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REPORT OF

THE AIR PROVING GROUND COMMAND

EGLIN FIELD, FLORIDA

TESTS CONDUCTED BY

AAF PROVING GROUND

EGLIN FIELD, FLORIDA

RETURN TO
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APG - FILE NO 4885
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22 OCT 46

SUBJECT

COMPARATIVE TEST OF THE EFFECTIVENESS OF LARGE BOMBS AGAINST REINFORCED CONCRETE STRUCTURES (ANGLO-AMERICAN BOMB TESTS PROJECT "RUBY")

Bombs & Concrete Penetration - Tests
Bomb Conc
Proj. #APG 1-46-7
Ruby

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1-46-7 4885

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DATE
31 October 1946

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HEADQUARTERS
AIR PROVING GROUND COMMAND
EGLIN FIELD, FLORIDA

31 October 1946

PROJECT NO. 1-46-7

COMPARATIVE TEST OF THE EFFECTIVENESS OF LARGE BOMBS AGAINST REINFORCED CONCRETE STRUCTURES (ANGLO-AMERICAN BOMB TESTS-PROJECT RUBY)

1. Inclosed is copy of Final Report of Air Proving Ground Command, Eglin Field, Florida, subject as above.

2. This project was initiated at the request of Headquarters AAF by letter to Commanding General, AAF Center, Orlando, Florida, subject: Anglo-American Bomb Tests, dated 3 January 1946.

3. Object: To compare the performance of large British and American bombs when used against massive reinforced concrete targets.

4. Purpose of equipment tested: The bombs tested are designed to penetrate and destroy resistant targets when dropped from high altitudes. Bomb sizes ranging from 2000-lb. SAP and AP to 22,000-lb. GP and SAP were used, as well as the 4500-lb. concrete piercing rocket assisted Disney Bomb and a 1650-lb. scale model of a 12,000 lb. concrete piercing rocket assisted bomb.

5. Description: This was a joint Anglo-American bombing project carried out against the reinforced concrete submarine assembly plant at Farge, Germany, and the U-Boat Shelter at Heligoland. Inert loaded bombs were dropped at Farge to determine penetration and case strength of the various bombs and suitability of the fuzes and adapter boosters employed in these bombs. The drops at Heligoland were with explosive fillers of various types to determine their sensitivity to impact.

6. Conclusions:

a. Not any of the bombs tested are suitable for use against massive reinforced concrete.

b. The 22,000-lb. SAP Amazon bomb (T28) and the 4500-lb. CP/RA Disney Bomb produced the greatest penetration of the bombs tested, but case strength needs to be increased to withstand break-up on secondary impact after perforating a reinforced concrete roof which substantially reduces the bomb's velocity.

c. The rocket assist on the 4500-lb. CP/RA Disney bomb is not reliable in functioning.

d. All of the explosive fillers tested (see Inclosure 12 of subject report) are sufficiently insensitive to withstand high altitude impact against reinforced concrete.

e. The D-9 Shackle is suitable for use with the 22,000-lb. Grand Slam bomb but is unsuitable for use with the 22,000-lb. SAP Amazon bomb.

7. Recommendations:

a. Action be taken to design, manufacture, and test against a resistant target such as Farge, a bomb with smaller diameter, more pointed nose, and greater case strength than the 22,000-lb. SAP Amazon bomb, but with weight of explosive charge not materially reduced.

b. Consideration be given to a means of increasing case strength other than by increasing weight and thickness of bomb body.

c. Improvement in the reliability of functioning of rocket motors be effected, and provision be made for use of rocket assist on bombs designed as above.

d. The explosive filler with the greatest explosive power, selected from one of the types tested, be used in concrete piercing bombs. For a list of the fillers tested see Inclosure 12 of subject report.

e. A shackle be developed for large bombs which will function satisfactorily regardless of bomb weight, and angle of suspension of the shackle.

8. This test was carried out only under temperate climatic conditions.

9. Inclosures:

Inclosure 1 - Test Directive
Inclosure 2 - Final Report (1-46-7)

CARL A. BRANDT,
Brigadier General, U.S.A.,
Commanding

CONFIDENTIAL
~~SECRET~~ ------Authy. Ltr. Hq. AAF
11 January 1946

HEADQUARTERS, ARMY AIR FORCES
WASHINGTON

3 JAN 1946

AFREP

SUBJECT: Anglo-American Bomb Tests

TO: Commanding General, Army Air Forces Center, Orlando, Florida

1. It is desired that the Army Air Forces Center organize, monitor, and assume operational responsibility for the entire Army Air Forces' phase of the subject tests.

2. At the present time, three B-29 aircraft, with flight and maintenance crews, have been allocated to this project. These aircraft are now undergoing winterization at San Antonio, Texas, and will be available for movement to the United Kingdom by the first of February. Four (4) additional B-17 aircraft, with flight and maintenance crews, will be required for completion of this project. Due to the complete lack of maintenance facilities in the United Kingdom, sufficient supplies and equipment must accompany the flight echelon for it to be entirely selfsustaining for a period of six months. While the B-17's and B-29's will be able to carry much of the equipment, personnel and supplies, it will be necessary to utilize Air Transport Command facilities to transport the remainder.

3. A project officer to direct this operation in the United Kingdom will be required. Lt. Colonel D. G. Hawes of your command is recommended for this purpose. Flight crews of these aircraft must be of superior caliber.

4. It is imperative that this project proceed with the least practicable delay. Air lift for supplies and necessary equipment will be provided by the Air Transport Command. Your command is authorized to communicate direct with continental commands in obtaining necessary personnel and equipment for this project.

5. This project is assigned an A-1 priority.

BY COMMAND OF GENERAL ARNOLD:

C O P Y

/s/ C. C. Chauncey

Inclosure 1, Page 1

C. C. CHAUNCEY
Major General, U. S. Army
Deputy Chief of Air Staff

~~SECRET~~
CONFIDENTIAL

V-68310

[redacted]

THE ARMY AIR FORCES BOARD
ARMY AIR FORCES PROVING GROUND COMMAND
ORLANDO, FLORIDA

GLR/mep-F
23 May 1946
Armament Branch

SUBJECT: Anglo-American Bomb Tests (Project "Ruby")

TO: Commanding Officer, AAF Proving Ground,
Eglin Field, Florida
Attn: Proof Division

1. The AAF Board activated project No. M-4885 this date. The following information is relative to the project:

a. Title: "A Comparative Test of the Effectiveness of Large Bombs against Reinforced Concrete Structures."

b. Authority: President, AAF Board.

c. Priority: 1A.

d. Classification: Confidential.

e. Project Officer: Colonel G. L. Robinson, phone 1310.

2. The test program will be that prepared by representatives of the United States and Great Britain for the Anglo-American Large Bomb Project now in progress in England, with any amendments thereto approved by the Military Attache, London, England, and the Commanding General, USAFE.

3. The tests will be conducted by Proving Ground personnel with equipment detailed to the "Ruby" detachment, Marham, England, and organized under authority of letter directive, Headquarters, AAF, dated 3 January 1945, subject: Anglo-American Bomb Tests.

4. All previous arrangements relative to jurisdiction, weekly reports, and general operation of subject tests remain unchanged.

5. It is desired that the final report be submitted to the AAF Board for concurrence prior to publication.

FOR THE PRESIDENT:

C O P Y

/s/ Wm. W. Momyer

Inclosure 1, Page 2

Wm. W. MOMYER
Colonel, Air Corps
Executive

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[redacted]

HEADQUARTERS
AIR PROVING GROUND COMMAND
EGLIN FIELD, FLORIDA

FINAL REPORT

ON

COMPARATIVE TEST OF THE EFFECTIVENESS OF LARGE BOMBS AGAINST REINFORCED CONCRETE STRUCTURES (ANGLO-AMERICAN BOMB TESTS - PROJECT "RUBY")

PROJECT NO. 1-46-7

Inclosure 2

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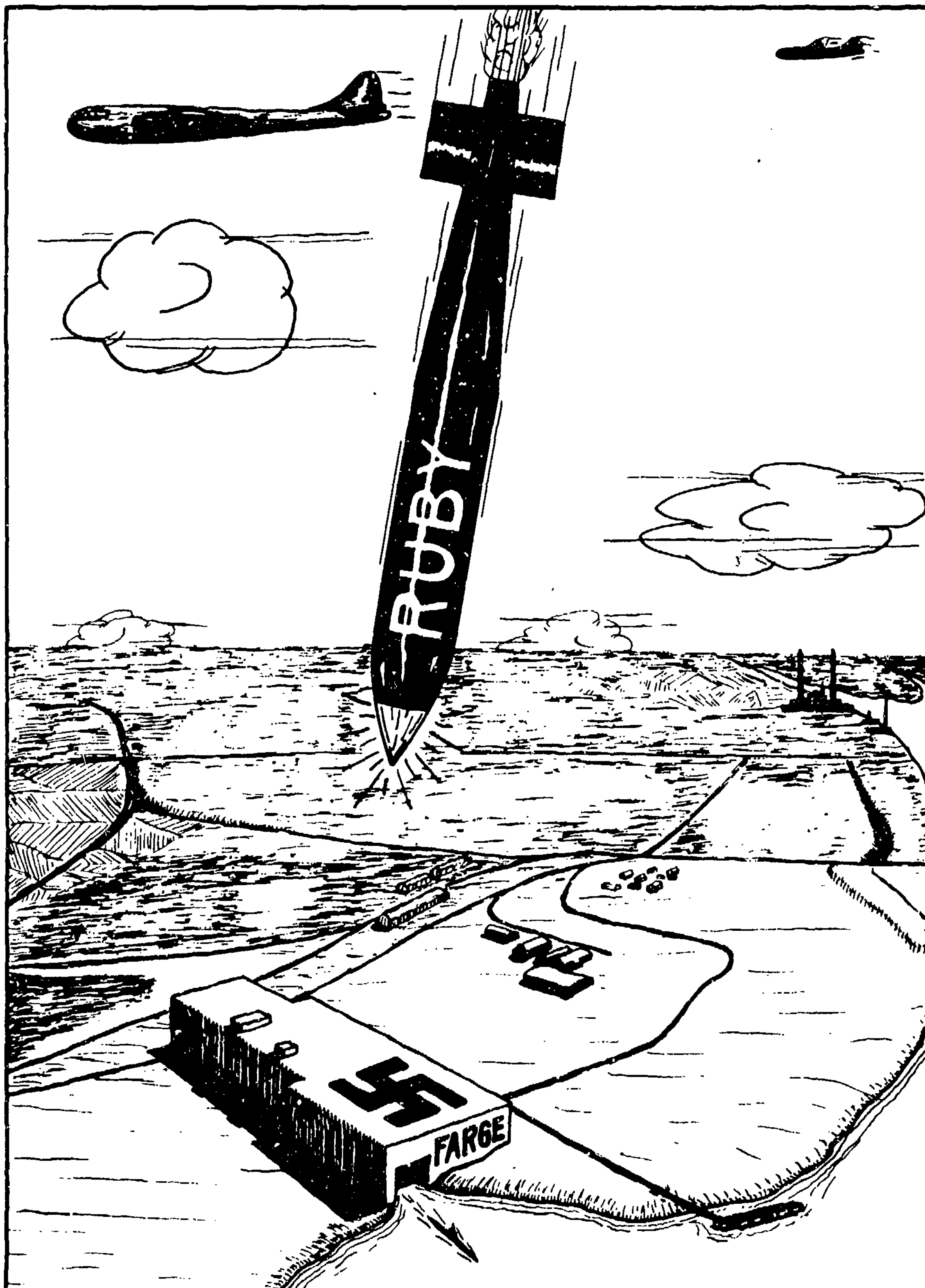
RUBY
FARGE

1. OBJECT:

To compare the performance of British and American bombs of standard and special design when used against reinforces concrete targets. Particular attention will be given to the following:

a. Penetration.

b. Strength of cases.

c. Insensitivity of exploder system.

d. Reliability of pistols and fuzes.

e. Insensitivity of main fillings.

2. INTRODUCTION:

a. The end of World War II left both the AAF and the RAF with many unanswered questions concerning the effectiveness of bombs against reinforced concrete structures. One problem was to find out why heavy bombs developed toward the end of the war (the British 12,000-lb. Tall Boy and 22,000-lb. Grand Slam and the American counterparts, the 12,000-lb T10 and 22,000-lb. T14) failed to penetrate thick concrete in the manner predicted by formulae. This was thought to be the result of breaking up of the case on impact, or else because the sensitivity of the explosive filling or exploder system was such that the bomb exploded on impact prior to fuze action.

b. Running parallel with the development of large bombs was a project for obtaining high striking velocities by means of a rocket assisted 4,500-lb. British bomb called the Disney. For technical reasons this bomb could be carried only on B-17 aircraft, and was used by the Eighth Air Force towards the end of the war. In striking concrete the same difficulties were encountered as with the Tall Boy and Grand Slam. Both the RAF and the AAF, therefore, were interested in the problem of bomb versus concrete. Post war tests were initiated by the RAF to answer some of these questions. As early as June 1945, the concrete V-weapon structure at Watten was used as a target (Trials I, II, and IV, see Inclosure 2), but it was too small a target for comprehensive tests. Later the more heavily reinforced and larger Submarine Assembly Plant at Farge, Germany, became available, but as this was located in the American Enclave, the British had to seek American cooperation to use it. Trial VII was completed and Trial IV repeated in August 1945 using the Farge target. In Trial IV, the British 2,000-lb. AP bomb was used.

c. Up to this point, American participation had consisted of B-17 aircraft of the 40th Combat Wing dropping the Disney bombs for the British. Then, because of the rapid retrenchment of organizations and elimination of bases in the UK after termination of the war in Europe, directives were issued by USAFE for the assignment of three B-17 airplanes complete with crews to RAF Station, Mildenhall, England, which was to be the base of operations for this test. A joint RAF-AAF program for bombing the Farge and Heligoland targets was drafted. This program included the following American bombs: 2,000-lb. SAP (M103), fabricated Tall Boys (T10) and fabricated Grand Slams (T14). British bombs to be tested included: cast Tall Boys, Disneys, and a 1,650-lb. model of a 12,000-lb. concrete penetrating rocket assisted bomb (an enlarged version of a Disney).

d. Because of lack of maintenance personnel, inadequate supply channels, inexperience of bombing teams and vagaries of the weather, the B-17 aircraft at Mildenhall were unable to accomplish any missions. It was then decided that, to expedite the test, a self-sustaining detachment of highly skilled air crews, maintenance, supply, technical and administrative personnel would be assembled in the United States, furnished with three B-29 aircraft and four B-17 aircraft, and flown to England. This marked the beginning of Project "Ruby". This contingent arrived at RAF Station, Marham, its base of operations, on 15 March 1946 and bombing operations commenced on 25 March. Meanwhile, the three B-17 aircraft and crews at Mildenhall had been moved to Marham to be added to Project "Ruby". As the test progressed, the program was enlarged to include the newly developed American 22,000-lb. SAP (T28) bomb, called the Amazon. The program, as finally revised, included Trials I through XXII, three of which had already been accomplished, (Trials II, IV and VII), and two of which were subsequently cancelled (Trials III and VIII). This left eight Trials to be accomplished at Farge (Trials VI, IX, X, XI, XII, XVIII, XIX, and XXI) for the purpose of determining penetration, case strength, reliability of fuzes, and insensitivity of exploder system, and nine Trials to be accomplished at Heligoland (Trials I, V, XIII, XIV, XV, XVI, XVII, and XX, for the purpose of determining insensitivity of various explosive fillers, and Trial XXII to determine the performance of the 2000-lb. SAP HE bomb dropped with 0.10 second delay fuzes).

e. The Submarine Assembly Plant at Farge makes an ideal target for penetration and case strength tests of inert loaded bombs, being sufficiently large (1400' x 318') and sufficiently thick (14'-9" to 23'-0"), and presenting several different types of roof reinforcing (See Inclosure No. 4). However, its location close to the village of Farge, with houses within the 500 yard danger area and an electric power plant just outside this area, makes it impractical for use with HE bombs. For this reason, all sensitivity trials were conducted against the U-Boat Shelter on the uninhabited island of Heligoland in the North Sea. The roof of this target is ten feet thick, the shelter being 506 feet in length, and 310 feet wide (see Inclosure 10).

3. CONCLUSIONS:

a. Penetration.

(1) Not any of the bombs tested are capable of perforating the 23 foot thickness of the Farge roof.

(2) The 22,000-lb. Amazon bomb, with a striking velocity of 1100 feet per second, will perforate the 14'-9" thickness of the Farge roof, and can be expected to perforate up to 15'-10" of reinforced concrete at this striking velocity.

(3) The rocket assisted 4500-lb. Disney bomb, with a striking velocity of 1450 feet per second, will perforate the 14'-9" Farge roof, and can be expected to perforate up to 16'-4" of reinforced concrete at this striking velocity.

(4) The 4500-lb. Disney bomb without rocket assist, with a striking velocity of 1150 feet per second, will scab the underside of the 14'-9" Farge roof, will perforate the 10 foot thick roof of the Heligoland target, and can be expected to perforate up to 12'-10" of reinforced concrete at this striking velocity.

(5) The American 22,000-lb. fabricated Grand Slam (T14) bomb will penetrate 7'-8" into reinforced concrete at 1150 feet per second striking velocity, 5'-2" at 850 feet per second, and 4'-7" at 620 feet per second striking velocity.

(6) The American 12,000-lb. fabricated Tall Boy (T10) bomb will penetrate 5'-8" into reinforced concrete at 850 feet per second, and 3'-5" at 620 feet per second striking velocity.

(7) The British 12,000-lb. cast Tall Boy will penetrate 5'-7" into reinforced concrete at a striking velocity of 1150 feet per second, 3'-9" at 850 feet per second, and 3'-0" at 620 feet per second.

(8) The British 2000-lb. AP bomb, with a striking velocity of 1150 feet per second, will penetrate 6'-0" into reinforced concrete.

(9) The inert loaded 2000-lb. SAP (M103) bomb, with a striking velocity of 1030 to 1100 feet per second, will penetrate only 3'-1" into reinforced concrete.

(10) The Picratol filled 2000-lb. SAP (M103) bomb, fuzed for 0.10 second delay, and dropped from 20,000 feet, will scab the underside of the ten foot thick Heligoland roof. The bomb will blow through lesser thicknesses of concrete, such as the roof overhang, averaging six feet thick.

(11) The 1650-lb. Model bomb, with a striking velocity of 1000 feet per second, will penetrate 4'-4" into reinforced concrete. With a striking velocity of 800 feet per second it will penetrate 3'-3".

b. Case strength.

(1) The Amazon bomb normally is strong enough to withstand impact on concrete at striking velocities approximating 1100 feet per second, but is not strong enough to withstand side impact occurring after perforation of a 14'-9" roof. Weakness of the rear austenitic weld contributes to break-up of this bomb. No other welds failed.

(2) The Disney bomb normally is strong enough to withstand impact on concrete at striking velocities approximating 1450 feet per second, but is not strong enough to withstand side impact occurring after perforation of a 14'-9" roof.

(3) The Disney bomb normally is strong enough to withstand secondary impact after perforating a 10 foot roof with striking velocities of 1150 to 1450 feet per second.

(4) The 2000-lb. SAP bomb at striking velocities of 1030 to 1100 feet per second has approximately a 70 per cent chance of remaining intact upon impact with reinforced concrete. Those which break up fail when the rear portion of the case strikes against the back of the crater as the bomb traces a ricochet path in concrete. Of those which remain intact, about one-half are badly dented by this same action.

(5) The fabricated Grand Slam bomb will break up upon impact on concrete at striking velocities of 850 feet per

second or higher, but the hardened steel nose will withstand impact at velocities up to 1150 feet per second. The weakness of the stainless austenitic weld joining the base ring to the bomb body contributes to the break-up of this bomb. None of the other welds failed. Break-up is caused by the striking of the rear portion of the bomb against the back of the crater as a ricochet path is traced in concrete.

(6) The fabricated Grand Slam has an even chance of remaining intact upon impact with concrete at a striking velocity of 610 feet per second, but ricochet and denting are probable.

(7) The fabricated Tall Boy has a better than 50 per cent chance of remaining intact upon impact with concrete at a striking velocity of 610 feet per second, but ricochet and denting are very probable. The weakness of the case at the rear weld, although externally reinforced by addition of extra welded metal strips, contributes to break-up of this bomb. Break-up occurs in the same manner as the Grand Slam.

(8) The Cast Tall Boy will break up completely upon impact with concrete at velocities of 620 feet per second and above. Ricochet of the nose section is very probable at the lower striking velocities. Fractures occur down into the hardened nose.

(9) The 2000-lb. AP bomb is sufficiently strong to withstand impact on concrete at a striking velocity of 1150 feet per second, but the bomb tends to ricochet or rebound from the crater.

(10) The 1650-lb. Model bomb is sufficiently strong to withstand impact on concrete at a velocity of 1000 feet per second, but its length to diameter ratio is apparently too great to prevent bending of the bomb case. Because of the tendency to bend upon impact, the bomb rebounds from the crater.

c. Fuses and pistols.

(1) The British Tail Pistol No. 58 functions satisfactorily on 4500-lb. CP/RA Disney bombs dropped on reinforced concrete targets.

(2) The British Tail Pistol No. 47A MK II functions

satisfactorily on Tall Boy and Grand Slam bombs dropped on reinforced concrete targets.

(3) The T723 tail fuse fitted to Amazon bombs will withstand impact on heavy concrete provided that the bomb does not break up. Picatinny Arsenal tests on the M39 Special Primer show that this Primer sometimes fails to ignite the delay powder.

d. Boosters and exploders.

(1) The exploders in Disney bombs are probably sufficiently insensitive to withstand impact on concrete without detonating. Results at Farge are inconclusive because of the possibility that live detonators and percussion caps were used with the pistols.

(2) The exploders and auxiliary exploders in Tall Boy and Grand Slam bombs are sufficiently insensitive to withstand impact without detonation.

(3) The composition "A" auxiliary boosters used in the Amazon bomb are insensitive to impact on concrete, and are satisfactory for use in concrete penetrating bombs.

(4) The adapter booster in the 2000-lb. SAP bomb is insensitive to impact provided that the bomb does not break up.

e. Fillers.

(1) All of the types of explosive fillers tested at Heligoland will satisfactorily withstand impact against concrete. ~~For a~~ list of the fillers tested see Inclosure ~~12~~.

f. General.

(1) Not any of the bombs tested are suitable in their present form for use against massive reinforced concrete.

(2) While the Amazon bomb is dimensioned properly for good penetration, it needs modification to increase its case strength to resist break-up on side impact. The stainless austenitic weld in this bomb is unsatisfactory. All other welds are satisfactory.

(3) While the Disney bomb is dimensioned properly for good

penetration, it also needs modification to prevent break-up on side impact. The stud holes in the case contribute to break-up on side impact. The bomb also needs modification to increase the reliability of functioning of the rocket assist. Redesign of the arming wire system to reduce the lengths of the arming wires would eliminate some rocket failures, but improvement in the firing system is also needed to insure complete rocket action from all rocket tubes. The explosive charge of the Disney is not large enough to cause material damage to a massive concrete target.

(4) The 2000-lb. AP and SAP bombs, because of their small penetration and their small explosive charge, are ineffective against heavy concrete targets.

(5) The Tall Boys and Grand Slams are not properly dimensioned to give good penetration in concrete. While the fabricated bombs are stronger than the corresponding cast bombs, neither type nor size is strong enough to resist break-up in initial impact from high altitudes.

(6) In bomb design a material increase in penetration for a given weight is obtained by increasing striking velocity. Since an increase in release altitude above 20,000 feet results in only slightly increased striking velocit., rocket assist is essential. Decreasing the bomb diameter also results in greater penetration, but if the ratio of length to diameter exceeds a certain critical value, (approximately 8 to 1) the bomb will bend excessively. A slight gain in penetration is also obtained by increasing the caliber radius of the nose ogive, and by decreasing the striking obliquity.

(7) The D-9 shackle is satisfactory for use with Tall Boy and Grand Slam bombs, but is unsatisfactory for use with Amazon bombs.

4. **RECOMMENDATIONS:**

a. That action be taken to design, manufacture, and test against such a target as Farge a bomb with smaller diameter, more pointed nose and greater case strength than the Amazon, but with weight of explosive charge not materially reduced.

b. Consideration be given to means of increasing case strength other than by increasing weight and thickness of bomb body, i.e., using multiple layer walls, internal ribs or corrugations, or the use of special alloys.

c. Improvement in the reliability of functioning of rocket motors be effected, and provision be made for use of rocket assist on bombs designed in accordance with paragraphs a. and b. above, to further increase penetration.

d. A means be developed for obtaining a striking angle of zero degrees in order to increase penetration, eliminate the uncertainties in bomb behavior, and avoid the added stresses arising from non-normal incidence.

e. The Farge target or other suitable targets be used for continued tests of bombs and projectiles against concrete.

f. The explosive filler with the greatest explosive power, selected from one of the types tested, be used in concrete-penetrating bombs,

g. A shackle be developed for large bombs which will function satisfactorily regardless of bomb weight, and angle of suspension of the shackle.

5. RECORD OF TEST:

Test was conducted in accordance with Test Program, copy of which is attached as Inclosure 2.

6. DISCUSSION:

a. Farge Trials:

(1) Target: The 1400 foot long Submarine Assembly Plant at Farge has a reinforced concrete roof 4-1/2 meters (14'-9") thick covering 68 per cent of the roof area of 380,600 square feet. The remainder has been thickened by the addition of a top layer of concrete 2-1/2 meters thick, giving this portion a total thickness of 7 meters, or 23 feet. This top layer had been started at the Eastern end of the structure and had progressed toward the middle where work was abandoned when the region fell into Allied hands. Several types of reinforcing were used in the first roof layer (described fully in Inclosure 4), but the principal method consisted of the use of precast, prestressed, reinforced concrete bowstring trusses (see Inclosure 4, page 2). The roof plan (Inclosure 6, page 1), shows the arrangement and size of all roof slabs and indicates the type of reinforcing used.

Since the aiming point for the bulk of the releases was a bullseye painted on the 4-1/2 meter roof at a distance 300 feet from the West end, the distribution of Project "Ruby" bomb hits on this target (see Inclosure 6, page 2) is concentrated on the Western half of the building. When hits were desired on the 7 meter roof, bombardiers shifted their aiming point Eastward towards the center of the building. Two holes through the 4-1/2 meter roof, but bordering on the 7 meter portion, were sometimes used for aiming points. These holes were caused by Grand Slams dropped during the war by the RAF. These bombs had exploded after partial penetration and had blown a hole through the roof. Inclosure 4 (pages 13 and 14) shows the location of these holes, and the damage to the roof caused by these bombs.

