuzing and firing drop tests.[69]

The bomb diameter was 61 inches, its length 128 inches, and its weight 8170 pounds. (b)(1), (b)(3)

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Prior to takeoff, aircraft power was supplied to timer and battery heaters and trigger-circuit filaments. (b)(1), (b)(3)

The safing switch was placed to the arm position.

At bomb release, the pullout switches closed, starting the safe-separation timer and the inverters, and switching the trigger-circuit filaments from aircraft power to internal battery power. At the end of the preset safe-separation time, battery power was provided to the arming relay, which could not operate until the arming baroswitch closed and furnished a path to ground. (b)(1), (b)(3)

Operation of the arm relay then connected the inverter output to the firing-set charging circuits. The firing set completed its charge in about 0.5 second. Three seconds after safe-separation time, another switch in the safe-separation timer closed, completing the fuzing-baroswitch ground circuit, and the weapon was now ready for air-burst detonation.

If the fuzing baroswitch had been set for air burst, it closed at the predetermined altitude, forming a negative pulse which was applied to the trigger-circuit cathodes, firing both thyratrons. The output pulse of the trigger circuit fired both gaps, discharging the main bank condenser energy into the detonator bridge wires, with resultant weapon detonation. If the air-burst fuze failed, detonation occurred at impact.

If the fuzing baroswitch had been set for contact detonation, or if the air-burst fuze failed, impact of the weapon with the target resulted in detonation. The impact caused the crystals to generate a voltage which was applied to both thyratron grids, and the resultant firing of either thyratron initiated the firing sequence.[70]

(b)(3)

The Board met December 11, 1951 and accepted the proposed design.[60] Since the weapon was now no longer interchangeable with other Mk 6 Bombs--a different capsule being required--it was designated the Mk 18.

Only pit and capsule were affected, so most of the development work was carried out by Los Alamos. (b)(3)

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implosion system. However, upon cancellation of the TX-13 in August 1954, the TX-20 program was similarly deleted.

Retirement

With the development of thermonuclear weapons, as well as fission devices of more advanced design, the Mk 6 became obsolete. Removal from stockpile started in 1957 and by July 1962 all Mk 6 units had been retired.

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Glossary of Mk 4 Terms

Ad Hoc Working Group -- A group established by the Guided Missiles Committee to oversee the design of one particular missile-warhead installation.

Air Force Special Weapons Center -- That element of the Air Force Systems Command having to do with compatibility testing of nuclear devices with aircraft. Located at Kirtland Air Force Base, Albuquerque, New Mexico.

Armed Forces Special Weapons Project -- An interdepartmental agency formed to handle military functions related to atomic weapons.

Arming -- The act of arming a weapon, that is, preparing it for firing.

Ballistics -- The science governing motion of projectiles or bombs dropped from aircraft.

Barium Titanate Fuze -- An assembly which, when squeezed or struck, produces a pulse of electricity.

Barometric Fuze -- Fuze incorporating a baroswitch. A pressure device actuated increasing air pressure as the weapon descends in its trajectory.

Baroswitch -- A switch actuated by air pressure.

(b)(3)

Department of Defense -- The Armed Forces, i.e., the Army, Navy and Air Force.

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Kilogram -- A metric weight approximating 2.2 pounds.

Kiloton -- A means of measuring the yield of an atomic device by comparing its output with the effect of an explosion of TNT. A 1-kiloton yield is equivalent to the detonation effect of 1000 tons of high explosive.

(b)(3)

Mach -- A measure of speed. Mach 1.0 is the speed of sound, or 738 miles per hour at sea level.

Megaton -- A measure of yield of a large weapon. One megaton is the equivalent of 1,000,000 tons of high explosive.

Military Characteristics -- The attributes of a weapon that are desired by the Military.

Military Liaison Committee -- A department of Defense committee established by the Atomic Energy Act to advise and consult with the AEC on all matters relating to military applications of atomic energy.

NAVAHO -- A supersonic long-range missile developed for the Air Force by North American Aviation, Inc.

Neutron -- An uncharged particle of slightly greater mass than the proton.

Nose Probe -- A hollow tube extending in front of a bomb to register air pressure in relatively undisturbed air.

Nuclear Insertion -- Insertion of the nuclear capsule when the weapon is ready to be armed for detonation. An atomic weapon with a retracted capsule is relatively safe, and will only produce a yield equivalent to the amount of high explosive in the weapon.

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13. SRD Ltr, RS 1200/215, Sandia Corporation to Armed Forces Special Weapons Project, dtd 7/25/50, subject, Aerodynamic Spoiler Bands. SC Archives, microfilm reel MF-SF-SC-126.

14. SRD Ltr, RS 1210/5141, Department 1210 to Director 1200, Sandia Corporation, dtd 8/1/50, subject, 41 Case Design. SC Archives, microfilm reel MF-SF-SC-28.

15. SRD Ltr, Field Command to Sandia Corporation, dtd 8/7/50, subject, Improved Baro Sensing for the Mk 6 Weapon. SC Archives, microfilm reel MF-SF-SC-28.

16. SRD Minutes, RS 3466/67992, Sandia Weapons Development Board to Distribution, dtd 8/16/50, subject, Minutes of the 43rd Meeting. SC Archives.

17. SRD Ltr, Los Alamos Scientific Laboratory to Division of Military Application, dtd 6/7/48, subject, Airborne Nuclear Insertion and Extraction. AEC Files, 471.6.

18. SRD Ltr, Division of Military Application to Santa Fe Directed Operations, dtd 7/14/48, subject, Airborne Nuclear Insertion and Extraction. AEC Files, MRA-9, 6/48-6/49.

19. SRD Ltr, Department 1210 to Director 1200, Sandia Corporation, dtd 8/23/50, subject, Meeting Between Sandia and Los Alamos Representatives on 60-Inch Implosion Weapon Concepts. SC Archives, Transfer No. 43025.

20. (b)(3)

21. SRD Ltr, Santa Fe Operations Office to Distribution, dtd 9/20/50, subject, Weapon Designation. SC Archives, microfilm reel MF-SF-SC-28.

22. SRD Ltr, Military Liaison Committee to Division of Military Application, dtd 6/5/51, subject, New Improved 60-Inch Atomic Bomb. SC Archives, microfilm reel MF-SF-SC-28.

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