(2) Previous Trials: Prior to activation of Project "Ruby", the British had completed two trials on the Farge target with results as outlined below:

(a) In Trial IV, thirteen 2000-lb. AP bombs were dropped from 20,000 feet by Lancaster aircraft, to give a striking velocity of 1140 feet per second, and seven hits were scored. One bomb ricocheted after penetrating 2'-4", struck a vertical wall, and fractured the base plate. The remaining six were intact, although one had bent slightly, and another had flattened considerably at the base. Only four of the six were considered to be fair hits, as one struck on the edge of the roof, and another struck on a vertical face of concrete. Craters of the four good hits varied from 5'-6" to 6'-5" deep, with crater diameter averaging 10 feet. One bomb ricocheted, one rebounded from its crater, and two remained in their craters. All exploders were intact. Pistols were not fitted to these bombs. The penetrations of the AP bombs on Farge were consistent with earlier results at Watten. There two hits were obtained from 18,000 feet (striking velocity 1090 feet per sec.) with penetrations of 5'-1" and 5'-5". Both bombs were intact, but one had bounced and the other had ricocheted out of the crater.

(b) In Trial VII, Five cast Tall Boys were dropped by Lancasters from 20,000 feet (striking velocity 1150 feet per second), scoring four hits. All bombs which struck broke into a large number of pieces. Penetration varied between 5'-5" and 5'-8". Inclosure 7, page 1, shows one of the Tall Boy craters with nose section of the bomb lying in the crater. Also shown is a photograph of the base of the same bomb. Exploder containers were broken in some instances, but exploders had not detonated. Pistols were examined and found to have functioned.

(3) Trial X (Disneys without rocket assist): Project "Ruby" B-17 aircraft dropped 12 Disney bombs from 20,000 feet with rocket assist not functioning (striking velocity 1150 feet per second). The bombs were dropped with rocket fuses and generators "safe" (see Inclosure 3 for sketch of Disney bomb). The Disneys used in these trials were from a Vickers Armstrong lot which had been condemned for manufacturing flaws. Seven hits, all in the 4-1/2 meter roof, were scored. Results are tabulated in Inclosure 8, Page 1. A detailed description of each hit is given below. All bombs have been assigned a plot number, and the location of each hit is shown on the roof plan, Inclosure 6, page 1. Crater profiles are shown in Inclosure 9, pages 1 to 4.

(a) Plot No. 2: This bomb penetrated 11'-0" into a roof slab with bowstring truss reinforcing. Bomb lodged in roof at an angle of 28 degrees to the vertical, intact. Ceiling below was slightly scabbed. (See Inclosure 7, pages 2 and 3). Bomb was fitted with Mark 58 pistols and dummy (wood) exploders. Detonators and firing caps were not fitted to the pistols. Examination of the pistols showed that they had functioned, but the striker points had flattened upon hitting the shoulder of the empty detonator holder.

(b) Plot No. 3: This bomb struck close to the junction of four roof slabs over a supporting wall, and penetrated 11'-1" into bowstring truss roof slab. The bomb remained intact, lodged in roof at an angle of 21 degrees to the vertical. (See Inclosure 7, page 4). Pistols functioned properly. Bomb was fitted with dummy exploders. Detonators and firing caps were omitted.

(c) Plot No. 9: This bomb struck at the junction of four roof slabs of bowstring truss construction. The rear portion of bomb case broke off near lug, fractured into a number of pieces which fell around the crater. The nose section lodged in the crater at an angle of 32 degrees to vertical. There were cracks 18" long running toward the nose of the bomb from the fractured edge. Two possible explanations for the break-up of this bomb are advanced. One is that the bomb bent excessively and snapped. The other is that the bomb got squeezed between the roof sections. (Another bomb, Plot No. 37, which also hit under similar circumstances, broke up in the same way). Penetration was 10'-7", only slightly less than in the two previous cases. Pistols functioned satisfactorily. Bomb was fitted with wood dummy exploders. Detonators and firing caps were omitted. See Inclosure 7, pages 5 and 6 for photographs of crater.

(d) Plot No. 10: This bomb struck on roof slab having short span concrete truss reinforcing. For description of this type of construction, see Inclosure 4, page 3. Bomb penetrated 9'-5" into roof, remaining intact in crater, ledged at an angle of 29 degrees to the vertical. Pistols functioned properly. Bomb was fitted with dummy exploders. Detonators and firing caps were omitted. See Inclosure 7, page 7, for photographs of bomb and crater.

(e) Plot No. 26: This bomb struck on roof slab having 60 cm. steel I-beam reinforcing. Point of impact was near junction of four roof slabs. Bomb rebounded 55 feet from crater, landing flat. (See Inclosure 7, pages 8 and 9). The nose broke into three pieces on secondary impact. Inspection of the fractures showed that the break-up occurred because of two internal flaws in the nose. One flaw ran almost entirely across the nose of the bomb at a point about 2-1/2 inches ahead of the filler cavity. The other flaw, starting at the transverse flaw, was in a plane through the bomb's longitudinal axis, extending to the cylindrical portion of the case. Inclosure 7, page 10, shows these flaws. Penetration of this bomb was below normal, being only 8'-7". Angle of penetration, judged from the back slope of the crater, was 28 degrees. Bomb was fitted with dummy exploders. Pistols functioned satisfactorily, firing the live caps which had been fitted. Because this was a faulty bomb, the penetration has not been included in the average of this trial.

(f) Plot No. 28: This bomb penetrated 10'-6" at the center of a roof slab having bowstring truss reinforcing. The bomb severed the upper chord of one bowstring truss and deflected a second one upward, as shown in Inclosure 7, page 11. The bomb came to rest intact, lodged in roof at an angle of 25.5 degrees to the vertical. The ceiling below was slightly scabbed. This can be seen in Inclosure 7, page 3, at the top left. This bomb hit on the same roof slab as Plot No. 2. Bomb was fitted with dummy exploders and live caps. Pistols functioned satisfactorily, firing the caps.

(g) Plot No. 29: This bomb hit at the junction of two roof slabs, over a supporting wall. Short span concrete truss reinforcing was used in these slabs. The bomb penetrated 9'-3", bounced out, and came to rest 15 feet behind crater. (See Inclosure 7, page 12.) Bomb case was slightly bent, but intact. (See Inclosure 7, page 13). Angle of penetration, judged from back slope of crater, was 34 degrees. Bomb was fitted with dummy exploders and live caps. Pistols functioned satisfactorily, firing the caps. Since this bomb bounced out of the crater, all of its energy was not expended in the impact. Therefore, the penetration is not representative, and is not included in the average for this trial.

(4) Summary, Trial X: Considering only Plots 2, 3, 9, 10 and 28 as representative of Disney impacts without rocket assist, the following average crater characteristics are deduced:

Average vertical penetration	10'-6"	Std. Dev. 0'-8"
Maximum penetration	11'-1"	
Minimum penetration	9'-5"	
Average angle of rest	27.0 deg.	Std. Dev. 4.0 Deg.
Average crater length	13'-0"	Std. Dev. 2'-6"
Average crater width	13'-8"	Std. Dev. 1'-2"
Average depth of spall	4'-6"	Std. Dev. 1'-0"

If Plot No. 9 is omitted on the assumption that it is not a representative hit because of break-up, the average penetration would be unaffected. The penetration predicted by the latest formula (Inclosure 14, page 2) gives 11'-4" for the unassisted Disney bomb.

(5) Trial XII (Disney bombs, rocket assisted): This trial consisted of releasing the Disney bombs with rocket fuse and generator "armed". The M111A2 mechanical time delay fuze was set for a delay of 34.1 seconds, allowing free fall of 15,000 feet before initiation of the rockets. The burning time of the rockets is approximately three seconds. This imparts an additional velocity to the bomb, and brings it above sonic velocity. When dropped from 20,000 feet altitude with a true airspeed of 220 mph, the striking velocity is 1450 feet per second. Prior to dropping these bombs with live rockets, it was necessary for safety reasons to demonstrate that all bombs dropped would fall within a radius of 500 yards of the aiming point. Practice drops were made at Orfordness, England. Each of four bombardiers dropped one bomb from 20,000 feet. Rockets functioned on three of the four bombs. Errors were respectively, 50 feet (left), 100 feet (Over), direct hit, and 100 feet (short and right), thus demonstrating the aimability of these bombs. Twenty-two Disneys were then dropped from 20,000 feet at Farge, scoring eleven hits and eleven misses. Seven of the eleven hits were rocket assisted and seven of the eleven misses were also rocket assisted, giving a percentage functioning of 63.6 per cent for the rockets. A description of each hit is given below. Crater profiles are given in Inclosure 9, pages 5 to 10.

(a) Plot No. 37: This bomb hit at a junction of four roof slabs, over a supporting wall. Bomb penetrated 9'-1" into a roof slab having 60 cm. steel I-beam reinforcing. The rear section of the bomb broke up, leaving nose section lodged in crater. (See Inclosure 7, page 14). This break-up was similar to that of the unassisted Disney hit, Plot No. 9, and under similar conditions of impact. Angle of penetration was 37 degrees. Inspection of the rocket tubes in the vicinity of the crater showed that the rocket action had been incomplete. This was determined in two ways. Firstly, there was rocket propellent scattered around the crater, and secondly, some of the rocket tubes recovered failed to show the two characteristic blued bands at the end where the nozzle is welded to the tube. Between the two blued bands is a white ash deposit. If ignition occurs after impact, these characteristic markings are not present. Inclosure 7, page 24 illustrates the appearance of the tubes in the case of proper functioning. Since the rocket action was incomplete, and since the bomb broke up in the crater, the penetration of this bomb had not been included in the average for this trial. Pistols functioned satisfactorily, firing the live caps. Bomb was fitted with live exploders. The explosive train was interrupted by use of dummy detonators. One exploder had been broken and was set off by a secondary impact. The other exploder was intact. (See Inclosure 7, page 15).

(b) Plot No. 39: The rocket assist failed to function on this bomb; hence, penetration is not usable in average for Trial XII. Bomb struck on bowstring truss roof slab at center of span. Penetration was 10'-9", which conforms to the average for unassisted rockets. Bomb remained intact and lodged in roof (see Inclosure 7, page 16), at an angle of 30 degrees to the vertical. The upper chords of two bowstring trusses were damaged in the same manner as in the case of Disney bomb, Plot No. 28, which hit under similar conditions. Pistols did not function, as the safety pins had not been removed. Live exploders had been fitted and these were intact. Pistols had been fitted with live primer caps and dummy detonators.

(c) Plot No. 59: The rocket assist failed to function on this bomb; hence, the penetration is not usable in the average for Trial XII. Bomb struck on roof slab having 60 cm. steel I-beam reinforcing. Penetration was only 6'-8". Bomb was not lodged in roof, as is normally the case, but was resting in crater, at an angle of 41 degrees to the vertical, intact but badly bent. The extent of bowing of the bomb case was five inches at the middle (see Inclosure 7, page 17). Penetration was not usable in average for Trial X because of the deformation of the bomb case. Live exploders were fitted to this bomb. Both exploders had blown, leaving a black residue.

Both pistols and detonators were missing. One detonator holder was in position but was bulged outwards and blackened. Project "Ruby" Ordnance Officer stated that live caps and dummy detonators had been fitted to the pistols.

(d) <u>Plot No. 60:</u> The rocket assist functioned properly. Bomb struck on bowstring truss roof slab where the roof thickness is 16'-7" (certain portions of the roof had a slope of one foot in seventy for drainage, making the thickness at the center greater than at the edges). The bomb penetrated 15'-3" remaining lodged in the roof, intact, at an angle of 36 degrees to the vertical. Ceiling below was considerably scabbed. The lower chords of two bowstring girders were bulged downward approximately 18 inches. (See Inclosure 7, page 19). One pistol was found near crater. Detonator was broken into small pieces in detonator holder which had separated from pistol. The striker of this pistol was examined by a British Ordnance expert who judged that the striker had moved sufficiently far forward to ignite the live cap, part of which was found and determined to have been fired. The head of another pistol was also found near crater. Both detonator holders were bulged from underneath. Both exploders had blown.

(e) <u>Plot No. 80:</u> The rocket assist functioned properly. Bomb perforated the 3-1/2 meter thick roof of the West Periscope Tower where roof reinforcing consists of 100 cm. steel I-beams. The bomb passed between two I-beams and struck a steel H-beam on the building floor. Bomb case broke up circumferentially at middle, and nose point broke off at an internal flaw similar to the transverse flaw in nose of Disney bomb, Plot No. 26. However, in this case, the curvature of the break was opposite to that of Plot No. 26. The borehole in the roof was so nearly the width of the bomb that the rocket motor plate remained lodged in the top of the hole. Photographs of the crater and efthe bomb are shown in Inclosure 7, pages 20 and 21. Angle of perforation was 23 degrees to the vertical. Pistols were missing form bomb. One exploder was missing, the other was removed from bomb and found to be a wooden dummy.

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(f) Plot No. 81: The rocket assist failed to function on this bomb. Hit occurred on 4-1/2 meter thick roof slab having 60 cm. steel I-beam reinforcing. The nose point broke off of the bomb and rebounded 130 feet. The bomb penetrated only five feet, and came to rest at an angle of 39 degrees to the vertical, slightly bent. This hit is not usable in the average for Trial X because of breakage of the nose which again was traced to an internal flaw. Inclosure 7, page 22 shows a view of the bomb resting in the crater and a view of the nose fragment. Pistols were missing from this bomb. Both exploders had blown, leaving a black gummy residue. Part of the arming wire was found attached to the rocket fuse pot, suggesting that the bomb had been dropped with the M111A2 fuse "safe". This could not be verified as the fuse had been completely smashed.

(g) Plot No. 84: This is the only rocket assisted Disney bomb which hit on the seven meter roof thickness. The bomb penetrated 13'-2", lodging itself in the roof at an angle of 21 degrees to the vertical. The bomb appeared to be intact. Views of the crater are shown in Inclosure 7, page 23. A rocket tube in the crater bearing markings characteristic of a properly functioning rocket motor, is shown in Inclosure 7, page 24. This bomb had live exploders fitted. One exploder was intact, the other had burned partially. One piece of striker of a pistol was found. One detonator holder was missing, the other was in position in the bomb.

(h) Plot No. 85: The rocket assist failed to function on this drop. The airplane brought back a broken arming wire; hence, this bomb probably was dropped "safe". The bomb struck on the five meter thick roof of the East Periscope Tower directly over the tower wall where the thickness of concrete is effectively infinite (actually 13 meters). Reinforcing in the roof slab consisted of steel trusses, (see Inclosure 4, page 4). The bomb penetrated 17'-1", boring a hole into the concrete between two trusses (see Inclosure 7, page 25). The two trusses between the borehole and the edge of the tower were deflected outward approximately 3 inches, bulging the wall slightly. Since this

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bomb hit close to the edge of the tower roof, the penetration is not comparable with the average for Trial X. The rocket tubes were found in a bundle in the crater and bore no signs of having functioned in flight. The base plate of the bomb was eight feet below roof level. From the angle of the base plate in the bore hole, it was judged that the angle of penetration of the bomb was 23 degrees to the vertical. One exploder was intact in bomb. The other exploder had blown. One pistol with arming wire still in place was found on the main roof below the tower. The striker and detonator were missing. The live cap had fired. Detonator holder attached to the pistol was bulged from underneath. The other pistol was in place, with arming wire still attached, thus confirming that the bomb had been dropped "safe". The striker had not operated. Detonator and cap were intact. Both the cap and detonator were live, the latter consisting of black powder pellets in a short stem tube. Since a live detonator was found in this bomb, through error in loading, it is possible that live detonators were erroneously used in other bombs of this trial, thus possibly explaining why a number of the exploders blew. Because of this uncertainty no conclusions can be drawn concerning the insensitivity of the exploders in this trial.

(i) Plot No. 87: This is the first of two complete perforations through the 4-1/2 meter roof by a rocket assisted Disney bomb. The impact occurred on a roof slab having bowstring truss reinforcing. The bomb emerged between the lower chords of two trusses, perforated the three foot concrete floor at ground level and buried in the sand beneath (See Inclosure 7, pages 26 and 27), and was not recovered. From the cleanout appearance of the hole in the floor, the bomb was probably intact. Angle of perforation in roof was 17 degrees to the vertical.

(j) Plot No. 88: This Disney bomb, with rocket assist functioning, struck on a roof slab having short span concrete truss reinforcing. Thickness of slab at point of impact was 16'-9". The bomb penetrated 13'-2" and lodged in the roof intact at an angle of 31 degrees to the vertical. (See Inclosure 7, page 28). Ceiling underneath the crater was slightly scabbed. Both live exploders were intact.

One pistol with dummy detonator and live cap had functioned, and cap had fired. The other pistol had sheared off flush with container and could not be removed for inspection.

(k) Plot No. 89: This is the second of two complete perforations through the 4-1/2 meter roof by rocket assisted Disney bombs. The perforation occurred in a roof slab having 60 cm. steel I-beam reinforcing. The bomb perforated the ceiling between two I-beams, struck the concrete floor at ground level, and broke off at the stud holes of the carrying lug. (See Inclosure 7, page 29). The nose had lodged in the floor, pointing 90 degrees to the heading. Angle of roof perforation was 21 degrees to the vertical. There was very little scabbing of the ceiling, the break-through being contained in one direction by the I-beam reinforcing. The pistols of this bomb were missing. The live exploders were intact.

(6) Summary, Trial XII:

(a) There are only three examples of rocket assisted Disney bomb hits (Plot Nos. 60, 84 and 88) usable for computation of average vertical penetration. From these, the average penetration is 13'-10", with a standard deviation of 14 inches. The penetration predicted by the latest formula (Inclosure 14, page 2) gives 16'-8" for the rocket assisted Disney bomb. The rocket action, which if complete, increases the striking velocity by 26 per cent, has increased the penetration of the Disney bomb by 31 per cent. This increase in penetration, though below expectations, is sufficient for the bomb to perforate the 14'-9" roof (Plots 87 and 89). In no case was the bomb able to perforate the 14'-9" roof without rocket assist, although some had just reached the scab limit. Even though the rocket assisted Disney bomb is able to perforate the 4-1/2 meter roof, it is evident from Plots 80 and 89 that the bomb case is not strong enough to withstand a side impact, and break-up is likely to occur if the bomb falls flat on secondary impact, as it does when the roof substantially reduces the bomb's velocity. This means that the fuse delay must be just sufficient to allow the bomb to perforate the roof and yet must be short enough so that the explosion occurs before secondary impact can take place. Because of the small explosive charge of the Disney bomb (500-lb), damage to structure such as Farge would be slight, and damage to contents and machinery would be confined to a small area.

(b) The average crater dimensions, depth of spalling and angle of rest or perforation for Trial XII are obtained from all bombs in which the rocket assist functioned, exclusive of the one bomb (Plot 37) which broke up in the roof. Average crater dimensions were 11'-11" long by 12'-6" wide, depth of spalling, 4'-10", and average angle of the bomb or borehole was 25 degrees. These averages are not significantly different from those obtained from the non-assisted Disney bombs of Trial X. (See Inclosure 8, pages 1 and 2).

(c) It is apparent from these two trials that the mechanics of penetration of the Disney bombs is as follows: During the initial phase of penetration the bomb, striking at an angle of 15 degrees, spalls more concrete ahead of the nose than behind it. Hence, the resisting force is not axial but has a forward component which causes the bomb nose to lift. This sets up a turning moment which rotates the bomb away from the normal, causing it to trace a ricochet curve in concrete. During this phase the bomb is subject to bending. When the nose has reached a depth of 4 to 5 feet, the bomb has rotated about 10 degrees. At this point the bomb is no longer able to spall more concrete ahead of it, but bores a hole at an angle of 25 to 30 degrees until it is brought to rest in the concrete, or else perforates the slab.

(d) The reliability of the arming and firing system of the Disney rockets is not satisfactory. Of the eight bombs (33 per cent) of Trial XII which failed to function rocket assist, two cases of broken arming wires were found (Plot Nos. 81 and 85). Improvement in the arming wire system is necessary if failures of this type are to be eliminated. One example was found in which the rocket action was incomplete (Plot No. 37), and one bomb which missed the target was observed to fall flat, which may have been due to instability of bomb before functioning of the rocket motor, or to partial functioning of the rockets themselves. Therefore, improvement in the firing system is also desirable if this type of bomb is to be employed.

(7) Trial VI (2,000-lb. SAP bomb). This bomb, developed from the T7, and standardized in 1945 as the M103, had not been dropped in combat, and had yet to be tested against massive concrete such as that presented by the Farge target. It therefore was desirable to drop this bomb under the same conditions as the Grand Slam, Tall Boy and Disney bombs. To obtain a comparable striking velocity (1,100 feet per second) it was necessary to release this bomb from 26,250 feet altitude. Project "Ruby" B-17 aircraft dropped the first 27 bombs (singly and in trains of two each) from this altitude, but accuracy was extremely poor. Only one hit resulted from the first nine bombs dropped singly. Of the next 18, one hit and one near miss were scored with 50 foot trains. In the case of one train, both bombs were observed to be unstable in flight, one wobbling, the other landing flat. These bombs fell on opposite sides of the target, and when plotted, were found to be 900 feet apart. (See bombs 51 and 52, Inclosure 6, page 2). This large dispersion may be the result of insufficient fin stabilization at sonic velocities. For the remaining nine bombs dropped on this trial the altitude was reduced to 20,000 feet (striking velocity 1030 feet per second) and accuracy was improved considerably. Three hits and one near miss were obtained from this altitude, making a total of five hits and two near misses for the trial. The near misses were both usable for case strength purposes as the bombs hit on the concrete footing of the building wall. A description of each hit is given below. The results are also tabulated in Inclosure 8, page 3. Crater profiles are given in Inclosure 9.

(a) Plot No. 43: This bomb, dropped from 26,250 feet, struck at the junction of two roof slabs having short span concrete truss reinforcing. Roof thickness at point of impact was 16 feet. The bomb penetrated 2'-7" and ricocheted 200 feet, falling to the ground on the West side of the building. The bomb was found flat on the ground, intact, but dented near the rear lug (see Inclosure 7, page 30). The maximum depth of the dent was 5 inches at a point 51 inches from the nose. The dented area included the rear lug. The bomb was slightly bulged 90 degrees circumferentially from the dent but no cracks had formed. The crater profile (Inclosure 9, page 11), gives a clue as to how the dent was made. As the bomb penetrated into the concrete, its angle to the vertical increased until the rear section of the bomb struck on the back edge of the crater, producing the dent on the bottom and the bulges on the sides. The elongated crater has a characteristic anvil shape on the back slope where the blow spalls away additional concrete. The live adapter booster (M115A1) was intact. Fuze was not fitted to the bomb.

(b) <u>Plot No. 55:</u> This bomb, dropped from 26,250 feet, struck on the 4-1/2 meter roof 8 feet in front of the vertical face of the West periscope tower. The bomb penetrated 2'-10" and broke up, with nose section coming to rest crosswise in the crater. A ragged circumferential break had occurred about three-quarters of the distance back from the nose (see Inclosure 7, pages 31 and 32), resulting from the blow against the back slope of the crater. The anvil is more pronounced than in the previous bomb hit. (See Inclosure 9, page 12). The bomb showed the same signs of denting and bulging as previously noted. In addition, a long crack running forward from the circumferential break to a few inches beyond the front lug and terminating in a hairline, had occurred on one of the bulged sides. The base of the bomb was found beside the crater. The adapter booster had separated from the base plate and was not recovered. Tetryl powder was scattered over the inside surface of the base of the bomb. It is possible that this bomb may have ricocheted and rebounded from the wall, but no obvious marks were found on the wall to substantiate this hypothesis.

(c) <u>Plot No. 72:</u> This bomb, dropped from 20,000 feet, struck on a short span roof slab at a point where the concrete thickness is 1[illegible] feet. The bomb penetrated 3'-10", bounced and fell flat in the crater with the nose pointing opposite to the heading. (See Inclosure 7, page 33). The crater was open on one side as it overlapped an old Tall Boy crater. The bomb was intact without bulges, dents or cracks. Fin tail cone was still in place. The live adapter booster was intact.

(d) Plot No. 73: This bomb dropped from 20,000 feet, struck on the 4-1/2 meter roof on a slab having 60 cm. steel I-beam reinforcing. Impact occurred close to the junction of four roof slabs. The crater, 3'-6" deep, overlapped that of a bomb previously dropped. The bomb ricocheted 40 feet after impact. The bomb was intact but dented near the rear lug and bulged at the sides in a manner similar to Plot No. 43. The dent was 5 inches from the nose. The base of the bomb had been deformed, being elliptical instead of circular, and sealing compound had been squeezed out around the base plate. The live adapter booster was intact. Views of the bomb and crater are shown in Inclosure 7, page 34.

(e) Plot No. 78: This bomb, dropped from 20,000 feet, struck on the 4-1/2 meter roof on a slab having 60 cm. steel I-beam reinforcing. The bomb made a very small crater, 8'-6" in diameter and 2'-6" deep, with a small anvil on the back slope. (See Inclosure 7, page 35). The bomb broke up and ricocheted in several large pieces. The nose section ricocheted 300 feet to the West edge of the building. The base of the bomb ricocheted 85 feet. The adapter booster had blown on secondary impact. The cup was recovered and found to be cracked, with charcoal residue adhering. Yellow tetryl powder was found on the inner surfaces of the base of the bomb. Views of the nose and base sections are given in Inclosure 7, page 36. The bomb body had the characteristic dent near the rear lug and a crack running forward from the bulged portion to the vicinity of the front lug.

(f) Plot No. 61: This bomb, dropped from 26,250 feet, struck on the concrete footing 4 feet out from the North wall of the target. The bomb came to rest in the crater with its nose pointing opposite to the heading. The angle of rest of the bomb was 45 degrees to the vertical. The footing extends out from the wall 2.5 meters and is the foundation on which the second wall thickening was to have been poured. The bomb was cracked at the rear shoulder as shown in Inclosure 7, page 37, and was dented near the rear lug. The live adapter booster was intact. Crater profile was not measured. Crater was approximately 7' long, 8' wide and 4' deep.

(g) Plot No. 71: This bomb, dropped from 20,000 feet, struck at ground level at the intersection of the North wall and the concrete footing. The bomb bounced back about 70 feet and was found lying flat on the ground. The bomb was intact but bulged at the front shoulder, 18" to 24" back of the nose. This bomb was calipered and the increase in diameter at the shoulder was found to be 7/8 inches. The crater, partly on the building wall and partly on the footing, was not profiled. Crater depth was approximately three feet. The live adapter booster was intact.

(8) Summary, Trial VI: There is no apparent difference in the behavior and penetration of the 2000-lb. SAP bombs when striking concrete from 26,250 feet and 20,000 feet. In both cases the bombs tend to ricochet out of the crater. In doing so, the back of the bomb strikes against the back edge of the crater producing a dent approximately 15 inches forward from the base. The bomb is bulged 90 degrees circumferentially from the dent and in one instance at each altitude the bomb gave way at the bulge, cracking longitudinally and at the same time breaking up circumferentially in the vicinity of the dent. Also in one instance at each altitude, the bombs dented but did not break up. Penetration was slight, being 3'-10" for the one bomb which did not richochet, while 2'-6" was the minimum penetration for a bomb which broke up and ricocheted the greatest distance. The average penetration for all five roof hits was 3'-1", with a standard deviation of 7 inches. The penetration predicted by formula (Inclosure 14, page 2), is 4'-3" for drops from 26,250 feet and 3'-5" for drops from 20,000 feet. Average crater dimensions were 11'-5" by 9'-5", with a characteristic anvil. The adaptor booster withstood the shock of impact in all bombs which did not break up. When the bomb breaks up, the booster may go off low order.

(9) Trial XI (12,000-lb. fabricated Tall Boy's from 20,000 feet: The American fabricated Tall Boy(T10) bomb has the same dimensions, weight and wall thickness as the British cast Tall Boy and differs only in the method of manufacture. The American fabricated bomb consists of five sections welded together. The solid nose and

the base are made of forged steel, while the three center sections are fabricated from rolled plate, longitudinally welded. The British bomb is made of cast steel with a solid nose plug. In Trial VII, it was found that the cast Tall Boys broke up completely when dropped from 20,000 feet. It therefore was desirable to compare the fabricated Tall Boy at the same altitude. British Lancaster aircraft dropped four fabricated Tall Boys from 20,000 feet, but unfortunately all bombs missed the target. The remaining bomb of five allotted for this trial was then brought to the target by a Project "Ruby" B-29 airplane, but because of improper positioning of the A-4 release (positioning had been made for the Grand Slam instead of the Tall Boy) this bomb could not be released automatically and was manually salvoed into the North Sea. No further drops were made on this trial. Information gained from subsequent trials showed that this bomb also would have broken up from 20,000 feet.

(10) Trial IX (22,000-lb. fabricated Grand Slam from 20,000 feet): The fabricated Grand Slam (T14) is an enlarged version of the fabricated Tall Boy (T10) and has the same dimensions as the British cast Grand Slam. Project "Ruby" B-29 aircraft dropped nine fabricated Grand Slam bombs from 20,000 feet (striking velocity 1150 ft. per second) and scored three hits. All three bombs broke up as described below. Crater profiles of two of the hits are given in Inclosure 9; data for the third are not available.

(a) Plot No. 4: This bomb was not considered to be a fair hit as it struck at the base of an isolated slab cast on top of the 4-1/2 meter roof to form the second roof thickness. This slab was 8'-6" high, 16'-6" wide and about 100 feet long, with its length running East-West. The direction of flight of the bomb was toward the Northwest. Some of the energy of impact was transmitted to the vertical face of the upper roof slab, cracking out large pieces from the back face and top surface. Altogether several hundred tons of concrete from the upper roof slab were displaced. (See Inclosure 7, page 39). The main roof at the point of impact contained bowstring truss reinforcing. Beneath the point of impact was a supporting wall which was scabbed for a distance of fifteen feet. The bomb penetrated 7 feet and broke up, with nose section remaining in crater.

The ogive had a number of eggshell cracks, one of which extended to within a few inches of the solid point of the nose. (See Inclosure 7, page 40). The nose section broke off irregularly, three to five feet from nose. There was no sign of failure of the front weld 26 inches back from the nose. However, there were signs that the rear weld had failed. The base ring had separated from the bomb body circumferentially along the rear weld. This is a stainless austenitic weld, not heat treated for stress relief. The exploders had broken off at the base plate but had not blown. Enough pieces were found on the roof to account for all three exploders. The auxiliary exploders had scattered over the roof but had not detonated. The tail pistols (No. 47A MK II), with 60 minute delay elements, had functioned properly.

(b) Plot No. 30: This bomb struck on the roof close to the West edge of the building, over the supporting wall. The bomb struck on a roof slab having short span concrete truss reinforcing. Penetration was 7'-6". The bomb broke up, with the nose section remaining in the crater. The base of the bomb and most of the bomb body fell over the side of the building and were not recovered. The nose, section was broken off similarly to that of the previous hit, but there were no cracks running close to the solid nose, and the wax filler had remained in the nose cavity. The impact of the bomb had cracked and displaced a portion of the roof slab at the edge so that it bulged out over the wall of the building. The exploders and pistols were not recovered. Some of the RDX pellets from the auxiliary exploders were found on the ground below.

(c) Plot No. 31: This bomb struck on a Bowstring truss roof slab close to the South edge of the building where a recess had been left in the wall for construction of a ventilation shaft. (See Inclosure 7, page 45). The crater was surrounded on three sides by vertical faces of roof slabs forming the second roof layer. Penetration was 8'-6". The entire 4-1/2 meter depth of the slab was broken out at the edge terminating at the ventilator shaft. (See Inclosure 7, page 45). The bomb broke up, with nose section remaining in crater. The nose broke up in a manner similar to the two previous hits. In this instance, however, the irregular break goes up to the solid nose (See Inclosure 7, page 44). The base of the bomb had fallen to the ground, and was found with base ring cracked and with unmistakable evidence that the base ring had separated from the bomb body at the rear stainless steel weld. One body fragment which fitted onto the base ring was found with a piece of the welding material stripped back and adhering at one end of the fragment. (See Inclosure 7, page 46). The pistols were examined and found to have functioned and percussion caps had fired. The exploders had been broken off at the base plate. The center exploder had not blown, one other had blown and the third may have blown. Two fragments of exploder containers were found, blued, with shear tears but no sign of gas wash; hence, the ignition was probably a low order detonation caused by secondary impact.

(11) Trial XXI (12,000-lb. cast Tall Boys from 10,000 feet): Lancaster aircraft dropped three cast Tall Boys from 10,000 feet (striking velocity 850 feet per second), scoring two hits. Both bombs broke up, as described below. Crater profiles are given in Inclosure 9.

(a) Plot No. 90: This bomb struck on a 4-1/2 meter roof slab having bowstring truss reinforcing, penetrating 3'-6". It broke up into larger pieces than when dropped from 20,000 feet. One side wall fragment was five feet long. The nose ricocheted 225 feet and the base fell beside the crater. The nose section had been cracked off on one side so that the threads of the nose plug were exposed for their full length (See Inclosure 7, page 47). Two large fragments of the tapered portion of the bomb body were still attached to the base plate but were bulged outward, (See Inclosure 7, page 48). The exploders had broken off but had not detonated. The auxiliary exploder pellets were found scattered on the roof. Pistols were not fitted to this bomb. The crater profile exhibit a characteristic anvil shape, indicating that the bomb body struck the back edge of the crater upon ricocheting.

(b) Plot No. 92: This bomb struck on the 4-1/2 meter roof on a slab having 60 cm. I-beam reinforcing. The penetration was 4 feet. The bomb broke up into large pieces, two side wall pieces being 4 to 5 feet long. The nose ricocheted 45 feet and the base fell at the crater's edge. The nose was cracked up to the nose plug as in the previous hit, but the nose plug threads were not exposed. (See Inclosure 7, page 49). The fragments attached to the base plate were larger than the previous hit and had been bulged outward to a greater extent. The exploders had been broken but had not blown. RDX pellets from the auxiliary exploders were scattered over the roof. Pistols were not fitted to this bomb. Crater profile exhibits characteristic anvil shape, indicating that the bomb body struck against the back edge of crater upon ricocheting.

(12) Trial XXIa (12,000-lb. cast Tall Boys from 5,000 feet): Lancaster aircraft dropped two cast Tall Boys from 5,000 feet (striking velocity 600 feet per second), scoring two hits, with results as shown below. Crater profiles are given in Inclosure 9.

(a) Plot No. 93: This bomb struck on a pile of sand bags on top of a 4-1/2 meter roof slab having bow-string truss reinforcing. The bomb penetrated 3'-4", breaking up with nose section remaining in crater and base section rebounding 300 feet. A fragment from the nose section, measuring 5 feet long, was found near the crater. One body fragment attached to the base plate measured 3 feet in length (see Inclosure 7, page 52). Two exploders were intact in the base plate, the third exploder had been broken off but had not blown. The pistol (with delay element) fitted to the exploder tube which broke, had functioned prior to examination. The other two pistols functioned after approximately 60 minutes delay.

(b) Plot No. 94: This bomb struck on the 4-1/2 meter roof at the junction of two roof slabs, one having short span concrete truss reinforcing, the other concrete bowstring truss reinforcing. The bomb broke up on impact and the nose and base sections ricocheted off the roof to the West of the building and were not recovered. Several large fragments from the bomb body were found on the roof near the crater. (See Inclosure 7, page 53). The bomb penetrated 2'-7". Crater profile shows the characteristic anvil shape on the back slope, indicating that the bomb body had struck on the crater edge on ricocheting. Several of the recovered fragments showed that the bomb had been dented near the base.

(13) Trial XXIb (12,000-lb. fabricated Tall Boy from 5000 feet): Having found that the cast Tall Boys broke up when dropped from as low as 5000 feet, it was desirable to drop the fabricated Tall Boys from the same altitude to find out whether they too would break up. The purpose of the various subdivisions of Trial XXI was to find out from what altitude the fabricated Grand Slams and Tall Boys could be dropped and not break up. Since nine of the twelve available fabricated Grand Slams had already been expended in Trial XX from 20,000 feet, and five of the ten available fabricated Tall Boys had been expended in Trial XI from 20,000 feet, the cast Tall Boys had been used in Trials XXI and XXIa in an attempt to find the critical release altitude. It was inadvisable to release much bleow 5000 feet as the striking angle would reach the value at which ricochet would be certain to occur. Three of the five remaining fabricated Tall Boys were therefore dropped from 5000 feet by Lancaster aircraft flying at a true airspeed of 175 miles per hour, scoring two hits, the first breaking up, the second remaining intact. A description of the hits is given below. Crater profiles are given in Inclosure 9.

(a) Plot No. 102: This bomb struck on a 4-1/2 meter roof slab having concrete bowstring truss reinforcing. The bomb penetrated 3'-1" and broke up. The nose section ricocheted off the roof to the North side of the building and was not recovered. One observer who saw the nose section ricochet, judged it to be about two calibers long. Sections from the base of the bomb were found on the roof. The base ring had separated from the bomb body at the rear weld despite the fact that additional beads of welding material had been added externally over the original rear weld to furnish additional strength. Inclosure 7, page 54, shows views of the break at the rear weld. Recovered fragments from the bomb body indicated that the bomb had been dented near the base. The crater profile exhibited a slight anvil shape on the back slope. This bomb was not fitted with exploders or pistols.

(b) Plot No. 104: This bomb struck on the 7 meter roof. The bomb penetrated 3'-9", ricocheted out of the crater and came to rest 130 feet beyond, in the crater of a Disney bomb previously dropped (Plot No. 37). The bomb was intact but dented on the side wall where the rear taper begins. The maximum depth of this dent was three inches. The bomb was not fitted with exploders or pistols. The crater was open on one side as the bomb struck close to the edge where the 7 meter roof terminates, and the 4-1/2 meter roof continues. This bomb had been strengthened by welding extra beads on the inside of the bomb over the rear weld. The reason for the external reinforcing on the bomb of Plot No. 102 was that the bomb had already been loaded with wax filler at the time the decision was made to strengthen the bomb. One other bomb had been externally reinforced but it missed the target.

(14) <u>Trial XXIc (22,000-lb. fabricated Grand Slam from 4,750 feet)</u>: Two of the three remaining fabricated Grand Slams were dropped by Lancaster aircraft from 4,750 feet (striking velocity 600 feet per second) at a true air speed of 200 miles per hour, scoring two hits, one bomb breaking up, the other remaining intact as described below. Crater profiles are given in Inclosure 9.

(a) <u>Plot No. 96</u>: This bomb struck on the 4-1/2 meter roof slab having bowstring truss reinforcing. The bomb penetrated approximately 5'-2" and came to rest in the crater intact, at an angle of 20 degrees to the horizontal. The bomb had slid back about 1-1/2 feet from its most forward position, leaving an impression of the nose in the forward slope of the crater (see Inclosure 7, page 58). The base of the bomb was resting on the back slope of the crater. A dent in the bomb body had occurred three to four feet from the base, one inch deep. This dent was uppermost on the bomb, indicating that it had made one-half of a revolution before coming to rest after the bomb body struck on the crater edge. The base plate was removed from the bomb and the filler removed from the inside in the vicinity of the dented area. No signs of an internal crack were found. Each of the three exploder tubes showed a fine crack at the weld, but the exploders had not blown. The auxiliary exploders had cracked up at the base end but had not blown. Pistols had not been fitted to this bomb.

(b) Plot No. 97: This bomb struck on a 4-1/2 meter roof slab having bowstring truss reinforcing. The bomb penetrated 4 feet, broke up and ricocheted out of the crater. The nose section, measuring more than one-half the total length of the bomb, fell to the ground West of the building. A fine crack in the casing was noted on the inside surface running forward toward the nose. This crack did not extend through the metal to the outer surface. The base of the bomb remained on the roof near the crater. The same characteristic break at the rear weld had occurred (see Inclosure 7, page 60) as in the other fabricated Grand Slam and Tall Boy drops. Large fragments from the bomb body were scattered on the roof ahead of the crater. Some of these showed that denting of the case had occurred. One One exploder tube was intact in the base plate, and one was cracked and one was broken. None had blown. The auxiliary exploders were scattered on the roof, unburned.

(15) Trial XXIc (Fabricated Grand Slam from 10,000 feet): Since the cast Tall Boys had been dropped from 10,000 feet as well as from 5000 feet, it was desirable to complete the Tall Boy comparison by dropping the last remaining fabricated Grand Slam bomb from 10,000 feet. This was accomplished by a Lancaster airplane, and a hit was scored on the 4-1/2 meter roof on the slab containing the craters of Plot Nos. 10 and 72. This bomb (Plot No. 113) broke up completely. The nose section was not found. The base was found about 25 feet from the crater. Again the base ring had separated from the bomb body at the rear circumferential weld. (See Inclosure 7, page 61). Two exploders had broken off flush with the base plate and one had broken off at the weld. There were no signs of ignition of the exploders. Pistols were not fitted to this bomb. The crater of this bomb is not well defined as it overlaps the craters of several other bombs. Penetration was measured to be 5'-2". The back slope of the crater, which was well defined, exhibited the characteristic anvil shape previously noted for ricocheting bombs. Fragments indicated that severe denting of the case had occurred. 113

(16) Trial XXId (Fabricated Tall Boy from 10,000 feet):

(a) The last two remaining fabricated Tall Boys were also dropped by Lancaster aircraft from 10,000 feet to complete the comparison at this altitude. One hit was scored (Plot No. 114), the hit occurring on the roof slab on which the fabricated Grand Slam, Plot No. 113, struck. The bomb penetrated 5'-8" remaining in the crater intact, at an angle of eight degrees to the horizontal. About 2-1/2 feet of the nose was buried under a ledge raised by the bomb. The bomb was not visibly deformed or cracked. Pistols and exploders were not fitted to the bomb. This bomb had been strengthened by a stainless austenitic weld added to the inner surface of the bomb over the original rear weld.

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(17) Summary of Grand Slam and Tall Boy hits:

(a) Following is a tabulation of the average penetrations obtained from all the Tall Boys and Grand Slams dropped on these trials:

Altitude	Trial	Bomb	No. of Bombs Dropped	Hits	Avg. Penetr.	Remarks
20,000	VII	Cast Tall Boy	5	4	5'-7"	All bombs broke up
	XI	Fab. Tall Boy	5	0	-	Missed target
	IX	Fab. Grand Slam	9	3	7'-8"	All bombs broke up in crater
10,000	XXI	Cast Tall Boy	3	2	3'-9"	Both bombs broke up, ricocheted
	XXId	Fab. Tall Boy	2	1	5'-8"	Bomb intact in crater
	XXIe	Fab. Grand Slam	1	1	5'-2"	Broke up, ricocheted
5,000	XXIa	Cast Tall Boy	3	2	3'-0"	Both bombs broke up, one ricocheted
	XXIb	Fab. Tall Boy	3	2	3'-5"	One intact, one broke up, both ricocheted
4,750	XXIc	Fab. Grand Slam	2	2	4'-7"	One intact in crater. One broke up, ricocheted

(b) The cast Tall Boy is definitely weaker than the modified fabricated Tall Boy and cannot even withstand a drop from 5,000 feet. Because of its greater tendency to break up, the penetration at a given altitude is less than for the fabricated Tall Boy. Both the fabricated Tall Boy and the fabricated Grand Slam have an even chance of remaining intact when dropped to give a striking velocity of 600 feet per second. All three have a tendency to ricochet when dropped from 10,000 feet or lower.

(18) Trial No. XVIII (22,000-lb. SAP Amazon, T28): The American 22,000-lb. SAP (T28) bomb, known as the Amazon, was produced in an effort to obtain the maximum possible case strength and penetration consistent with adequate explosive capacity. This bomb has the same overall length as the Grand Slam; has a smaller diameter, 38 inches compared with 46 inches; a greater wall thickness, three inches compared with 1.75 inches and a thicker nose. The bomb consists of a forged steel nose, forged base, and four body sections welded together along six circumferential welds. The rear weld joining the base ring to the body is a stainless austenitic weld. A comparison of the size of this bomb with the other bombs dropped on this project is given in Inclosure 3, Page 1. Project "Ruby" B-29 aircraft dropped twelve Amazons, each equipped with three unarmed T723 fuses, inert adapter boosters, and no auxiliary boosters. Four more were dropped with one each composition "A" auxiliary booster but without fuses. The release altitude was 17,500 feet in order to obtain the same striking velocity as the 2000-lb. SAP bombs dropped from 26,000 feet (1100 feet per second). It was thought that this bomb would not break up at this altitude because some of the 2000-lb. SAP bombs did not break up at this striking velocity. (The 2000-lb. SAP bomb is approximately half scale model of the Amazon bomb; when reduced to the same scale, the two bombs have practically the same diameter, wall thickness and length). Of fourteen bombs dropped at the target, ten hits were obtained. Two additional bombs had to be salvoed into the North Sea because of malfunctioning of the D-9 shackle. In these two cases, the A-4 release failed to exert sufficient force to actuate the shackle when loaded with the Amazon bomb. The cause of this failure is given in Inclosure 15. Of the ten Amazons which hit the target, four perforated the 4-1/2 meter roof. These bombs broke up on secondary impact within the building. Of the six bombs which did not perforate, one broke up in the crater on the 4-1/2 meter roof, two hit on edges of the periscope towers and broke up, and three remained intact after partial penetration of the seven meter roof. A description of each individual hit is given

below. Crater profiles are given in Inclosure 9.

(a) Plot No. 95: This bomb struck on the 4-1/2 meter roof over the lock chamber. The bomb perforated the roof close to the North wall of the building and dropped into the water-filled lock chamber, 36 feet deep. Roof reinforcing consisted of bowstring concrete trusses. Inclosure 7, page 63, shows the hole made in the roof. A diver was sent down to the bottom of the lock chamber to inspect the bomb. The diver found that the bomb had broken up, the nose section being at least five or six feet in length. The bomb had made a 3 foot deep crater at the bottom of the lock chamber on the North side under the perforation hole and had bounced forward and laterally to the South side of the chamber. The base of the bomb was not located. Arrangements were made to pump out the water of the chamber to find the base of the bomb, but this operation had not been completed by the time the test was terminated.

(b) Plot No. 100: This bomb struck on the 4-1/2 meter roof on a slab having concrete bowstring truss reinforcing. The bomb perforated the roof, carrying fin assembly with it, struck on the concrete floor of the building and broke up. From the appearance of the crater made on secondary impact, it was judged that the bomb had struck on its side. Measurements showed that the bomb had been deflected as it perforated the roof. The exit hole was left of the point of impact on the roof. Likewise, the point of secondary impact at ground level was approximately 18 feet left of the exit hole in the ceiling. Inclosure 7, page 65, shows the underneath surface of the roof. The lower chords of four bowstring trusses were severely damaged and deflected downward. One was moderately damaged and one slightly damaged. The upper chords of three of the trusses were severed by the bomb. The reinforcing rods of these members can be seen in the photograph of the crater, Inclosure 7, page 65. The front section of the bomb measured 66-1/2 inches from nose to the nearest broken edge, although a crack ran to within 56 inches of the nose. (See Inclosure 7, page 66). The longest section measured 110 inches in length. The base of the bomb was found about 300 feet beyond the nose, in the direction of the heading. The base ring had separated from the bomb body along the circumferential weld for a distance of 12 inches; the rest of the break being in the metal of the rear section of the bomb body, and for 12 inches in the metal of the base ring. The three fuses were intact in the base plate, one being badly deformed. These were sent to Picatinny Arsenal for examination. The inert adapter boosters were intact in the base plate. (See Inclosure 7, page 66)

(c) Plot No. 101: This bomb struck on the Northeast corner of the East periscope tower and fell to the ground on the North side of the building. The bomb probably broke up on striking the tower. The crater in the ground was elongated in the direction of flight, and a few fragments were recovered from the crater. A piece of the base ring was found just beyond the forward edge of the crater, with a fracture indicating that the rear weld had again failed. A piece of nose section six inches thick at the front end and four inches thick at the rear was found in front part of crater. The nose was not found. The corner of the periscope tower was cracked over a radius of 15 feet. Roof reinforcing consisted of steel trusses. These, however, were not exposed.

(d) Plot No. 106: This bomb struck on the 4-1/2 meter roof on a roof slab having 60 cm. I-beam reinforcing. The bomb penetrated to a depth of 12'-5", and broke up into large fragments in the crater. The angle of penetration was approximately 30 degrees. The ceiling was scabbed between four I-beams. Two of the beams were deflected three feet downward, one being broken. (See Inclosure 7, page 70). It is thought that the resistance of the I-beams contributed to the break-up of the bomb. One body fragment of the bomb measuring 7'-6" long, semicircular at rear, had a portion of the base ring attached. (See Inclosure 7, page 69). On one side the base ring had broken away from the bomb body through the weld. The diameter across the semicircular portion was 39 inches, one inch greater than the original bomb diameter, indicating that the rear of the bomb body had been deformed by the impact before break-up occurred. Another fragment recovered from the crater, also from the rear portion of the bomb, showed a break along the rear weld for a distance of 30 inches. The nose and base plate were found in the crater. The recovered pieces, constituting practically the entire bomb, were shipped to Watertown Arsenal for examination. The fuses and damaged adapter boosters were shipped with the base plate.

(e) Plot No. 107: This bomb struck on the seven meter roof 15 feet East of an unfinished section where the roof steps down to 4-1/2 meters. A crater 10 feet deep, open at front end, was formed. The bomb came to rest in the crater, intact and undeformed, at an angle of 15 degrees to the horizontal. The bomb had turned 20 degrees to the right. The tail assembly had telescoped into the base plate (See Inclosure 7, page 72), and had to be cut away to recover the three fuses which were intact. These were removed and shipped to Picatinny Arsenal for examination. Inspection of the roof slab showed that an open crack with origin at point of impact extended laterally from the crater edge to the North edge of the building.

(f) Plot No. 109: This bomb struck against the East wall of the West periscope tower near a corner (see Inclosure 7, page 73), and broke up into a large number of fragments which rebounded and fell over a wide area including the village of Fargo. In striking the periscope tower, the bomb exposed one of the 100 cm. I-beams used as reinforcing in the roof slab. This I-beam was dented on the upper flange and bore marks of metal to metal impact. The bomb body probably broke up as the result of side impact against this I-beam. Inclosure 7, page 74, shows some of the fragments recovered from the bomb. The base plate was broken, as well as the base ring. Other fragments had passed through the walls of houses in the village, over 500 yards from the point of impact. One adapter booster was intact in the base plate, one was broken off and one was missing. Two fuses were recovered and shipped to Picatinny Arsenal for examination. The third fuse was not found.

(g) Plot No. 116: This bomb struck on the 4-1/2 meter roof on the same roof section as Plot No. 95. The bomb perforated the roof and produced a crater on the concrete floor beside the lock chamber. (See Inclosure 7, page 76). The bomb broke up on secondary impact, the nose section dropping into the water of the lock chamber. Inclosure 7, page 76, shows the hole in the roof made by the bomb. The lower chord of one bow-string truss was completely severed, one was badly damaged and deflected downward four or five feet and three others were scabbed. The base of the bomb was found alongside the lock chamber, 150 feet ahead of point of secondary impact. The break had occurred in the metal of the bomb body near the rear weld. (See Inclosure 7, page 77). At no point was the weld exposed. Fuses and adapter boosters were not fitted to this bomb. One auxiliary booster was fitted, filled with composition "A". This booster was found on the floor of the upper level of the lock chamber. It was crushed at one end but had not blown.

(h) Plot No. 117: This bomb struck on the 4-1/2 meter roof over the lock chamber, producing a perforation followed by secondary impact on some steel trusses intended for fabrication of the lock gates. Inclosure 7, page 78, shows the crater on the roof and a view looking down through the perforation. Inclosure 7, page 79, shows the damage to the ceiling. The lower chords of two bowstring trusses were severed, three were badly deflected downward and one was slightly scabbed. The break-up of this bomb was more complete than in the case of the previous perforations. The base ring had separated from the bomb body, and had broken. Inspection showed that the rear weld had failed. The auxiliary booster had dropped into the water of the lock chamber.

(i) Plot No. 118: This bomb struck on the West periscope tower roof directly over the South wall of the tower. At the point of impact, the roof thickness was seven meters in two layers of 3-1/2 meters each. The bomb cleared off the top layer for a distance of one-third to one-half of the length of the slab and ricocheted to the main roof, deflecting to the left, and falling flat. The bomb remained intact, but was slightly dented near the rear of the body. The bomb was cut open at the base for examination of the composition "A" booster. This was found to be in satisfactory condition. Inclosure 7, page 81, shows a view of the undamaged bomb. Penetration on the tower roof was 3-1/2 meters (11'-6").

(j) Plot No. 119: This bomb struck on a narrow roof slab of seven meters thickness. The bomb penetrated 12 feet, breaking up the slab across the narrow dimension. The bomb turned 90 degrees in the crater, pointing approximately North. This bomb was dropped on a heading of 260 degrees. The bomb was intact as far as could be determined. Inclosure 7, page 83, shows the crater and the bomb buried in the debris, lying in a horizontal position.

(19) Summary of Trial XVIII:

(a) Of ten Amazon hits, only three are usable for a measure of penetration. These are Plots 107, 118 and 119, which occurred on the seven meter roof. The others either perforated the 4-1/2 meter roof, hit on corners, or broke up in the crater. The average of these three examples gives a vertical penetration of 11'-2". The penetration predicted by the formula of Inclosure 14, page 2, is 10'-7". The actual penetration of the Amazon is comparable with that of the Disney without rocket assist; but because of the large diameter, the Amazon perforated the 4-1/2 meter roof in every instance (except for one which broke up in the crater), while the Disney never perforated without rocket assist. This is in agreement with the formula for perforation given in Inclosure 14, page 4. This formula gives for the Amazon a perforation limit of 15'-10" for a vertical penetration of 11'-2". It might appear that the Amazon bomb, if it did not break up on impact, could be made to perforate the seven meter roof by dropping it from higher altitudes. Using the penetration and perforation formulas, it is found that a release from 35,000 feet would increase the penetration 50%, thus raising the perforation limit to 22 feet. The bomb would still fail to perforate the 23 foot roof even if it were strong enough to withstand the higher striking velocity. Other alternatives are: use rocket assist, decrease bomb diameter, or both.

(b) The condition of the eight recovered T723 fuses and adapter boosters is described in a report furnished by Picatinny Arsenal, copy of which is attached as Inclosure 16. All but one fuse had successfully withstood impact on concrete. The one fuse which failed had fired its primer when the fuse body was crushed by secondary impact. The bomb from which this fuse was recovered had broken up. The Picatinny Arsenal report further indicates that the M39 Special Primer used in this fuse is not reliable. Two primer failures occurred out of nine primer detonators tested from a lot which was loaded at the same time that the Project "Ruby" T723 fuzes were loaded.

(20) Trial XIX (1650-lb. Model Bombs): These bombs were made from the cases of Disney bombs by reducing the outer diameter, increasing the inner diameter, reducing the length, and changing the nose shape. The result is an experimental British model of a 12,000-lb. CP/RA bomb. The model was fitted with a conventional cylindrical fin instead of a rocket motor assembly. The bomb was designed by Mr. H. L. Pugh, Director of the British Road Research Laboratory. The bomb and the theory on which its design is based is covered in MOS Report No. 475,- "Design of Anti-concrete Bombs". Since the Disneys used in Trials X and XII were found to have flaws in the nose, each bomb case to be made into a model bomb was X-rayed for flaws before machining. The purpose of this trial was to determine the altitude at which this bomb would begin to break up. Three bombs were dropped by Lancaster aircraft from 9,600 feet (striking velocity 800 feet per second), scoring three hits. The bombs bent but did not break up. The altitude was then increased to 15,600 feet (striking velocity 1000 feet per second), and nine bombs were dropped, scoring one hit. This bomb also bent but did not break up. This is as far as the Trial had progressed at the time Project "Ruby" returned to Eglin Field. Subsequently, two drops were made from 20,000 feet (striking velocity 1100 feet per second), scoring one hit. (Plot No. 129). In this case the bomb fell flat because the tail structure had come loose. The bomb had dented on one side and cracked on the side opposite. Further drops at 18,000 feet were then to be made, with precautions taken to insure that the tail structure did not break away. Following is a description of each hit. Crater profiles are given in Inclosure 9.

(a) Plot No. 110: This bomb, dropped from 9,800 feet, struck on the North wall of the target, denting the wall as shown in Inclosure 7, page 84. The bomb glanced off the wall, hit the footing, and rebounded 300 feet, striking on its nose on a concrete platform, and making a small round dent in the concrete. The bomb was badly bent into an "S" shape. (See Inclosure 7, page 85). The bomb was flattened at the base, and the base plate had broken off. This bomb withstood a tremendous amount of side stress.

(b) Plot No. 111: This bomb dropped from 9,600 feet, struck on the 4-1/2 meter roof on a slab having bowstring truss reinforcing. The bomb made a crater 3'-3" deep and bounced to the crater edge intact, but considerably bent. Inclosure 7, page 86, shows the crater and the condition of the bomb after impact.

(c) Plot No. 112: This bomb, dropped from 9,600 feet, struck on the 4-1/2 meter roof at the junction of two roof slabs. Again the bomb bounced to the crater edge, bent but intact. Crater depth was 3'-2". Inclosure 7, page 88, shows views of the crater and bomb. Both bombs which hit from this altitude had been bowed two to three inches out of line by the impact.

(d) Plot No. 124: This is the only bomb dropped from the 15,600 foot level which struck the target. This bomb penetrated 4'-4" and bounced out of the crater, coming to rest 50 feet away, intact. The bomb body was bowed 3-3/4 inches out of line. Views of the bomb and crater are given in Inclosure 7, page 89. Impact occurred on a roof slab with bowstring truss reinforcing.

(21) Summary of Trial XIX: It appears that the case strength of the model bomb is great enough to resist breaking up when dropped to reach a striking velocity of 1000 feet per second, but the ratio of length to diameter is too great, 8.5 compared with 7.9 for the Disney; hence, the tendency for the bomb body to bend and bounce out of the crater.

(22) Farge Bomb Plot: Two bomb plots have been prepared for the Farge target. One shows only those bombs dropped by Project "Ruby" aircraft (Inclosure 6, page 2). This plot shows the location of impacts of 98

bombs dropped, including both hits and misses. Eight of the bombs (Plots 18 to 25, inclusive) were 100-lb. practice bombs, dropped to check bombing equipment. The number of hits was 40, giving an overall percentage of hits of 41 per cent. If the 2000-lb. SAP bombs dropped from 26,250 feet are excluded as being erratic in flight, the percentage of hits becomes 38 out of 74 bombs dropped or 51 per cent. The percentage of hits with Amazon bombs was 71 per cent. The last shipment of four Amazons was dropped with 100 per cent accuracy, as all hit the target. The other bomb plot, Inclosure 6, page 1, shows only those bombs which hit the target and includes those dropped by Lancasters as well as those dropped by Project "Ruby" aircraft. Practice bomb hits are not shown. On this plot there are 53 hits, including two which hit on the footing, and one which hit on the wall. There are several close near misses, including a Grand Slam bomb, Plot No. 13.

b. <u>Heligoland Trials:</u>

(1) <u>Target:</u> The Heligoland target consists of a reinforced concrete U-boat shelter 506 feet long and 310 feet wide. The roof thickness is 10 feet. The shelter is constructed partly over water and partly over land. The portion built over the water is divided into three pens, to admit submarines. Each pen measures 340 feet long and 70 feet wide. The portion on land contains machine shops and testing equipment. The two side walls have windows with provision for hinged steel shutters. The roof is built with a 10 foot overhang. The height of the structure is 37 feet above ground level. Roof reinforcing consists of 1" and 1/2" steel bars running lengthwise and crosswise at top and bottom of each roof slab, as well as vertical bars. At the center of the roof is a circular emplacement containing radar equipment. This made a convenient aiming point for the trials. Altogether 133 bombs were dropped at Heligoland, and 45 hits were scored. (See Inclosure 12, page 1). All bombing was accomplished from 20,000 feet altitude with B-17 aircraft.

(2) <u>Trial I (Disneys with 70/30 Shellite):</u> In the initial trial at Heligoland a 70/30 mixture of Shellite (picric acid/dinitrophenol) was used in Disney Bombs dropped without rocket assist. The bombs were to be unfuzed and without exploders. Ten bombs were dropped, scoring four hits (Plots 1 to 4), three of which perforated the roof, and the fourth went through the edge

of the overhang. All four bombs fell through to the water and were not recovered. There were no indications of break-up of the bombs, nor of detonation of the filler. Photographs of the perforations are given in Inclosure 13, pages 1 to 4.

(3) Trial V (Disneys with RDX/Al/Wax, 64/20/16): In the next trial, the Disneys were filled with a mixture of RDX, aluminum powder, and wax in the proportions 64/20/16. Of 12 bombs dropped, without rocket assist, five hits were obtained (Plots 5 to 9). All five bombs perforated the roof, three dropping into water of the pens and two dropping into the shop area at the rear. These latter two bombs were found intact after cratering in basement floor. Photographs of the hits on this trial are given in Inclosure 13, pages 5 to 11. There was no indication of breakup of bombs nor of detonation of the filler.

(4) Trial XIII (Disneys with RDX/Al/Wax, 68/20/12): In this trial, the percentage of RDX was increased to 68 per cent, with the percentage of wax decreased to 12 per cent. Ten Disneys without rocket assist were dropped with this more sensitive filler, and two hits were scored (Plots 10 and 11). Both hits produced perforations in the roof over the pens. One fell through to the water, the other lodged in the concrete floor at the foot of the wall separating the pens from the shop area. The base of this bomb was 18 inches beneath the floor level, at an angle of 20 degrees to the horizontal. There were no indications that either bomb had broken up and no signs of detonation of the filler. Photographs of the craters and perforations are given in Inclosure 13, pages 12 and 13.

(5) Trial XVI (Disneys with TNT): The next trial consisted of Disneys with TNT filler. Twelve bombs were dropped without rocket assist and five hits were obtained (Plots 12 to 16). All hits resulted in perforations of the roof over the pens. No bombs were recovered. There were no signs of breakup of these bombs nor of detonation of the filler. Photographs of the perforations are given in Inclosure 13, pages 14 to 20. One bomb (Plot No. 13) came through the roof between supporting pillars, struck the edge of the pillar, and buried beneath the floor of the catwalk of the pen. One bomb of this trial which missed the target on the North side went through the roof of a steam tunnel leading to the building. The bomb struck against the wall of the tunnel and apparently broke up, as a tail fragment was

found with an impact type of fracture. The TNT filler must then have been set off by the break-up, and the detonation progressed from low order at the base to high order toward the nose. Both low order and high order type fragments were recovered. The metal ring which fits over the base of the bomb was found with six inches of the threads torn off. The ring itself was badly deformed. The rocket fuze pot, rocket motor plate, and one pistol were also found in the tunnel. (See Inclosure 13, page 21). The pistol was unexpected, as the Programme of Trials specified that fuzes were not to be fitted. Project "Ruby" Ordnance Officer's records were checked and it was found that Disney bombs on Trials I, V, XIII, XVI and XX, were dropped with pistols containing dummy detonators and live percussion caps.

(6) Trial XIV, (Disneys with RDX/TNT/Al/Wax/carbon black, 20/60/20/6/2): In this trial, a 20/60/20 mixture of RDX, TNT, Aluminum powder was further mixed with wax, and carbon black and used in the Disney bombs. Ten bombs were dropped without rocket assist, scoring three hits (Plots 17-19). Two of the hits produced perforations in the roof over the pens, the third perforated the roof overhang. The bombs were not recovered. There were no indications of detonation of the filler. Photographs of these perforations are shown in Inclosure 13, pages 22 to 24.

(7) Trial XV (Disneys with RDX/TNT/Wax/Carbon Black, 20/80/10/2): In this trial, a 20/80 mixture of RDX and TNT was mixed with wax and carbon black and used in Disney bombs. Ten bombs were dropped without rocket assist, and four hits were scored. (Plots 20-23). Three hits resulted in perforations of the roof and the fourth perforated the roof overhang. No bombs were recovered, as one fell through to the water, two buried into inaccessible parts of the basement, and one buried in a tunnel after perforating a one inch steel plate on the ground. There were no signs of detonation of the filler.

(8) Trial XX (Disneys with Picratol): In this trial, 12 Disneys with picratol filler were dropped with rocket assist, and five hits were scored (Plots 33-37), three with rocket assist functioning, and two in which the rockets failed to function. All bombs which hit perforated the roof. One bomb was recovered in the machine shop area which had perforated the roof of the middle pen, struck against a pillar and ricocheted,

perforating the wall between the pens and the machine shop area. From aerial photographs and Ordnance records, this bomb was identified as coming from the perforation, Plot No. 33. There were no signs of detonation of the filler for any of the hits on this trial.

(9) Trial XVII (2,000-lb. SAP bombs with Picratol): In this trial, 37 M103 bombs with picratol filler were dropped without fuses, and nine hits were scored. (Plots 24-32). In three instances the bombs broke up upon impact and the filler went off low order, scattering picratol over a wide area on the roof. (Plots 27, 28, and 32). Aerial photographs taken during impact of Plot 32 further confirm that this bomb detonated (see Inclosure 13, page 43). Fragments recovered from two of these three bombs exhibited impact type fractures rather than explosion type fractures. The third bomb was not recovered. The other six bombs which struck the roof were intact, but three were dented near the rear lug in a manner similar to the drops on Trial VI at Farge. Penetrations varied from 2'-6" to 3'-8", and averaged 3'-1". This is the same as the average obtained in Trial VI. Photographs of the craters are given in Inclosure 13, pages 34 to 42.

(10) Trial XXII (2,000-lb. SAP bombs with Picratol and live fuses): The final trial at Heligoland was arranged to test the effectiveness of the picratol filled 2000-lb. SAP bomb when fused with 1/10 second delay fuses. Twenty bombs were dropped, and eight hits were scored. (Plots 38-45). Crater photographs are given in Inclosure 13, pages 44 to 52. None of the hits resulted in perforations of the roof. Craters were only slightly deeper (36" to 45") than for the previous trial, but the roof was scabbed in some instances. One bomb hit on the overhang, and blew a hole through it. There was one dud, (Plot No. 41), and one low order detonation (Plot No. 44). One near miss also functioned low order. A base plate was found near the crater of Plot No. 44. This base plate was complete with fuse. The inner end of the fuse was crushed. The base plate contained wires stripped from the threads of the bomb body threads. The inference is that this bomb landed flat and squeezed out its base plate before fuze functioning. The bomb then ricocheted and scattered its filler, burning low order. The photograph, Inclosure 13, page 51, shows an aerial view of this impact.

(11) Summary, Heligoland Trials:

(a) All of the types of explosive fillers tested were sufficiently insensitive to withstand impact on the 3 meter roof. All Disney bombs which hit the pens either perforated the roof or the roof overhang without detonating or breaking up. One TNT filled Disney bomb which missed the target detonated upon side impact against a tunnel wall. This bomb broke up and detonation followed upon secondary impact.

(b) Three unfused picratol filled 2000-lb. SAP bombs went off low order upon break-up of the case. Here initiation of the adapter booster on secondary impact probably caused the detonation.

(c) The picratol filled 2000-lb. SAP bombs, fused for 0.10 second delay, will not blow through 10 feet of concrete, although in some cases scabbing of the underside of the roof occurs. This bomb will blow through lesser thicknesses of concrete such as the roof overhang.

7. INCLOSURES:

Inclosure 1 - Test Historical Data
Inclosure 2 - Test Program
Inclosure 3 - Bomb Drawings and Photos
Inclosure 4 - Construction Details - Fargo
Inclosure 5 - Bomb Release Records - Fargo
Inclosure 6 - Bomb Plots - Fargo
Inclosure 7 - Fargo Crater Photos
Inclosure 8 - Penetration Summaries - Fargo
Inclosure 9 - Crater Profiles - Fargo
Inclosure 10 - Heligoland Target Photos
Inclosure 11 - Bomb Release Records - Heligoland
Inclosure 12 - Bomb Plot - Heligoland
Inclosure 13 - Heligoland Crater Photos
Inclosure 14 - Penetration Formulas
Inclosure 15 - The B-9 Shackle
Inclosure 16 - T723 Fuze Report

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TEST HISTORICAL DATA

1. **INTRODUCTION:**

   a. Authority.--Testing conducted by authority of letter from Headquarters, AAF, dated 3 January 1946 to CG, AAF Center.

2. **DATE OF ACTIVATION:** 10 January 1946.

3. **DATE EQUIPMENT RECEIVED:**

   a. Aircraft and personnel arrived Marham, England 15 March 1946.

   b. First shipment of Amazon (T28) Bombs arrived Marham, England 20 June 1946.

   c. Last Amazon (T28) and picratol-filled Disney Bombs arrived Marham, England 7 July 1946.

4. **DATE TESTING STARTED:** 25 March 1946.

5. **DATE PROJECT COMPLETED:** 30 October 1946.

6. **SUSPENSIONS:** None.

7. **FLYING HOURS:** 547.6 hours.

8. **GROUND HOURS:** Approximately 1000 hours.

9. **RELATED TESTS:**

   a. Project No. 1-45-22, AAF Board Project No. F4474, "Test of Tall Boy Bomb Installation in B-29 Airplane."

   b. Project No. 1-45-57, AAF Board Project No. Q4711, "Effective Means for Attack of Japanese Caves and Pillboxes."

   c. Project No. 1-45-63, AAF Board Project No. F4726, "Test of Tall Boy and Grand Slam Installation in B-32 Airplane."

   d. Project No. 4-45-28, AAF Board Project No. F4757 "Operational Suitability of B-29 Airplane Equipped with External Bomb Racks."

   e. Project No. 1-45-43, AAF Board Project No. F4664, "Test of Tall Boy Bomb Installation in B-29 Airplane."

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f. AAF Board Project No. 461:A471.6, "Study of the Requirements, Employment and Effectiveness of Large Bombs."

10. Subject equipment has been tested only under temperate climatic conditions.

C[redacted]

AIR PROVING GROUND COMMAND
EGLIN FIELD, FLORIDA
OFFICE OF AC/S, A-3

15 August 1946

SUBJECT: Program for Comparative Test of the Effectiveness of Large Bombs Against Reinforced Concrete Structures (Anglo-American Bomb Tests - Project "Ruby", Project No. 1-46-7).

TO: Commanding Officer, Project "Ruby", Eglin Field, Florida.

1. GENERAL:

a. Description.--This test is a joint British-American project to determine the concrete penetrating performance of large bombs. The reinforced concrete Submarine Assembly Plant at Farge, Germany, and the U-Boat Shelter on the island of Heligoland will be used as targets. The target at Farge will be limited to drops with inert loaded bombs because of the proximity of the village to the target. All drops with H.E. loaded bombs will be carried out at Heligoland which is uninhabited. The types of bombs to be tested include the following:

(1) 2000-lb. SAP (M103)

(2) 4500-lb. CP/RA (Disney)

(3) 12,000-lb. M.C. (Tall Boy) } Both British and American versions to be tested.

(4) 22,000-lb. M.C. (Grand Slam) } Both British and American versions to be tested.

(5) 22,000-lb. SAP (Amazon)

(6) 1650-lb. model of 12,000-lb. CP/RA

Both British and American aircraft will be used to drop the above bombs. British participation will include Lancaster aircraft based at RAF Station, Mildenhall, England. American aircraft participating will include seven B-17's and three B-29's, the latter with bomb bay doors modified to carry Tall Boy and Grand Slam bombs. The base of operations and Headquarters of Project "Ruby" will be at RAF Station, Marham, England. A detachment of Project "Ruby" will be maintained at Farge, Germany. This detachment will consist of assessors and photographers.

b. Priority: 1A.

c. Project Officer: Captain C. D. Reifsteck.
Assistant Project Officer: Dr. Howard E. Heinecke.

d. Test Officer: Lt. Col. D. G. Hawes.

2. OBJECT:

To obtain information regarding the performance against reinforced concrete of British and American bombs of special and standard design, with particular reference to:

a. Penetration.

b. Case strength.

c. Insensitivity of exploder system.

d. Reliability of pistols and fuses.

e. Insensitivity of main fillings.

3. METHOD OF CONDUCTING TEST:

Test will be conducted in accordance with directive from RAF Bomber Command BC/S. 32104/5 ARMT dated 5 March 1946, entitled: "Instructions for Trials at Farge and Heligoland to Determine the Performance of Special Bombs and Components Against Concrete Targets", copy of which is attached as Inclosure No. 1.

4. RECORDS:

Complete records will be kept by Headquarters, Project "Ruby" of all bombs dropped by Project "Ruby" aircraft. These records will show type and weight of bomb dropped, bomb serial number, airplane serial number, release altitude, true air speed, trial number, and location of hit. A report will be written for each malfunction of bomb release equipment. Bombardiers will fill out completely and maintain a file of Forms 120 for each mission accomplished. Aerial photographs will be taken of all impacts if practicable.

The Project "Ruby" detachment at Farge will maintain complete records of the results of British and American bomb hits on both Farge and Heligoland targets. Depth of penetration, crater dimensions, crater profiles, behavior of bomb in flight and on impact, condition and angle of rest of bomb after impact, condition of bomb components and filler, functioning of pistols and fuses, functioning of rocket motor in the case of Disney bombs, will be recorded. Location of each bomb hit will be obtained and plotted on a roof plan of the target. All records will be substantiated as far as possible by photographs.

FOR THE AC/S, A-3:

Cuthbert L. Moseley Jr.
CUTHBERT L. MOSELEY, JR.,
Lt. Col., AC, Asst. A-3,
Chief, Proof Test Division

1 Incl - Instructions for Trials

Inclosure 2, Page 3

CONFIDENTIAL

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Approved by: E.F. Stoddard

E. F. Stoddard
Lt. Col., A.C.
Chief, Bombing Branch

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[redacted]

RESTRICTED.

INSTRUCTIONS FOR TRIALS AT FARGE AND HELIGOLAND
TO DETERMINE THE PERFORMANCE OF SPECIAL BOMBS
AND COMPONENTS AGAINST CONCRETE TARGETS.

- - - - - - - - - - - - - - - - -

COPY NO.____

APPENDICES.

"A" - PROGRAMME OF TRIALS.

"B" - ADMINISTRATIVE ARRANGEMENTS FOR TRIALS UNIT.

"C" - FARGE TARGET DATA AND RANGE ORDERS.

"D" - HELIGOLAND TARGET DATA AND RANGE ORDERS.

"E" - ASSESSORS.

"F" - RESPONSIBILITIES OF RANGE OFFICER, FARGE.

SIGNALS INSTRUCTIONS - BOMBER COMMAND SIGNALS INSTRUCTION No. 31
(LIMITED DISTRIBUTION ONLY).

INFORMATION

Nature and Scope of Trials.

1. The Air Ministry and the United States Army Air Force Authorities have decided that Trials be carried out to obtain information regarding the performance of H.E. Bombs of special design, with particular reference to:-

(a) Penetration.
(b) Strength of Cases.
(c) Insensitivity of Exploder Systems.
(d) Reliability of Pistols and Fuses.
(e) Insensitivity of Main Fillings.

2. Arrangements have accordingly been made to use the reinforced concrete structure at FARGE (GSGS 4416 M.3, Grid Reference 513143) situated 14 miles NORTH WEST of BREMEN, on the River WESER. The FARGE Target will be used for Trials with INERT FILLED BOMBS ONLY. Subsequent Trials with HIGH EXPLOSIVE FILLED BOMBS, will be carried out against the "U"-Boat Shelter at HELIGOLAND.

/ Responsibility for Trials.

[redacted]

Responsibility for Trials.

3. BOMBER COMMAND has been charged with the operational responsibility for these Trials. Air Crew, Maintenance crews, and aircraft will be provided for the Trials as follows:-

(a) No. 15 Squadron, MILDENHALL.

No. IX - 8 Rounds.
No. XI - 5 Rounds.
No.XIX - Number of Rounds not yet known.

(b) U.S.A.A.F. Detachment, MARHAM.

No. I - 12 Rounds.
No. V - 12 Rounds.
No. VI - 40 Rounds.
No. X - 12 Rounds.
No. XII- 12 Rounds.
No.XIII- 12 Rounds.
No. XIV- 12 Rounds.
No. XV - 12 Rounds.
No. XVI- 12 Rounds.
No.XVII- 80 Rounds.
No. IX - 4 Rounds.

For full details of the programme of Trials see Appendix "A".

Previous Orders.

4. This Instruction cancels the previous Instruction issued under Headquarters, BOMBER COMMAND Reference BC/S.31204/5 ARMT dated 13th October, 1945, as amended by Headquarters, BOMBER COMMAND letter BC/S.31204/5 ARMT dated 19th January, 1946, all copies of which are to be destroyed.

EXECUTION

Training.

5. Arrangements have been made through the Director Armament Research and Development for the United States Army Air Force Detachment to carry out Practice Bombing with 100-lb Sand Filled Bombs and Inert Filled CP/RA Bombs at ORFORDNESS. Before commencing Trials against the Target at FARGE the Officer Commanding

/ the American

the American Detachment will contact Mr. FRAME, Superintendent, ORFORDNESS, through the R.A.F. Liaison Officer at R.A.F. Station MARHAM, (Squadron Leader A. J. MOODY), and arrange details of these exercises, which are to be carried out from 20,000 ft. In addition to the facilities afforded at ORFORDNESS, Practice Bombing, with Sand Filled Bombs, but NOT CP/RA Bombs, may be carried out at RUSHFORD Bombing Range under arrangements to be made with Headquarters, No. 3 Group.

Targets.

6. The Target for the INERT FILLED Bomb Trials is to be the reinforced concrete structure at FARGE, full details of which are given in Appendix "C".

7. The Target for the HIGH EXPLOSIVE Filled Bomb Trials, is to be the "U"-Boat Shelter at HELIGOLAND, full details of which are given in Appendix "D".

Liaison Officers.

8. Squadron Leader A. J. MOODY is appointed Armament Liaison Officer with the United States Army Air Force Detachment at R.A.F. Station, MARHAM.

9. Flight Lieutenant C. H. WICKS is appointed Armament Liaison Officer with No. 15 Squadron, R.A.F. at R.A.F. Station, MILDENHALL.

Assessors and Range Staff.

10. Assessors and Range Staff are to be provided by the Director of Armament Research and Development and the United States Army Air Force Authorities, in cooperation with Headquarters, BOMBER COMMAND, the Ordnance Board, Chief Engineer Armament Design, Chief Superintendent Armament Research, the Anti-Concrete Committee and the Road Research Laboratory. Names and telephone numbers of the Assessors are given in Appendix "E".

11. The Representative for the United States Army Air Force Assessors is Colonel D. G. HANES (U.S.A.A.F. Representative from ORLANDO, FLORIDA), Officer Commanding United States Army Air Force Detachment, MARHAM, and Officer in charge Project "RUBY".

12. The Range Party at FARGE is under the command of Wing Commander GARNER (D.Arm.R.D's Staff). For the purposes of these Trials it is under the direct operational control of Headquarters,

/ BOMBER COMMAND

BOMBER COMMAND.

13. Details of the Range Party, establishments, etc. are given in Appendix "B".

14. The Range Party established at FARGE is under the administrative control of Headquarters, B.A.F.O. for the duration of the Trials.

15. The responsibilities of the Officer Commanding Range Party, FARGE, are set out in Appendix "F".

Flying Control.

16. The Commandant, Central Bomber Establishment, MARHAM, is responsible for ensuring that the Officer Commanding the United States Army Air Force Detachment is fully acquainted with, and is in possession of, all Instructions for Flying Control Procedure in the British Isles, and all Local Flying Regulations which are in force at MARHAM.

17. The Officer Commanding U.S.A.A.F. Detachment, MARHAM, is responsible for ensuring, in cooperation with the Commandant, Central Bomber Establishment, MARHAM, that United States Army Air Force Crews are fully conversant with Flying Control Procedure and Local Flying Regulations.

Conduct of Trials.

18. The Programme of Dropping is given at Appendix "A", and is to be strictly followed. The operating height for the Trials as given in Appendix "A" is to be strictly observed. Divergencies from the programme will be sanctioned by Headquarters, BOMBER COMMAND, if required.

Operational Control and Procedure.

19. Headquarters, BOMBER COMMAND (Command Armament Officer) - Telephone Extension 297 - will be the coordinating authority for these Trials and will inform the Deputy Director, Armament Development (Bombs) - Ministry of Aircraft Production, when a strike has been obtained on either Target.

20. The Deputy Director Armament Development (Bombs) will then arrange for the Assessors to be assembled and transported to the Targets, and will inform Headquarters, BOMBER COMMAND, of the

/ number of

number of Assessors, and their expected time of arrival at BREMEN Airfield (R.40) in order that the Officer Commanding Range Party at FARGE may make arrangements for their accommodation, etc.

21. Whenever a strike (or strikes) has been obtained, there will be a temporary suspension of bombing for at least 24 hours in the case of FARGE and 48 hours in the case of HELIGOLAND, for the purposes of assessment.

Headquarters, BOMBER COMMAND will advise MILDENHALL and MARHAM when aircraft should Stand Down.

22. The Officer Commanding R.A.F. Station, MILDENHALL is responsible for:-

(a) The coordination of the Flying Programme for the Trials. This requires close liaison and cooperation with the Officer Commanding the United States Army Air Force Detachment at MARHAM, and will include the allocation of the FARGE Target between aircraft of No. 15 Squadron and the United States Army Air Force Detachment aircraft from MARHAM.

(b) Drawing up the Daily Bombing Programme in cooperation with the Officer Commanding United States Army Air Force Detachment, MARHAM, and making detailed arrangements direct with the Officer Commanding Range Party at FARGE.

Briefing.

23. (a) The Officer Commanding R.A.F. Station MILDENHALL is responsible for the briefing of crews of No. 15 Squadron.

(b) The Officer Commanding United States Army Air Forces Detachment, MARHAM, is responsible for the briefing of United States Army Air Force crews.

Bombs and Bomb Fusing.

24. The number of Special Bombs available is limited and therefore they should be jettisoned only in emergency.

25. All Bombs are to be dropped WITHOUT detonators, but in the cases of the M.C. and 2000-lb S.A.P. Bombs, the appropriate Pistol and/or Fuse are to be fitted.

26. An individual aircraft carrying more than one Bomb is to complete the dropping of the complete load even if the Target is

struck by

struck by an early bomb. Should a second aircraft be airborne in the vicinity of the Target, when the first aircraft obtains a strike, it is also to continue bombing.

ADMINISTRATION

M.T. and Special Vehicles.

27. Headquarters, BOMBER COMMAND, will arrange for one 10-Ton Crane, special trolleys, and the necessary lorries and trailers, for the conveyance of the bombs at MARHAM.

28. The United States Authorities are arranging for the provision of necessary M.T. vehicles for the use of U.S.A.A.F. personnel while stationed at R.A.F. Station, MARHAM.

Accommodation and Messing, United States Army Air Force.

29. The Commandant, Central Bomber Establishment, MARHAM, is to be responsible for:-

(i) Providing accommodation and Messing for members of the United States Army Air Force Detachment at MARHAM.

(ii) Providing facilities and Technical accommodation for the use of the United States Army Air Force Detachment.

Supply of Special Bombs.

30. The Director of Armament Research and Development is responsible for the supply of Special Bombs required for the Trials. Each bomb will bear a special marking e.g. "PROC Q.3304", and also a Serial Number.

31. The Special Bombs are to be delivered to R.A.F. Stations MILDENHALL and MARHAM in accordance with the allocation of Trials as given in paragraph 3 sub paras (a) and (b) above.

Loading of Aircraft.

32. The Officer Commanding United States Army Air Force Detachment MARHAM is responsible for the loading of his aircraft at MARHAM.

COMMUNICATIONS.

/ Transport of

Transport of Assessors.

33. The Deputy Director of Armament Development (Bombs), Ministry of Aircraft Production, is responsible for collecting Assessors as necessary, and for arranging their transportation to and from the Targets when required.

Telephone and Teleprinter Facilities.

34. A special speech circuit is to be provided between the Operations Room at MILDENHALL and the Office of the Officer Commanding United States Army Air Force Detachment, at MARHAM. Private wire telephone circuits already exist between Headquarters, No. 3 Group (NEWMARKET) on the one hand, and MILDENHALL, MARHAM and Headquarters, BOMBER COMMAND, on the other.

35. Teleprinter circuits are in operation between Headquarters, No. 3 Group (NEWMARKET) on the one hand, and MILDENHALL, MARHAM and Headquarters, BOMBER COMMAND, on the other.

Point to Point.

36. W/T communication is to be provided between MILDENHALL, MARHAM and FARGE, signals control being exercised by MILDENHALL. This circuit is to be monitored by Headquarters, BOMBER COMMAND.

Only "Unclassified" messages may be sent by this channel. No de-coding facilities exist at FARGE.

Aircraft Control.

37. W/T communication between ground and aircraft is to be provided by transmitting and receiving equipment operated from Headquarters, No. 3 Group, (NEWMARKET). This Station is to be in teleprinter contact with MILDENHALL and MARHAM.

38. A single V.H.F. R/T channel is to be provided to afford communication between aircraft, and between the Range Control Officer at FARGE and aircraft. The Spotting aircraft is to also use this channel.

Flyin Control.

39. Communications Instructions will be issued later on the subject of Flying Control.

40. There will be no ground communications facilities at

/ HELIGOLAND.

HELIGOLAND.

41. Details of frequencies, callsigns, emergency facilities, etc. will be found in Bomber Command Signals Staff Instruction No. 31 (attached).

United States Army Air Force Detachment.

42. The Commandant, Central Bomber Establishment, MARHAM, is to issue Signals Publications to Officer Commanding the United States Army Air Force Detachment, in accordance with Bomber Command Signals Staff Instruction No. 31, para. 22.

43. The Commandant, Central Bomber Establishment, MARHAM, is to assist the United States Army Air Force Detachment in crystalising their communications equipment on channels peculiar to the R.A.F. organisation.

REPORTS.

44. Officer Commanding R.A.F. Station, MILDENHALL, is to forward a Report to Headquarters, BOMBER COMMAND, when a Hit is registered by aircraft of No. 15 Squadron. The Report is to be in triplicate and contain the following information:-

Serial Number and Type of Bomb.
Height of Release.
Ground Speed set in Bomb Sight.
True Air Speed.
Wind Velocity.
Q.F.F.

United States Army Air Force Detachment.

45. Officer Commanding United States Army Air Force Detachment will forward a Report to Headquarters, BOMBER COMMAND, whenever a Hit is registered by aircraft of the United States Army Air Force Detachment. The Report is to be in triplicate, and contain the following information:-

Serial Number and Type of Bomb.
Height of Release.
Ground Speed set in Bomb Sight.
True Air Speed.
Wind Velocity.
Q.F.F.

/ Bomber Command.

Bomber Command.

46. A Report on the conduct of the Trials will be prepared by the Command Armament Officer, Headquarters, BOMBER COMMAND.

Chief Superintendent Armament Research.

47. Reports on the effects of the impact of bombs, behaviour of fillings, components, etc. will be prepared by the Chief Superintendent Armament Research, in collaboration with the other Assessors.

Road Research Laboratory.

48. Reports on the penetration and effects of the various bombs on the Target structures will be prepared by the Road Research Laboratory in cooperation with the Anti-Concrete Committee.

Coordination of Reports.

49. The above Reports will be forwarded to the Director Armament Research and Development, Ministry of Aircraft Production, for collation and onward transmission to the sponsoring authorities.

50. ACKNOWLEDGE.

BC/S.32104/5/ARMT.
5th March, 1946.

CONFIDENTIAL

BC/S.32104/5/ARMT.dated

5th March.1946.

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Chief Engineer Armament Design, FORT HALSTEAD.	2.	
Chief Superintendent Armament Research.	2.	
Secretary Anti-Concrete Committee.	2.	
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- - - - - - - - - -

APPENDIX "A".

PROGRAMME OF TRIALS - FARGE.

THE ORDER OF PRIORITY WILL BE ADJUSTED TO SUIT AVAILABILITY OF STORES.

TRIAL NUMBER	BOMB AND NUMBER OF ROUNDS	FILLING	ROCKET, ASSISTED	FUZED	APPROX. S/V	DETAIL OF TRIAL	OBJECT OF TRIAL
VI.	2000-lb S.A.P. 40 ROUNDS	H.E.S.	NO	YES ADAPTOR BOOSTER AND LIVE FUZE.	1100	BOMBS TO BE DROPPED FROM 26,250' AT 200 MPH TRUE AIR SPEED.	6 PAIR KITS REQUIRED. (i) TO OBTAIN PENETRATING DATA. (ii) TO TEST STRENGTH OF CASE. (iii) TO TEST FUNCTIONING OF FUZE AND ADAPTOR BOOSTER.
IX.	22,000-lb MC. (FABRICATED) (12 ROUNDS.)	H.E.S.	NO	NO-BUT EXPLODERS AND PISTOLS TO BE INSERTED. NO DETONATORS.	1150	BOMBS TO BE DROPPED FROM 20,000' TRUE HEIGHT AND AIRSPEED TO BE RECORDED.	(i) TO OBTAIN PENETRATING DATA. (ii) TO TEST STRENGTH OF CASE. (iii) TO CONFIRM INSENSITIVITY OF EXPLODERS AND RELIABILITY OF PISTOLS.
X.	4500-lb CP/RA (12 ROUNDS)	H.E.S.	NO-BUT LIVE ROCKETS TO BE FITTED AND DROPPED "SAFE".	NO-BUT PISTOLS AND EXPLODER TO BE FITTED. NO DETONATORS.	1100	AS FOR TRIAL IX.	AS FOR TRIAL IX.
XI.	12,000-lb MC. (FABRICATED) (5 ROUNDS)	H.E.S.	NO	AS FOR TRIAL IX.	1100	AS FOR TRIAL IX.	AS FOR TRIAL IX.
XII.	4500-lb CP/RA (1[illegible] ROUNDS)	H.E.S.	YES	AS FOR TRIAL IX.	1400 (approx)	AS FOR TRIAL IX.	AS FOR TRIAL IX.

Continued - XII.

PROGRAMME OF TRIALS - F A R O E.

TRIAL NUMBER	BOMB AND NUMBER OF ROUNDS	FILLING	ROCKET ASSISTED	FUZED	APPROX S/V	DETAIL OF TRIAL	OBJECT OF TRIAL
XIX.	MODEL 12,000-lb C.P. (1650 lb)	R.S.S.	NO	NO-NO FUZING COMPONENT FITTED.	900	6 ROUNDS FROM 12,000' AT 200-250 MPH AIR SPEED. SUBSEQUENT SETS OF 6 BOMBS TO BE DROPPED FROM A HEIGHT DETERMINED BY BEHAVIOUR AT PREVIOUS TRIALS.	TO TEST STRENGTH OF CASE.
THE FOLLOWING TRIALS HAVE BEEN ADDED TO THE PROGRAMME:							
XVIII.	22,000-lb FABRICATED S.A.P. (12 ROUNDS)	R.R.S.	NO	NO-BUT EXPLODERS AND PISTOLS TO BE INSERTED. NO DETONATORS.	1150	AS FOR TRIAL IX.	AS FOR TRIAL IX.
XXI.	12,000-lb MC. (CAST) (12 ROUNDS)	R.R.S.	NO	NO	VARIOUS	TRIALS TO BE COMMENCED WITH RELEASE HEIGHT OF 10,000'. WHEN TWO HITS OBTAINED FURTHER INSTRUCTIONS WILL BE ISSUED REGARDING RELEASE HEIGHT FOR REMAINDER OF BOMBS.	TO OBTAIN CRITICAL HEIGHT OF RELEASE (BREAK-UP OF BOMBS) BEFORE CARRYING OUT TRIALS WITH FABRICATED BOMBS. TRIAL XXIa ETC. TO BE ISSUED LATER.

NOTES:-

(i) All above Trials are to be carried out at FAROE.

(ii) Trial XXI. only to be undertaken after it has been proved by preliminary dropping trials in U.K. that the accuracy is such that 100% of Bombs will fall within a 500 yard radius of the Aiming Point.

(iii) Bombs will be marked O.B. PROC No. Q.3304

(iv) Bombs to be marked Trial XXI and O.B. PROC No. Q.4286

PROGRAMME OF LIVE TRIALS - H E L I G O L A N D

THE ORDER OF PRIORITY WILL BE MODIFIED TO SUIT AVAILABILITY OF STORES.

TRIAL NUMBER	BOMB AND NUMBER OF ROUNDS	FILLING	ROCKET ASSISTED	FUZED	APPROX. S/V	DETAIL OF TRIAL	OBJECT OF TRIAL
I. REPEAT OF PROC. Q.3304	4500-lb CP/RA (12 ROUNDS)	SHELLITE 70/30	NO	NO-EXPLODERS TO BE REMOVED.	F/SECS. 1150	BOMBS TO BE DROPPED FROM 20,000' TRUE AIR SPEED AND HEIGHT TO BE RECORDED.	TO CONFIRM INSENSITIVITY OF FILLING.
V.	4500-lb CP/RA (12 ROUNDS)	RDX/AL/WAX 64/20/16	NO	AS ABOVE.	1150	AS ABOVE.	AS ABOVE.
XIII.	4500-lb CP/RA (12 ROUNDS)	RDX/WAX/AL 68/12/20	NO	AS ABOVE.	1150	AS ABOVE.	AS ABOVE.
XIV.	4500-lb CP/RA (12 ROUNDS)	RDX/TNT/AL/WAX/CARBON BLACK.20/64/20/6/2	NO	AS ABOVE.	1150	AS ABOVE.	AS ABOVE.
XV.	4500-lb CP/RA (12 ROUNDS)	RDX/TNT/WAX/CARBON BLACK 20/80/10/2	NO	AS ABOVE.	1150	AS ABOVE.	AS ABOVE.
XVI.	4500-lb CP/RA (12 ROUNDS)	TNT	NO	AS ABOVE.	1150	AS ABOVE.	AS ABOVE.
XVII.	2000-lb S.A.P. (80 ROUNDS)	PICRATOL	NO	AS ABOVE.	1100	BOMBS TO BE DROPPED FROM 26,250' AT 200 MPH TRUE AIR SPEED.	6 FAIR HITS REQUIRED TO CONFIRM INSENSITIVITY OF FILLING.
XX.	4500-lb CP/RA (12 ROUNDS)	PICRATOL	NO	AS ABOVE.	1150	BOMBS TO BE DROPPED FROM 20,000' TRUE AIR SPEED AND HEIGHT TO BE RECORDED.	TO CONFIRM INSENSITIVITY OF FILLING.
XXII.	2000-lb S.A.P.	PICRATOL	NO	YES-1/10 SEC. DELAY.	1100	BOMBS TO BE DROPPED FROM 20,000' AT 200 MPH TRUE AIR SPEED.	TO TEST EFFECTIVENESS OF BOMB WITH DELAY FUZE.

NOTES:- (i) All the above Trials to be carried out at HELIGOLAND.

(ii) Bombs will be marked O.B. PROC.NO.Q.3304. TRIAL No. X - X being the number of the trial as above, with one exception as under:-

Bombs for Trial No. XVII will be marked O.B.PROC.Q.3940.

APPENDIX "B".

RANGE PARTY - FARGE.

ADMINISTRATION.

ESTABLISHMENT.

1 Wing Commander (Tech Arm).

1 Flight Sergeant, Armourer.

1 Sergeant, A.C.H.

1 Corporal, A.C.H.

4 A.C.H.s

2 Wireless Operator Mechanics.

2 Drivers, M.T.

1 Fitter, M.T.

1 A.C. Photographer.

1 A.C. Cook.

ACCOMMODATION.

Accommodation is to be arranged by the Officer Commanding the Range Party, through the Town Major, FARGE.

MOTOR TRANSPORT.

Under arrangements made by the Ministry of Aircraft Production the Range Party is allotted the following motor transport:-

1 Staff Car or Utility.

1 30-cwt Lorry.

1 Jeep, or 15-cwt Lorry.

The Officer Commanding the Range Party and the Range Control Officer is Wing Commander R. H. GARNER.

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APPENDIX "C".

F A R G E.

TARGET DATA AND RANGE ORDERS.

1. The Target is a "U"-BOAT ASSEMBLY SHELTER at FARGE, situated on the River WESER, fourteen miles North West of BREMEN. The Target is at sea level.

2. The Danger Area provided is 500 yards radius, and a circular aiming point will be laid out 100 yards from the Southern end of the Target, which measures approximately 450 yards x 100 yards. Owing to the proximity of a road and habitations on the North and East sides of the Target attacks are NOT to be made between headings of 30° - 130°(True).

3. A Photograph of the Target, showing the aiming point, the 500 yards Danger Area and the Dead Sector of 30°-130° is attached.

RANGE ORDERS.

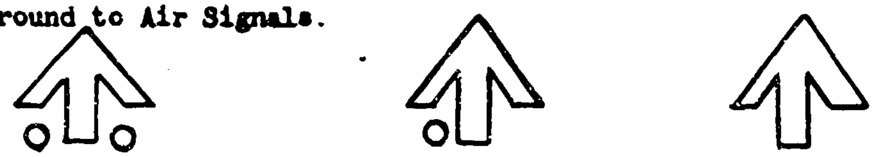
4. Briefing.

Prior to each exercise, the crews concerned are to be briefed by the Specialist Bombing Officer and Bombing Leader. The briefing is to include a summary and explanation of the Target, together with details of the specified exercises to be carried out. The Bomb Aimer is to be in possession of all exercise details including the serial number of the store carried, and the bombing height and track is also to be given.

5. Bombing Signals.

Standard Bombing Signals will be situated 600-800 yards North West of the aiming point. These will consist of an 80 ft arrow complete with two discs, the arrow being directed towards the Target. Detail stripe at the base of the arrow will not be provided. These Signals will be as follows:-

(a) Ground to Air Signals.



All Clear for Bombing - carry on. | Wait for a further Signal - do not bomb. | Cease Bombing - Go Home.

/ (b) Ground to

(b) Ground to Air Emergency Signal.

A smoke generator will be ignited whenever it may be necessary to call attention to the aircraft to a change in signals (this may be necessary in an emergency).

(c) Radio Telephony Communications.

The aircraft are to keep in constant touch with the Range Control Officer by Radio Telephony. Standard Procedure as laid down in current instructions is to be used.

Danger Area - FARGE.

6. The Danger Area, a circle of 500 yards radius, is to be bounded by RED flags, and clearly marked with Bi-lingual notices stating that when the Red flags are flying from the Target, and in the vicinity of the notices, entry into the Area is forbidden. Sirens will be sounded as a warning for personnel to leave the area immediately information is received that an attack will be made. The responsibility for providing the notice boards will lie with the Chief of Police, BREMEN, and he will provide Police Patrols to patrol the perimeter of the area and raise the Red Flags as required.

Arrangements for the control of river traffic during bombing will be made by the Naval Operations Staff, BREMEN Port Command, who will inform all persons using the River that they must keep outside Danger Area when Red Flags are flying from the Target.

Safety Precautions.

(a) Lancaster Bomb Doors are not to be opened until approaching the Target on the bombing run.

(b) Bomb Doors are to be closed, and the selector switch put to "off" immediately each bomb has been released.

(c) Special orders regarding the fusing of the stores to be released will be issued separately, and will be conveyed to the crews at briefing.

(d) In the event of failure to release, the Range Control Officer is to be contacted by R/T before attempts are made to jettison the store. Due to the special nature of the stores carried and the difficulty for provisioning, jettisoning action should be taken only as an emergency measure, and only in the special areas as given to the crews at briefing.

/ (e) The Officer

(e) The Officer Commanding the United States Army Air Force Detachment at **MARHAM** will be responsible that his aircrews are adequately briefed in respect of safety precautions in respect of Fortress and Super Fortress aircraft.

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CONFIDENTIAL

APPENDIX "D".

H E L I G O L A N D.

TARGET DATA AND RANGE ORDERS.

TARGET DATA.

1. The Target is the "U"-Boat Shelter at HELIGOLAND. This Shelter is situated on the South East corner of the Island of HELIGOLAND. The target is at sea level, and will not be marked with any specific aiming point. The Target's dimensions are 485 ft x 300 ft.

A Photograph of the Target is attached.

RANGE ORDERS.

2. The N.O.I.C CUXHAVEN, has arranged for the Target Area to be cleared on one week's notice. This notice will be given by Headquarters, BOMBER COMMAND, and the units concerned can operate after the one week's time limit has expired, without any prior warning, and whenever conditions are suitable. As the Island and surrounding area will be evacuated, no bombing signals will be displayed, and aircraft are to release their bombs without any signals from the ground.

Briefing.

3. Prior to each exercise, the crews concerned are to be briefed by the Specialist Bombing Officer and Bombing Leader. The briefing is to include a summary and explanation of the Target, together with details of the specified exercises to be carried out. The Air Bomber is to be in possession of all exercise details including the serial numbers of the stores carried, the bombing height and track is also to be given.

Spotting Aircraft.

4. Owing to the probability that Strikes on the Target will not be observed by the bombing aircraft flying at 20,000 ft, or above, the Officer Commanding the United States Army Air Force Detachment, MARHAM, will detail a second Fortress, or Super Fortress aircraft for spotting duties.

The Spotting Aircraft will proceed to the Target area in company with the Bombing aircraft, but at a lower level. The Bombing aircraft will keep in touch with the Spotting aircraft by Radio Telephony so that the latter can position itself so as to see where

/ the bombs

the bombs strike after they have been released, and take necessary photographs.

The Spotting aircraft is not to fly within 2000 yards of the Target or at a height of less than 3,000 feet.

Oblique photographs of the point of impact should, if possible, be taken by the Spotting aircraft.

Communications.

5. In addition to Radio Telephonic communication to be established between the Bombing and Spotting aircraft, as outlined in para. 4 above, both the Bomb dropping aircraft and the Spotting aircraft are to maintain W/T communication with Headquarters, No. 3 Group, NEWMARKET.

Safety Precautions.

6. (a) The Captain of the Bombing aircraft is responsible that no Bombs are released if ships or boats are within 500 yards of the Target.

(b) In the event of "hang-ups", Bombs are to be jettiscned in the sea, if the Captain of the Bombing aircraft considers it necessary. In view, however, of the limited number of Special Bombs available, the jettisoning of bombs is only to be undertaken as and emergency measure.

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Inclosure 2, page 26

[redacted]

APPENDIX "E".

A S S E S S O R S.

APPOINTMENT.	NAME.	TELEPHONE NUMBER.
The Secretary Ordnance Board	- Group Captain W. WYNTER MORGAN	- WESTERN 7266.
Chief Superintendent Armament Research	- Mr. L. F. MURPHY.	- SEVENOAKS 2301, Ext.220.
Director Road Research Laboratory	- Mr. N. L. L. PUGH. Mr. W. GLANVILLE. Mr. A. C. WHIFFIN.	- COLNBROOK 116, Ext. 54.
The Secretary Anti-Concrete Committee	- Mr. A. P. SHRIMPTON	- WELBECK 6677, Ext. 135.
Chief Engineer Armament Design	- Group Captain R.J.P. MORRIS. W/C D. S. KITE. S/L H. P. DEAN.	- SEVENOAKS 2301, Ext. 128

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APPENDIX "F".

RESPONSIBILITIES OF THE OFFICER COMMANDING RANGE PARTY - FARGE.

The Officer Commanding Range Party FARGE will be responsible for the following:-

1. Administration of the Range Party.

2. Liaison with Local Allied Formations, and, where necessary, the Civil Authorities in BREMEN.

3. Safety arrangements in the Danger Area at FARGE.

4. Coordinating arrangements for the inspection and marking of the Target at HELIGOLAND, and making arrangements with the Naval Authorities for the transportation of the Assessors and Range personnel by sea to and from HELIGOLAND, as required.

5. Informing MILDENHALL and MARHAM daily, at a time to be mutually agreed, of the weather conditions over the Target areas, and stating whether the Bombing Programme is to continue.

6. Informing Headquarters, BOMBER COMMAND direct of any proposed change in the programme which may appear desirable, or necessary, as the Trials proceed.

7. Informing Headquarters, BOMBER COMMAND, by W/T (repeating to MILDENHALL and MARHAM) of the bombing results as soon as possible after each sortie. Whenever possible a preliminary Report should be given by R/T to the aircraft while over the FARGE Target. Whenever a Strike is confirmed, he will inform MILDENHALL and MARHAM immediately by W/T in order to prevent subsequent aircraft becoming airborne.

8. Plotting each Strike on the Target, to facilitate the coordination of results.

9. The ground control of aircraft when over the Target at FARGE.

10. Arranging for Bomb Disposal personnel to be available at FARGE to deal with bombs dropped with live fuses.

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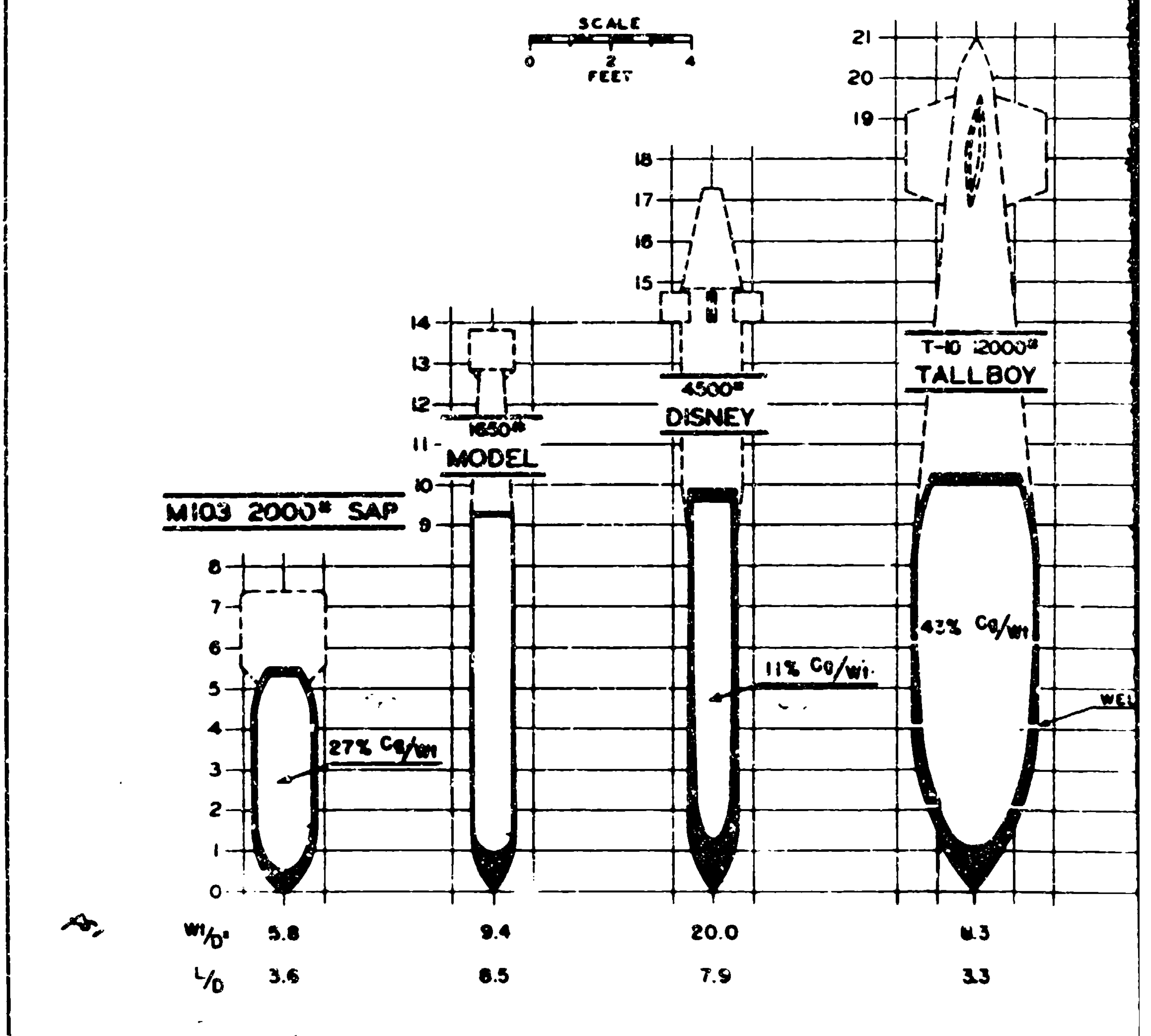
[redacted]

COMPARATIVE SIZES OF BOMBS USED ON PROJECT RUBY



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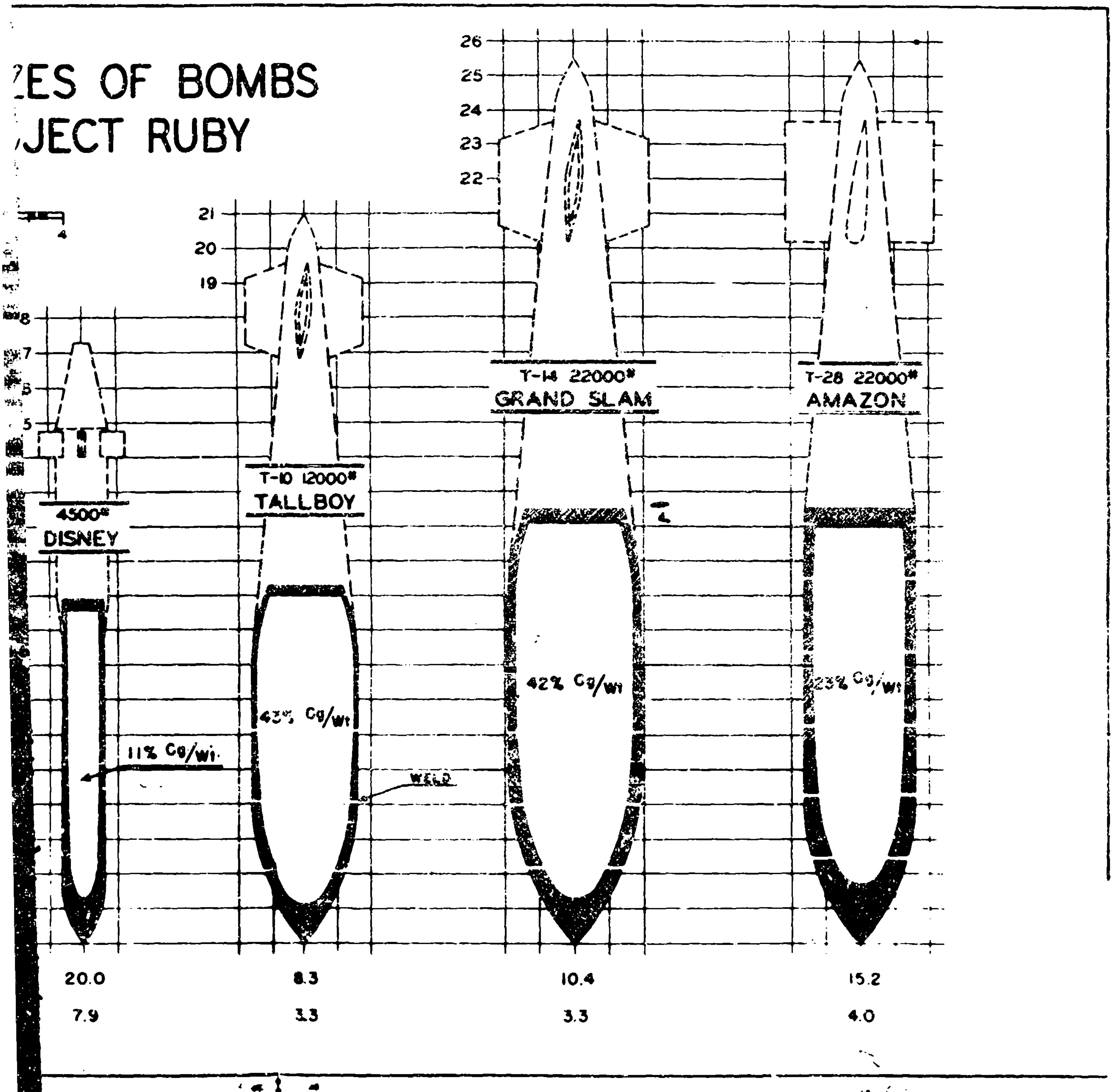
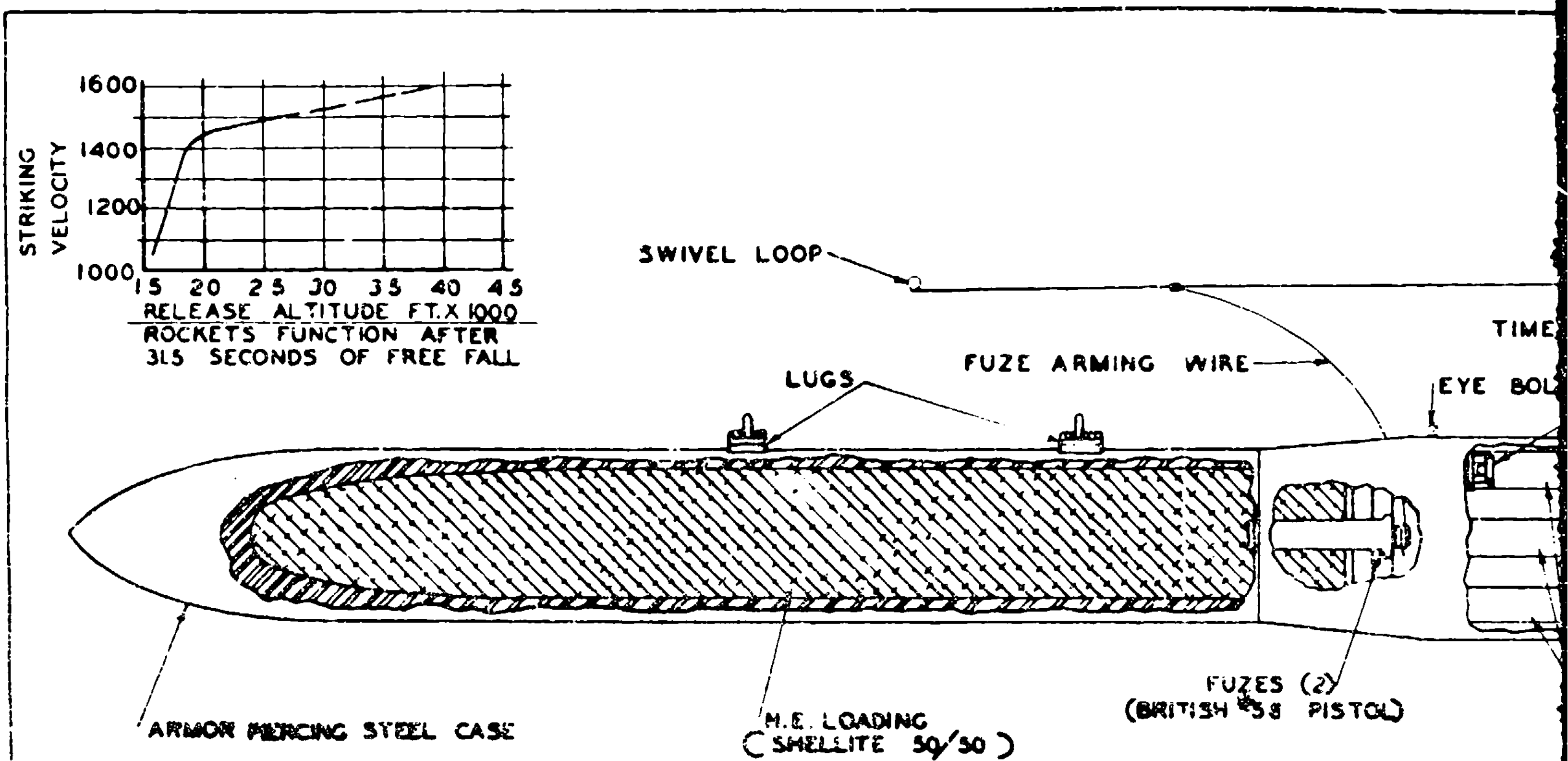
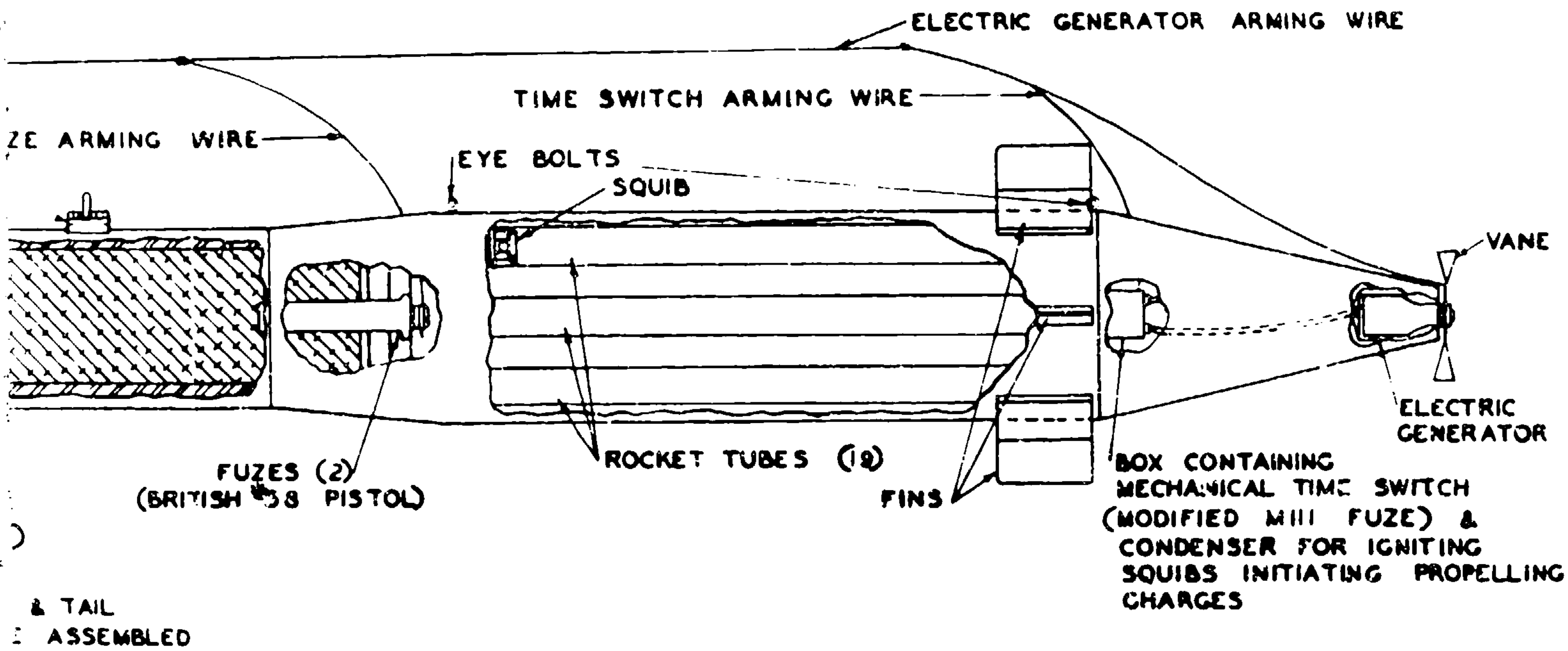


ZES OF BOMBS
JECT RUBY
4500#
DISNEY
11% Cg/wt.
T-10 12000#
TALLBOY
43% Cg/wt
WELD
T-14 22000#
GRAND SLAM
42% Cg/wt
T-28 22000#
AMAZON
23% Cg/wt
20.0
7.9
8.3
3.3
10.4
3.3
15.2
4.0



NOTE - BOMB BODY, ROCKET MOTOR & TAIL CONE SHIPPED SEPARATELY - TO BE ASSEMBLED AT A/C LOADING POINT



DETAILS OF 4500 LB CP/RA
DISNEY BOMB

2

Amazon bomb being lowered into position for loading in B-29.

Three 1650-lb. Model bombs in bomb bay of British Lancaster airplane.

CONSTRUCTION DETAILS OF FARGE TARGET

1. GENERAL:

a. Function of Structure.--The huge reinforced concrete structure at Farge, Germany, known by the code name of VALENTIN, was designed as a bombproof factory for the assembly of 1600-ton Type XXI submarines. Started in March 1943, the structure was only 90 per cent completed at war's end, and production of submarines was never begun. The Nazis intended to ship prefabricated submarine sections by rail and by barge to VALENTIN from various points in Germany, and to assemble them complete and ready for operation at the rate of 14 a month. Submarines were to have been launched into the Weser River through a special lock chamber incorporated into the building.

b. Dimensions.--The building measures 1400 feet in length and is 318 feet wide at the river end, 269 feet wide at the middle, and 220 feet wide at the opposite end. The height is 74 feet to the top of the first roof thickness, and 82 feet where the second roof thickness had been completed. Approximately 40 per cent of the second roof layer had been added, principally over the narrower Eastern portion. To provide headroom for testing of periscopes and air tubes, two towers projecting above the roof had been constructed on the North side of the building over assembly stations 11 and 12 (see page 15). This plant incloses a space of approximately 1,400,000 cubic yards, requiring the pouring of some 650,000 cubic yards of concrete.

c. Assembly Line.--Barges were intended to enter the structure through a water entrance at the North end of the West wall. A 200-ton crane would pick up a section and place it on a bogey on a turntable. The bogey would then move on a track running into the South bay to another turntable where another crane would unload the section and place it in a storage space along the South wall. The bogey would then turn left and proceed up the South bay. When a train of eight empty bogeys had accumulated, the crane would select eight appropriate sections to make up a complete submarine. The train would then move up the South bay to assembly stations 1, 2, and 3, where mounting of keel and straightening of sections would take place. At station 3, the train would move laterally on a transfer track to station 4, where welding of sections would start. The train proceeds to stations 5, 6, 7, and 8 to complete the welding operations. At station 9 the batteries are installed. Another lateral movement brings the submarine to station 10, where mounting of the periscope and air tube is accomplished. At stations 11 and 12 the supplying and equipping of the submarine takes place. At station 12 the submarine is in the upper level of the lock chamber. The gates are closed and the water level is raised until the submarine is floated. It is then moved laterally to station 13 over the deeper section of the lock chamber, where diving tests are conducted. The water level is then lowered to the level of the river, and the gates are opened to allow the submarine to float out into the river. The empty bogeys are run out of the lock chamber ready for another trip. Sections coming to VALENTIN by rail would enter the building through an opening in the South wall near the West end. Other openings near the East end were to be used for entrance of supplies.

2. FOUNDATION:

Walls and partitions are supported on monolithic concrete foundations extending to a depth of 55 feet at the lock chamber, and to lesser depths elsewhere. The bearing surface was dimensioned to transmit a pressure of eight tons per square foot to the subsoil. Page 5 shows views of foundation construction.

3. WALLS:

The outer walls were cast in blocks normally 57 feet long and 14' 9" thick. 'Brunswick Reinforcement' with a percentage of 30 kilograms of steel bars to one cubic meter of concrete (1.85 lb. per cu. ft.) was used. It was intended to increase the wall thickness to 23 feet, and one small section of the North wall near the East end had been increased to this thickness. Page 6 shows views of the walls during construction. Recesses at intervals along the outer walls were the unfinished portions of ventilating shafts. Provision was to be made for complete change of air every 40 minutes. In the winter the air was to be heated to 25 degrees Centigrade.

4. ROOF:

Roof construction was of four types, the principal one consisting of prestressed reinforced concrete arch trusses or bowstring girders (See page 7-8). These were cast on a site adjacent to the building, lifted to the roof and placed side-by-side with lower chords in contact. These trusses were 100 feet in length and 14 feet 9 inches in height at the center of the arch There are seven vertical concrete ribs with diagonal braces consisting of steel bars with turnbuckles. The lower chord, three feet wide at the base, contains a total of 104 steel rods 10 millimeters in diameter prestressed to 95,000 pounds per square inch. Upon setting of the concrete the tension is released and the stress drops to 60,000 pounds per square inch resulting in a prestressing of the concrete in the lower chord to 2,500 pounds compression per square inch. The trusses were originally designed to support the weight of only 14' 6" roof thickness. Since the roof thickness was to be increased to 23 feet, additional reinforcement was added. This consisted of three bundles of steel wire 10 millimeters in diameter placed on each side of the lower chord, running through holes in the ends of the trusses. These wires, ten to a bundle, were prestressed and clamped in place by driving steel cones into the holes. The reinforcing steel used in these trusses was a high quality cold drawn steel known by the trade designation of St 105. It contains approximately 7 per cent carbon, 3 per cent silica, and 1.2 per cent manganese. This steel had an ultimate tensile strength in excess of 150,000 pounds per square inch. The concrete of the truss was composed of special alumina cement and had a minimum compressive strength of 500 kilograms per square centimeter (7095 pounds per square inch).

In the spaces between trusses steel reinforcement bars of semi-circular shape, were placed with ends pointing up and arcs in contact with the lower chord. This reinforcing amounted to 25 kilograms of steel per cubic meter of concrete (1.5 pounds per square foot). Finally, steel reinforcing bars were placed through transverse holes in the lower chords and concrete was poured to form a roof slab 14'-9" in height, 100 feet long and 67 feet wide. The dead load before addition of the second roof thickness amounted to 6,800 pounds per running foot of truss. Concrete used to form the roof slab consisted of two types, one employing slag cement, the other employing Portland cement. The strength of the concrete in the roof slab was supposed to be 400 kilograms per square centimeter (5675 pounds per square inch), but because of lack of control of water content of the gravel, the strength after 28 days was found to average only 370 kg. per sq. cm. (German concrete strength measurements are based on 20 centimeter cubes, whereas American practice is to use 12-inch cylinders of 6-inch diameter). The maximum aggregate size ranged from 40 to 50 mm. (1.6 to 2.0 inches), and the water-cement ratio was 0.50. The aggregate consisted of river gravel from the Rhine and Weser Rivers, and from Denmark. The main component was quartzite, with some flint and soft limestone and shale. Fractures frequently occurred through pieces of the aggregate. A sample of concrete is shown on page 12.

After the first roof layer had hardened, a second layer of concrete was poured in blocks over the Eastern 40 per cent of the building. For drainage of rainwater, the top surface of the second roof thickness was sloped one part in 67 from the center to the North and South sides. This made the total roof thickness 24-1/2 feet at the center and 23 feet at the edges.

Starting at the West end of the building and extending for 267 feet East, a similar slope had been added to the first roof layer, making the thickness at the center 17 feet and at the edges 14'-9".

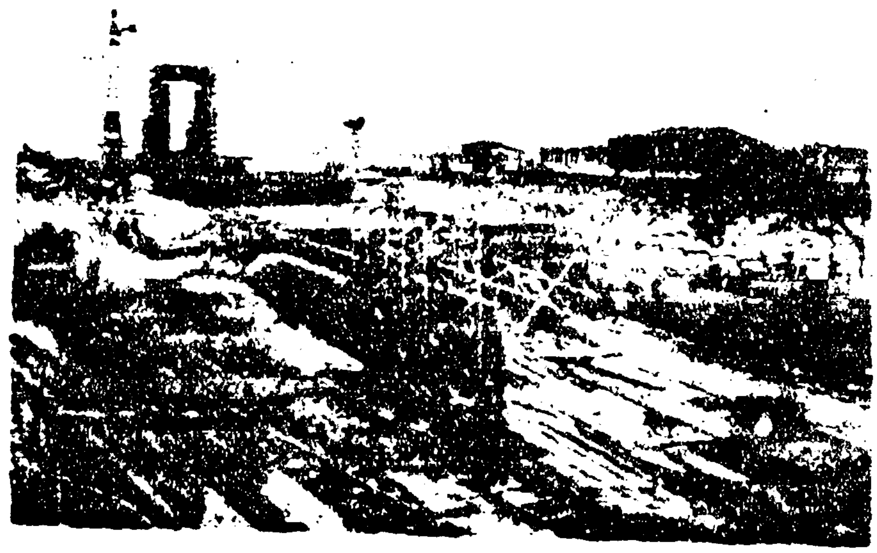
The second type of roof construction was employed only where the span between retaining walls was approximately one-half that of the type described above. Here a prefabricated concrete arch truss was also used, but the design was simpler (see page 9). These trusses were 47 feet long and 14'-9" high at the center. The web and upper chord were made of plain concrete, but the lower chord had 76 reinforcing rods prestressed in the same manner as for the large trusses. Concrete was poured over these trusses to make a roof slab 14'-9" high, 47 feet long, and 33'-6" wide. No semi-circular shaped reinforcing rods were placed between trusses in this type of construction.

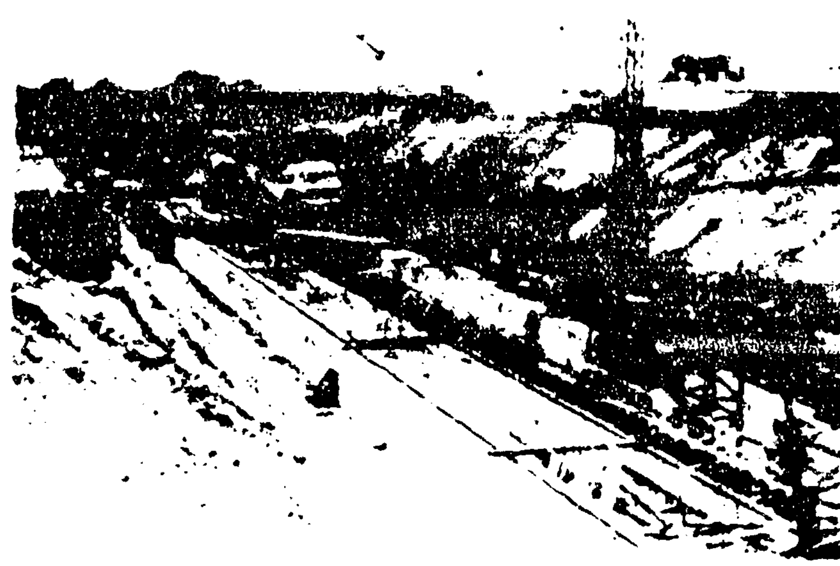
The third type of roof, resorted to when the supply of concrete arch trusses was insufficient, consisted of steel I-beams two feet high, spaced approximately three feet apart, with precast concrete slabs six inches thick placed between beams to form the boarding for the lower surface of the roof slab (See page 10). In the construction stage, these beams were supported by portable steel columns which were moved to the next section after the concrete had set. On the long spans (100 feet), the I-beams were made up of two 50 foot sections riveted together at the center. The roof slab of the West Periscope Tower contains I-beam reinforcing, but here the height of the beams was 3' 3", and the thickness of the first roof layer was only 11' 6". The second roof thickness over this portion was to be 11' 6" in order to bring the total thickness up to 23 feet.

The fourth type of reinforcing was found only over the East Periscope Tower. Here riveted steel trusses were used. (See page 11.) The height of this truss was 9' 2". They were spaced approximately three feet apart with corrugated metal sheets placed between bottom chords to form the boarding for the lower surface of the roof slab. Concrete was poured over the trusses to form a slab 16' 6" thick. The second layer was to have been 6' 6" thick to make a total thickness of 23 feet.

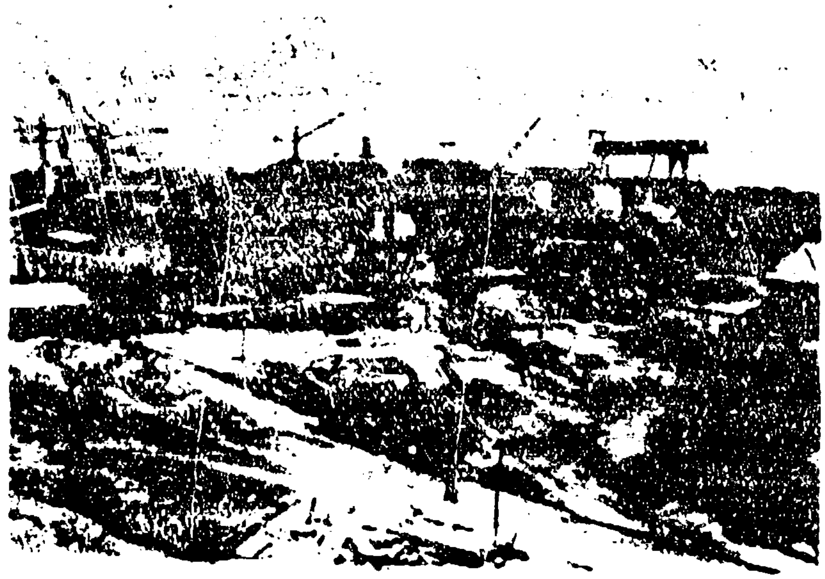
An aerial view of the Farge Target, 90 per cent completed, is shown on page 13. Two holes through the roof were made by H.E. Grand Slam hits obtained by the RAF in a raid of March 1945. These two holes are visible in the photograph. Close-up views of the roof damage caused by these bombs, which exploded in the roof, are shown on page 14. The hits occurred on the section of the roof containing concrete arch truss reinforcement.

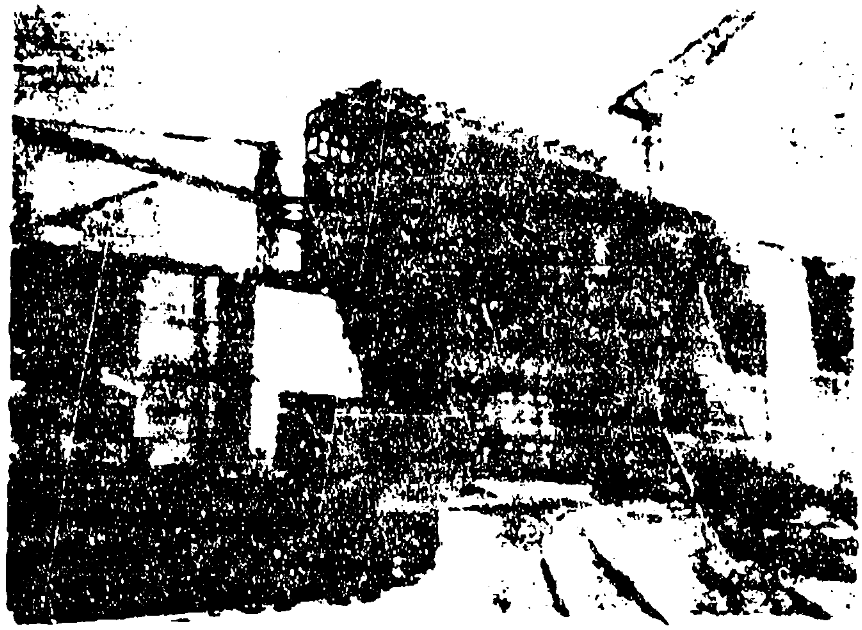
Pages 16, 17 and 18 contain detailed sketches of the concrete arch truss, the short span concrete girder, and the steel truss used in the Farge roof.





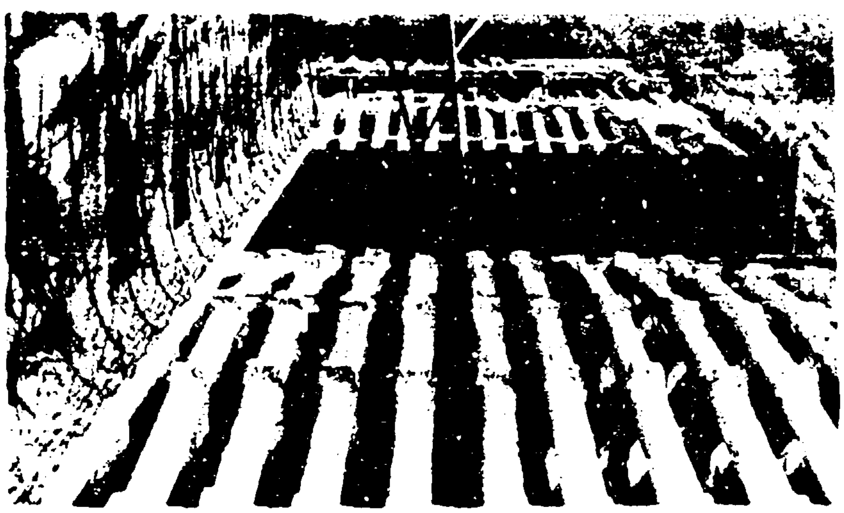
Views showing construction of foundations.



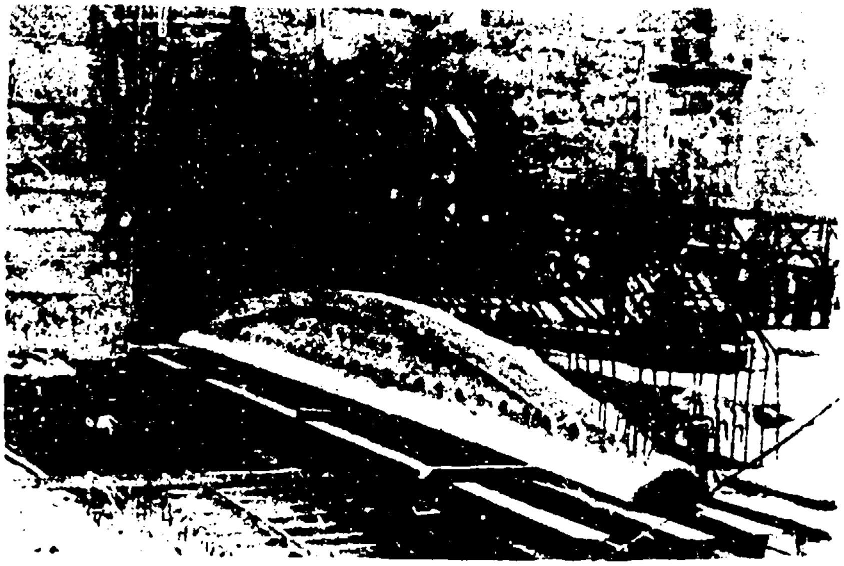


Views showing walls under construction.

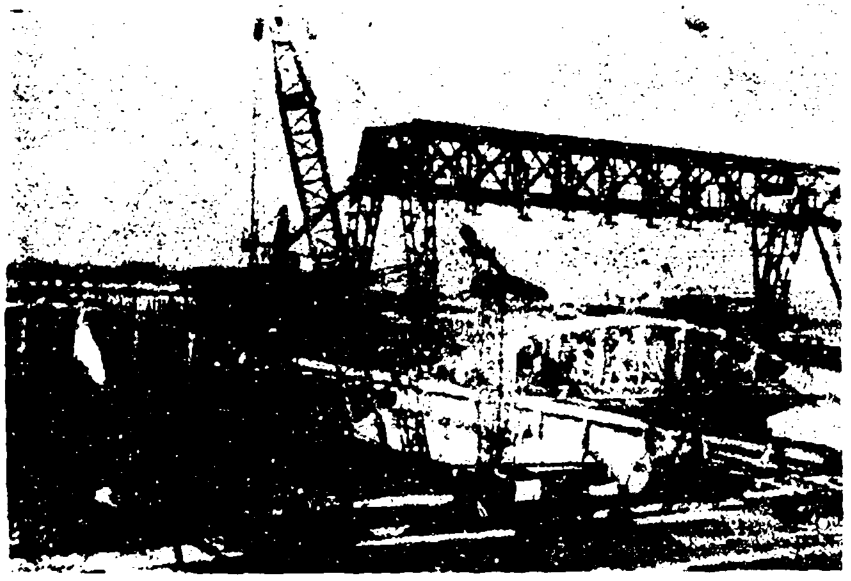
Upper view shows bowstring girders being fabricated.
Lower view shows end view of completed girder.



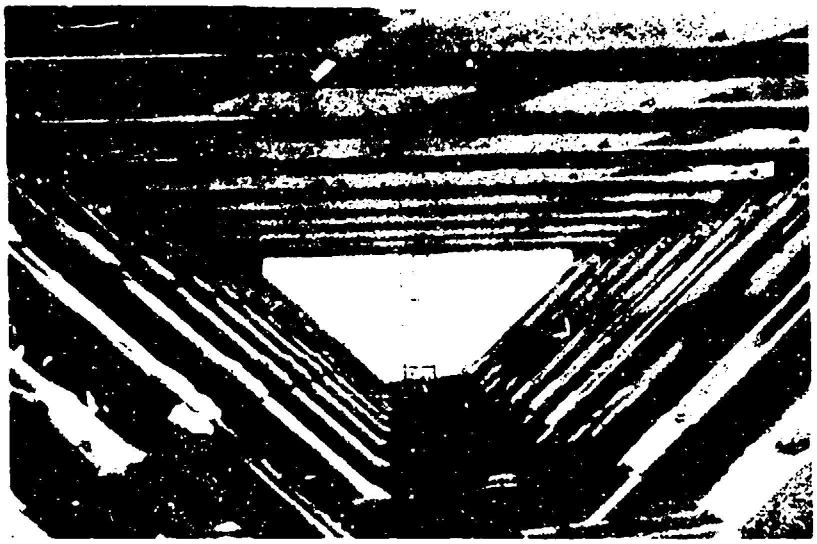
Views showing forms in place for pouring of roof slab.
Concrete is pumped into the forms.



View showing type of prefabricated concrete girder used for short span roof slabs.



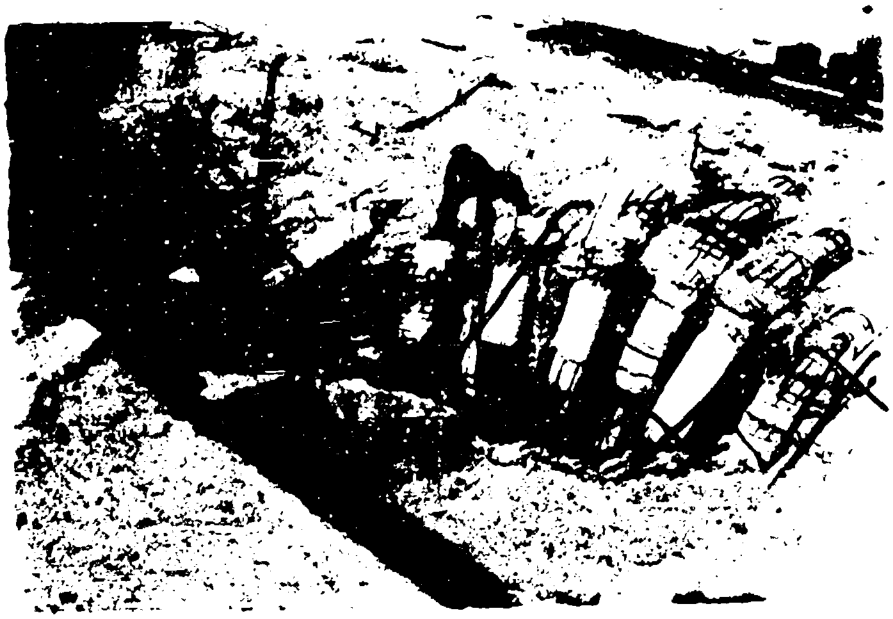
View showing I-beam type of roof construction in left foreground, with bowstring girders in left background and at right.



Views showing steel trusses used in the roof slab of the East periscope tower.

Sample of Farge concrete showing size of aggregate.

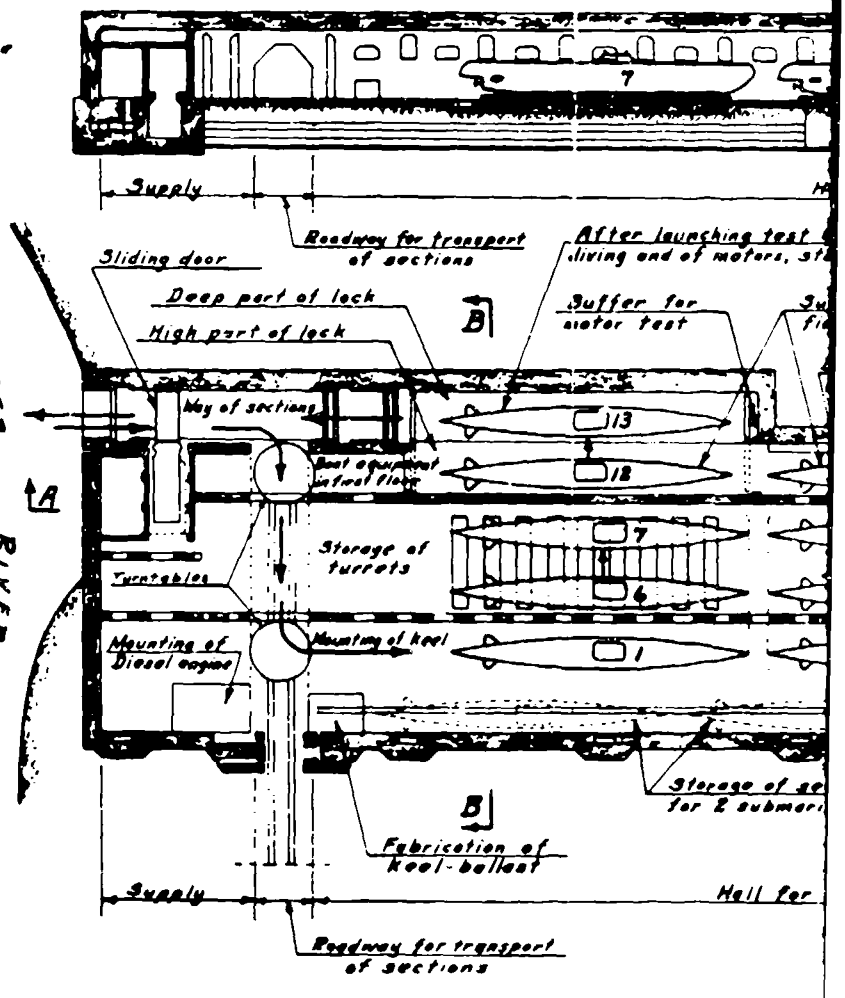
Aerial oblique view of Farge target. Note the second roof layer extending over the far half of the structure. The two holes seen in the center were produced by H.E. Grand Slams dropped during the war.



Craters made by two H.E. Grand Slams dropped during the war. The bombs exploded after partial penetration and blew holes through the roof.

SUBMARINE ASSEMBLY LINE

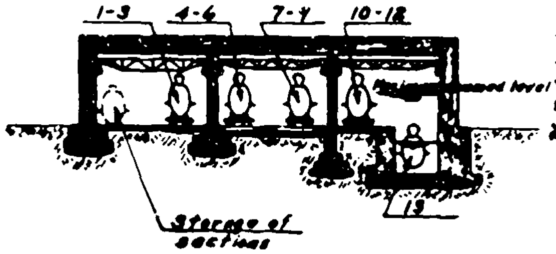
Longit



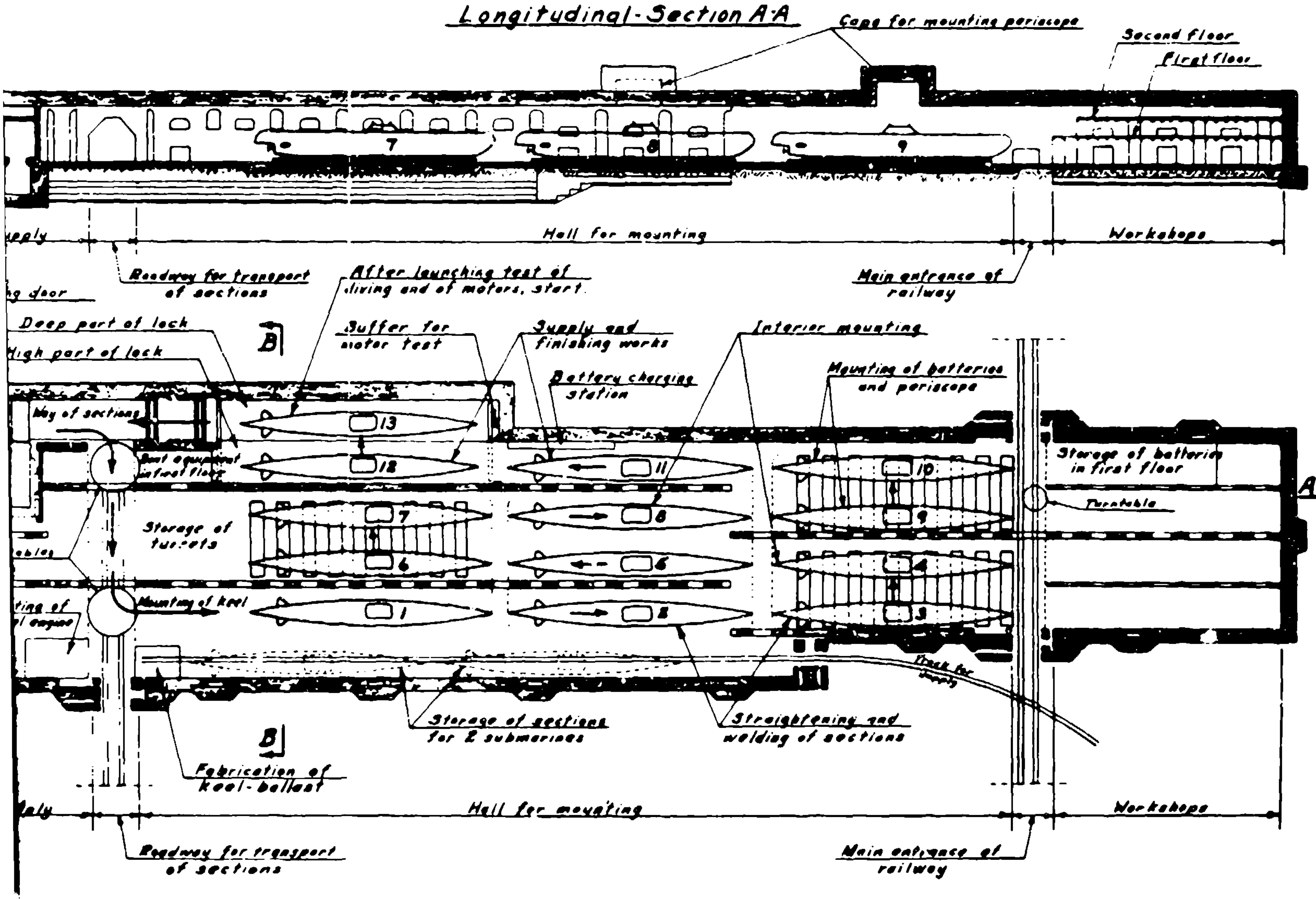
Working Schedule

1-3: Mounting of keel and straightening of sections.
4-8: Main welding works of joint-seams of pressure body and of exterior skin.
9-10: Mounting of batteries, periscope and air-tube
11-12: Finishing works at periscope, air-tube, antenna etc., charging of batteries, equipment of the boat and finishing work to prepare launching.
13: After damming up the level in the lock, lateral moving of the boat, diving test, test of engines and start of the ready submarine.

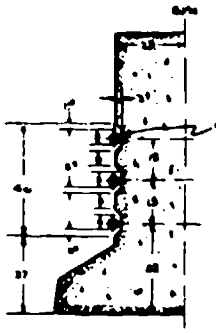
Cross-Section B-B



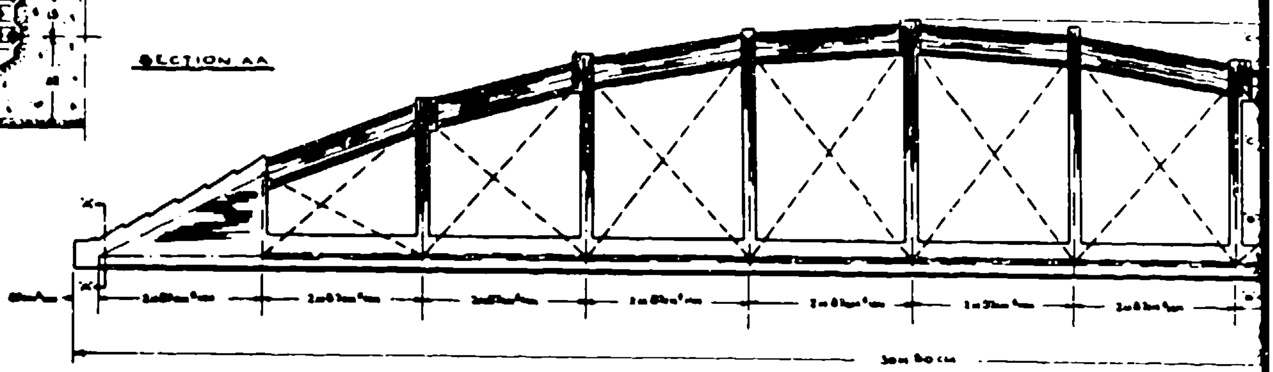
SUBMARINE ASSEMBLY LINE-FARGE



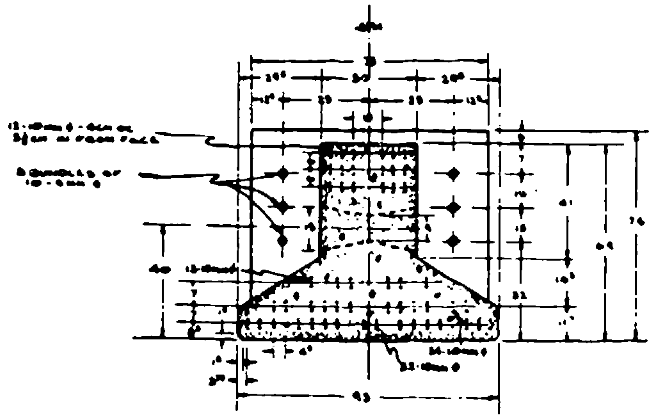
2



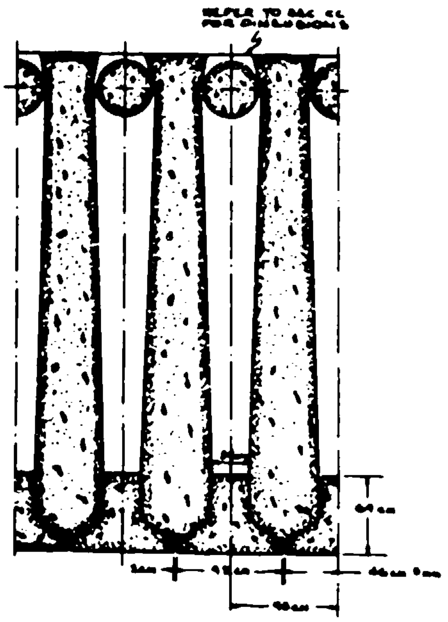
SECTION AA



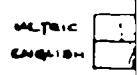
REINFORCED CONCRETE TRUSS
'BOWSTRING'



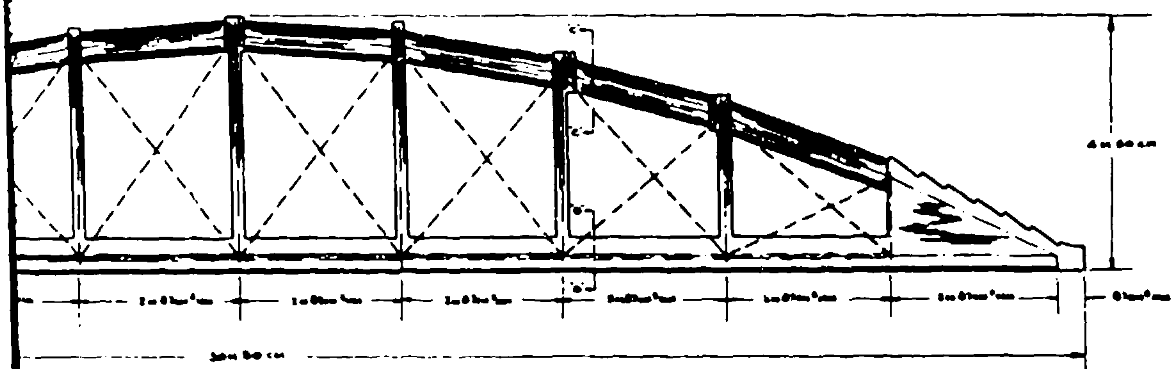
SECTION BB



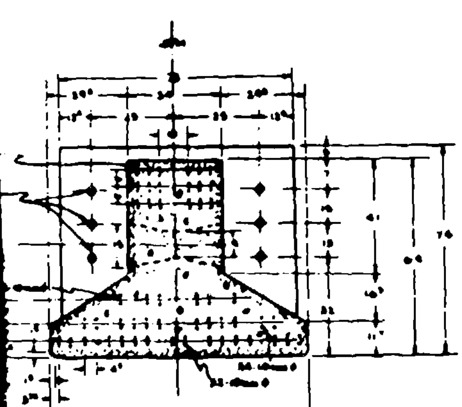
SECTIONAL VIEW SHOWING TRUSS SPACING



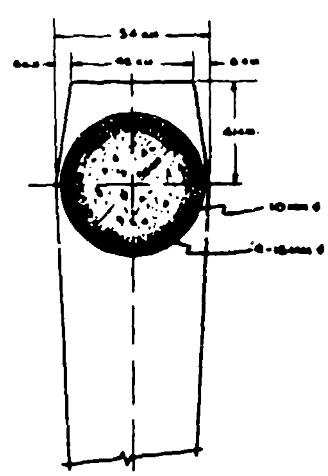
INCLOSURE 4, PAGE 16



REINFORCED CONCRETE TRUSS
"BOWSTRING"

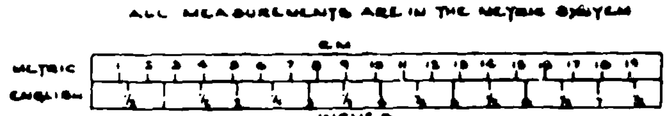


SECTION BB



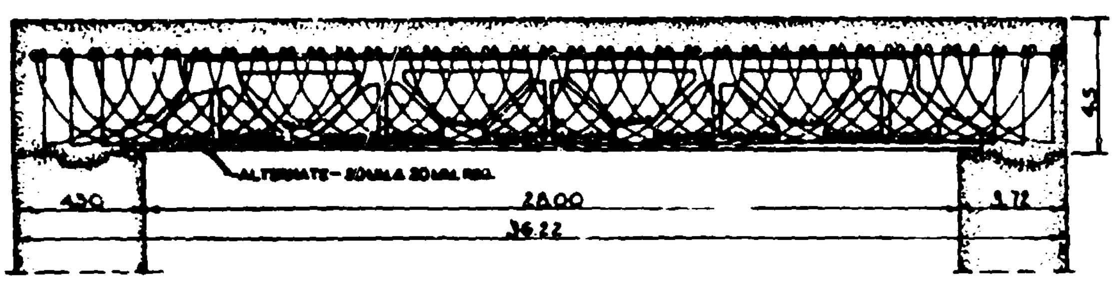
SECTION CC

ALL MEASUREMENTS ARE IN THE METRIC SYSTEM

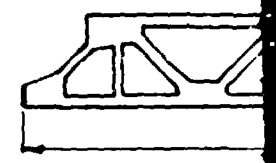


ATTENTION: This copy is missing page 101. (AFATL is aware)

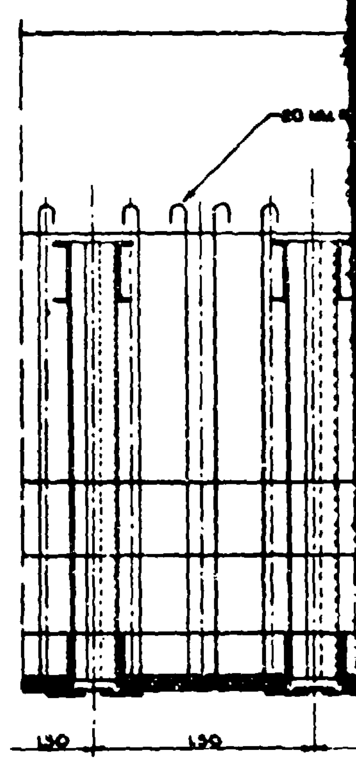
2



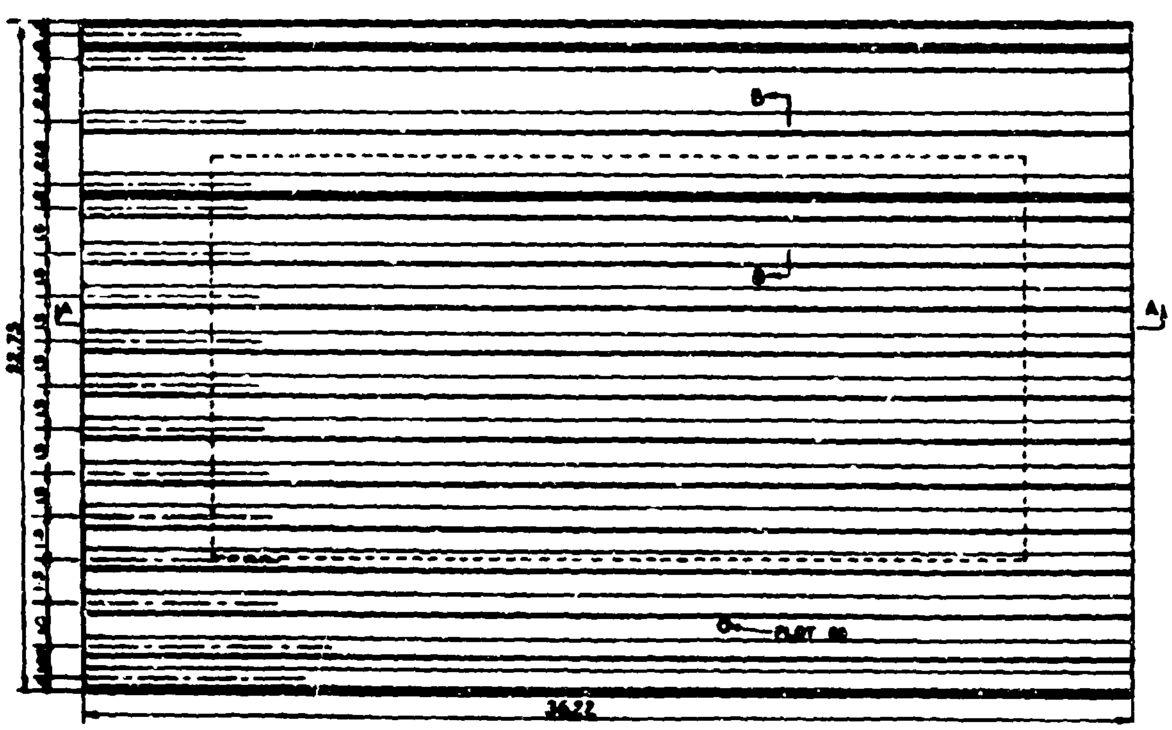
SECTION A-A SHOWING STEEL TRUSS & REINFORCING SYSTEM IMBEDDED IN CONCRETE



STEEL TRUSS OV



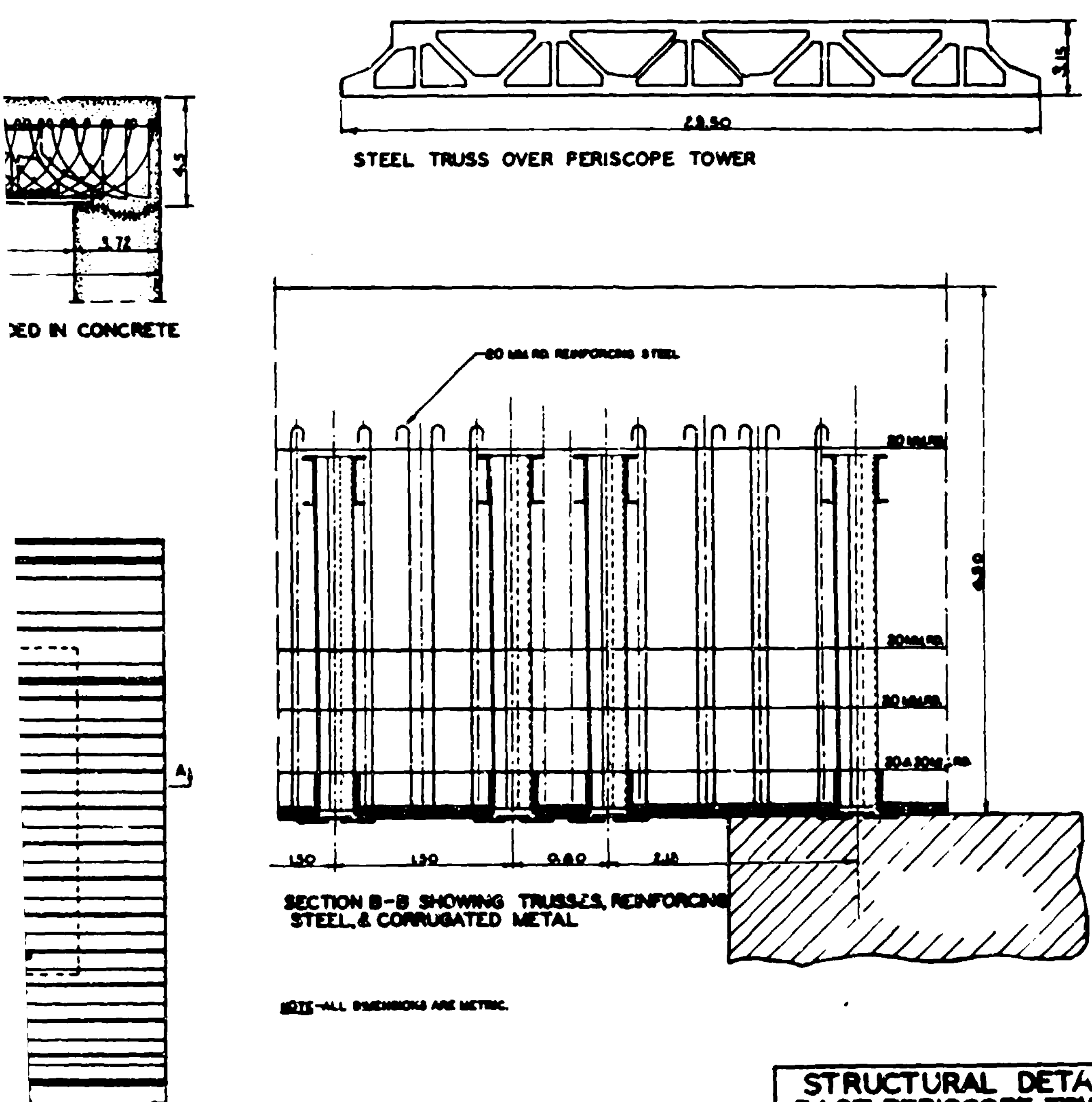
SECTION B-B SHOWING TRU
STEEL & CORRUGATED MET



PLAN VIEW IN SECTION OF PERISCOPE TOWER SHOWING TRUSS SPACING

NOTE-ALL DIMENSIONS ARE METRIC.

~~CONFIDENTIAL~~



STRUCTURAL DETAILS
EAST PERISCOPE TOWER
FARGE

[redacted]

BOMB RELEASE RECORD - RANGE

PLOT NO.	TRIAL NO.	DATE	AIRCRAFT NUMBER	BOMB NUMBER	BOMB TYPE	TRUE ALTITUDE	TRUE AIRSPEED	MAG. HEADING	TIME OF RELEASE	SCORE: DISTANCE IN YARDS FROM BULLSEYE	SCORE: TRUE BEARING FROM BULLSEYE	TYPE OF IMPACT	CASE STRENGTH	INSENSITIVITY OF EXPLODER SYSTEM	RELIABILITY OF PISTOLS AND FUZES	CRATER DATA: DEPTH OF SPALLING	CRATER DATA: DIAMETERS: LENGTH	CRATER DATA: DIAMETERS: WIDTH	REMARKS
C-4	XI	3/17/46	LANC T	—	12,000 T.B.	20,000	—	311°	1125	200	260°	MISS	—	—	—	—	—	—	DROPPED BEFORE PROJECT RUBY DET. ARRIVED AT RANGE
C-8	XI	3/17/46	LANC S	—	12,000 T.B.	20,000	—	309°	1135	121	212°	MISS	—	—	—	—	—	—	DROPPED BEFORE PROJECT RUBY DET. ARRIVED AT RANGE
C-7	XI	3/25/46	LANC V	—	12,000 T.B.	20,000	—	310°	1145	114	257°	MISS	—	—	—	—	—	—	DROPPED BEFORE PROJECT RUBY DET. ARRIVED AT RANGE
1	IX	3/28/46	B-29 B	A0S197	22,000 G.S.	20,000	274	350°	1455	154	216°	MISS	--	—	—	10'	25'	25'	
2	X	3/28/46	B-17 D	VA471	4500 CP/MA	20,000	222	279°	1543	64	356°	HIT ON 4 1/2 METER ROOF	OK.	DUMMY	FUNCTIONED (NO CAPS)	4'-5"	9'-10"	13'-6"	SCARRED UNDERSIDE OF ROOF
3	X	3/28/46	B-17 O	—	4500 CP/MA	20,000	222	170°	1612	23	059°	HIT ON 4 1/2 METER ROOF	OK.	DUMMY	FUNCTIONED (NO CAPS)	3'-2"	12'-0"	14'-3"	
4	IX	3/28/46	B-29 C	A0S195	22,000 G.S.	20,000	275	318°	1624	98	095°	HIT ON 4 1/2 METER ROOF	BROKE UP	BROKEN OFF. NO DETONATION	FUNCTIONED OK.	7'-0"	21'-0"	10'-0"	HIT AT BASE OF SLAB AT 2ND ROOF THICKENING
5	X	3/28/46	B-17 E	VA468	4500 CP/MA	20,000	219	320°	1631	124	214°	MISS	—	—	—	—	—	—	
6	X	3/28/46	B-17 O	—	4500 CP/MA	20,000	222	170°	1632	265	072°	MISS	—	—	—	—	—	—	
7	X	3/28/46	B-17 D	—	4500 CP/MA	20,000	222	205°	1633	452	097°	MISS	—	—	—	—	—	—	HIT LATRINE IN VILLAGE
8	X	3/28/46	B-17 E	VA485	4500 CP/MA	20,300	219	320°	1650	109	211°	MISS	—	—	—	—	—	—	
9	X	3/28/46	B-17 F	VA470	4500 CP/MA	25,000	220	360°	1654	19	348°	HIT ON 4 1/2 METER ROOF	BROKE UP	DUMMY	FUNCTIONED (NO CAPS)	4'-6"	14'-0"	11'-4"	HIT AT JUNCTION OF 4 ROOF SLABS
10	X	3/28/46	B-17 F	VA508	4500 CP/MA	20,000	220	160°	1759	34	328°	HIT ON 4 1/2 METER ROOF	OK.	DUMMY	FUNCTIONED (NO CAPS)	6'-0"	16'-6"	14'-3"	
12	—	3/28/46	LANC R	—	25-lb PRACT.	20,000	254	310°	1811	NOT RECORDED		HIT ON 4 1/2 METER ROOF	—	—	—	—	—	—	
12	XI	3/28/46	LANC R	—	12,000 T.B.	20,000	254	302°	1826	825	239°	MISS	—	—	—	—	—	—	RELEASED AT DUSK
13	IX	3/30/46	B-29 C	A0S204	22,000 G.S.	20,000	274	334°	1224	182	124°	MISS	—	—	—	—	—	—	HIT ON FOOTING, BOMB NOT RECOVERED
14	IX	3/30/46	B-29 B	A0S154	22,000 G.S.	20,000	268	350°	1254	154	218°	MISS	—	—	—	15'	30'	30'	HIT IN SAND
15	IX	4/ 3/46	B-29 B	A0S196	22,000 G.S.	20,000	274	300°	1057	156	224°	MISS	—	—	—	—	—	—	
16	IX	4/ 3/46	B-29 C	A0S212	22,000 G.S.	25,000	273	310°	1124	137	253°	MISS	—	—	—	—	—	—	
17	IX	4/ 3/46	B-29 A	A0S198	22,000 G.S.	20,000	270	315°	1211	250	275°	MISS	—	—	—	—	—	—	HIT IN RIVER
18	—	4/ 4/46	B-29 D	—	M56A2	25,000	281	280°	1221	136	114°	HIT ON 7 METER ROOF	HIT	—	—	—	—	—	PRACTICE DROP
19	—	4/ 4/46	B-29 B	—	M56A2	20,000	281	280°	1234	176	116°	HIT ON 7 METER ROOF	HIT	—	—	—	—	—	PRACTICE DROP
20	—	4/ 4/46	B-29 C	—	M56A2	20,000	281	280°	1244	460	106°	MISS	—	—	—	—	—	—	PRACTICE DROP
21	—	4/ 4/46	B-29 B	—	M56A2	20,000	281	280°	1254	69	246°	HIT ON 4 1/2 METER ROOF	HIT	—	—	—	—	—	PRACTICE DROP
22	—	4/ 4/46	B-29 B	—	M56A2	20,000	281	270°	1304	16	185°	HIT ON 4 1/2 METER ROOF	HIT	—	—	—	—	—	PRACTICE DROP
23	—	4/ 4/46	B-29 B	—	M56A2	20,000	281	280°	1313	178	054°	MISS	—	—	—	—	—	—	PRACTICE DROP
24	—	4/ 4/46	B-29 B	—	M56A2	20,000	281	280°	1323	96	179°	MISS	—	—	—	—	—	—	PRACTICE DROP
25	—	4/ 4/46	B-29 B	—	M56A2	20,000	281	278°	1333	154	080°	MISS	—	—	--	—	—	—	PRACTICE DROP
26	X	4/ 4/46	B-17 D	VA505	4500 CP/MA	20,000	218	306°	1514	61	117°	HIT ON 4 1/2 METER ROOF	BROKE UP	DUMMY	FUNCTIONED	4'-9"	14'-5"	12'-1"	BOMB REBOUNDED AND NOSE BROKE OFF. NOSE SECTION OF CASE BROKE IN TWO PIECES
27	X	4/ 4/46	B-17 E	VA491	4500 CP/MA	20,000	219	192°	1531	147	293°	MISS	—	—	—	—	—	—	
28	X	4/ 4/46	B-17 D	VA499	4500 CP/MA	20,000	218	304°	1535	58	076°	HIT ON 4 1/2 METER ROOF	OK.	DUMMY	FUNCTIONED	4'-6"	13'-9"	15'-4"	SCARRED UNDERSIDE OF ROOF

Inclosure 5, page 1

PLOT NO.	TRIAL NO.	DATE	AIRCRAFT NUMBER	BOMB NUMBER	BOMB TYPE	TRUE ALTITUDE	TRUE AIRSPEED	MAG. HEADING	TIME OF RELEASE	SCORE: DISTANCE IN YARDS FROM BULLSEYE	SCORE: TRUE BEARING FROM BULLSEYE	TYPE OF IMPACT	CASE STRENGTH	INSENSITIVITY OF EXPLODER SYSTEM	RELIABILITY OF PISTOLS AND FUZES	CRATER DATA: DEPTH OF SPALLING	CRATER DATA: DIAMETERS LENGTH	CRATER DATA: DIAMETERS WIDTH	REMARKS
29	I	4/ 4/46	B-17 E	VA462	4500 CP/RA	20,000	219	156°	1546	86	298°	HIT ON 4 1/2 METER ROOF	OK.	DUMMY	FUNCTIONED	5'-6"	14'-6"	14'-3"	BOMB BOUNCED OUT OF CRATER AND [illegible]
30	II	4/15/46	B-29 C	A08189	22,000 G.S.	20,000	275	090°	1009	102	305°	HIT ON 4 1/2 METER ROOF	BROKE UP	NOT RECOVERED	NOT RECOVERED	7'-8"	31'-3"	27'-8"	HIT CLOSE TO WEST EDGE
31	II	4/15/46	B-29 D	A08100	22,000 G.S.	20,000	275	020°	1014	117	130°	HIT ON 4 1/2 METER ROOF	BROKE UP	ONE EXPLODER DETONATED ON SEC. IMPACT	FUNCTIONED OK.	8'-8"	—	18'-8"	HIT CLOSE TO SOUTH EDGE BY VENTILATOR SHAFT
32	XII	4/26/46	B-17 E	VA534	4500 CP/RA	20,000	217	147°	0952	98	354°	MISS	—	—	—	—	—	—	
33	XII	4/26/46	B-17 A	VA479	4500 CP/RA	DROPPED IN TRAIN				102	019°	MISS	—	—	—	—	—	—	
34	XII	4/26/46	B-17 G	VA1302	4500 CP/RA	20,000	222	170°	1005	116	357°	MISS	—	—	—	—	—	—	
35	XII	4/26/46	B-17 O	VA503	4500 CP/RA	DROPPED IN TRAIN				117	354°	MISS	—	—	—	—	—	—	ROCKETS DID NOT FUNCTION
36	XII	4/26/46	B-17 F	VA496	4500 CP/RA	20,000	220	235°	1007	82	025°	MISS	—	—	—	—	—	—	BOMB FELL FLAT
37	XII	4/26/46	B-17 D	VA476	4500 CP/RA	20,000	220	299°	1009	64	090°	HIT ON 4 1/2 METER ROOF	BROKE UP	ONE EXPLODER BROKEN OFF & DETONATED ON SEC. IMPACT	FUNCTIONED (CAPS FIRED)	5'-3"	14'-3"	12'-8"	ROCKETS PARTIALLY FUNCTIONED HIT AT INTERSECTION OF FOUR SLABS
38	XII	4/26/46	B-17 F	VA1005	4500 CP/RA	20,000	220	232°	1029	95	359°	MISS	—	—	—	—	—	—	ROCKETS DID NOT FUNCTION
39	XII	4/26/46	B-17 D	VA595	4500 CP/RA	20,000	220	308°	1040	3	095°	HIT ON 4 1/2 METER ROOF	OK.	OK.	SAFETY PINS IN PLACE	4'-4"	15'-0"	16'-0"	ROCKETS DID NOT FUNCTION
40	XII	4/26/46	B-17 E	VA475	4500 CP/RA	20,000	220	275°	1130	224	051°	MISS	—	—	—	—	—	—	
41	XII	4/26/46	B-17 H	VA1041	4500 CP/RA	DROPPED IN TRAIN			1150	295	054°	MISS	—	—	—	—	—	—	
42	VI	4/30/46	B-17 R	A087-1 17	2000 S.A.P.	26,250	225	026°	0954	142	269°	MISS	—	—	—	—	—	—	
43	VI	4/30/46	B-17 E	A087-1 13	2000 S.A.P.	26,250	225	208°	1009	89	304°	HIT ON 4 1/2 METER ROOF	OK. DENTED	BOOSTERS OK.	NONE	2'-7"	14'-6"	8'-8"	RICOCHETED OFF BUILDING ABOUT 100 FEET FROM IMPACT
44	VI	4/30/46	B-17 J	A087-1 25	2000 S.A.P.	26,250	220	315°	1012	850	285°	MISS	—	—	—	—	—	—	HIT IN RIVER
45	VI	4/30/46	B-17 O	A087-1 18	2000 S.A.P.	26,250	224	210°	1020	420	138°	MISS	—	—	—	—	—	—	
46	VI	4/30/46	B-17 J	A087-1 26	2000 S.A.P.	26,250	220	330°	1022	142	095°	MISS	—	—	—	—	—	—	
47	VI	4/30/46	B-17 F	A087-1 27	2000 S.A.P.	26,250	224	240°	1025	300	302°	MISS	—	—	—	—	—	—	
48	VI	4/30/46	B-17 D	A087-1 22	2000 S.A.P.	26,250	230	275°	1025	97	223°	MISS	—	—	—	—	—	—	
49	VI	4/30/46	B-17 Q	A087-1 21	2000 S.A.P.	26,250	244	280°	1057	340	073°	MISS	—	—	—	—	—	—	
50	VI	4/30/46	B-17 D	A087-1 16	2000 S.A.P.	26,250	230	275°	1104	382	226°	MISS	—	—	—	—	—	—	
51	VI	5/ 4/46	B-17 E	13A08 71	2000 S.A.P.	26,250	225	000°	1500	180	095°	MISS	—	—	—	—	—	—	WOBBLED IN FLIGHT
52	VI	5/ 4/46	B-17 E	[illegible]A08 71	2000 S.A.P.	DROPPED IN TRAIN			1500	190	210°	MISS	—	—	—	—	—	—	
53	VI	5/ 4/46	B-17 J	4A0871	2000 S.A.P.	26,250	238	357°	1501	389	103°	MISS	—	—	—	—	—	—	
54	VI	5/ 4/46	B-17 J	32A05 71	2000 S.A.P.	DROPPED IN TRAIN			1501	349	098°	MISS	—	—	—	—	—	—	
55	VI	5/ 4/46	B-17 H	33A08 71	2000 S.A.P.	26,250	238	320°	1519	138	101°	HIT ON 4 1/2 METER ROOF	BROKE UP	MISSING	NONE	2'-10"	12'-0"	10'-0"	BROKE OFF ABOUT 4' FROM NOSE WITH CRACK TO NOSE
56	VI	5/ 4/46	B-17 H	30A05 71	2000 S.A.P.	DROPPED IN TRAIN			1519	102	090°	MISS	—	—	—	—	—	—	
57	VI	5/ 4/46	B-17 Q	14A08 72	2000 S.A.P.	—	—	—	1528	300	310°	MISS	—	—	—	—	—	—	ACCIDENTAL RELEASE
58	VI	5/ 4/46	B-17 Q	29A08 71	2000 S.A.P.	26,250	244	358°	1546	205	263°	MISS	—	—	—	—	—	—	HIT IN RIVER

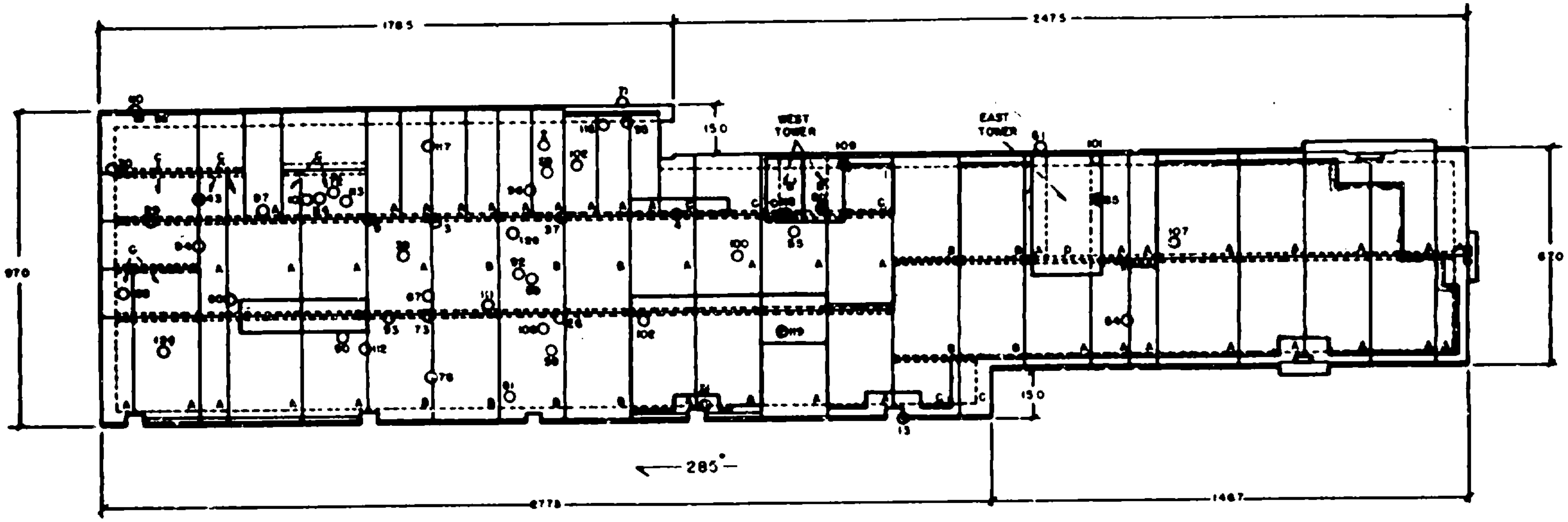
Inclosure 5, Annex 2

PLOT NO.	TRIAL NO.	DATE	AIRCRAFT NUMBER	BOMB NUMBER	BOMB TYPE	TRUE ALTITUDE	TRUE AIRSPEED	MAG. HEADING	TIME OF RELEASE	SCORE: DISTANCE IN YARDS FROM BULLSEYE	SCORE: TRUE BEARING FROM BULLSEYE	TYPE OF IMPACT	CASE STRENGTH	SENSITIVITY OF EXPLODER SYSTEM	RELIABILITY OF PISTOLS AND FUZES	CRATER DATA: DEPTH OF SPALLING	CRATER DATA: DIAMETERS LENGTH	CRATER DATA: DIAMETERS WIDTH	REMARKS
59	XII	5/ 4/46	B-17 D	VA1094	4500 CP/RA	20,000	220	300°	1558	86	131°	HIT ON 4 1/2 METER ROOF	OK	BOTH DETONATED	MISSING - PROBABLY BLOWN OUT	6'-8"	16'-5"	11'-6"	ROCKETS DID NOT FUNCTION. BOMB BENT
60	XII	5/ 4/46	B-17 D	VA1083	4500 CP/RA	20,000	220	300°	1631	57	274°	HIT ON 4 1/2 METER ROOF	OK.	BOTH DETONATED	ONE PISTOL FUNCTIONED. HEAD OF OTHER FOUND	5'-9"	12'-8"	16'-4"	UNDERSIDE OF GIRDER PUSHED DOWN ABOUT 18"
61	VI	5/ 6/46	B-17 O	2A08 71	2000 S.A.P.	26,250	245	197°	1056	231	092°	MISS	CRACKED	BOOSTERS OK.	NONE	4'-0"	8'-0"	7'-0"	HIT ON FOOTING OF BUILDING
62	VI	5/ 6/46	B-17 G	11A08 71	2000 S.A.P.	DROPPED IN TRAIN			1056	72	162°	MISS	—	—	—	—	—	—	
63	VI	5/ 6/46	B-17 P	15A08 72	2000 S.A.P.	25,240	224	155°	1057	2 MILES N.W.		MISS	—	—	—	—	—	—	ACCIDENTAL
64	VI	5/ 6/46	B-17 P	20A08 71	2000 S.A.P.	DROPPED IN TRAIN			1057	OF TARGET		MISS	—	—	—	—	—	—	RELEASE
65	VI	5/ 6/46	B-17 E	8A08 71	2000 S.A.P.	26,250	228	210°	1113	265	032°	MISS	—	—	—	—	—	—	
66	VI	5/ 6/46	B-17 E	6A08 71	2000 S.A.P.	DROPPED IN TRAIN			1113	193	185°	MISS	—	—	—	—	—	—	
67	VI	5/ 6/46	B-17 A	1A08 73	2000 S.A.P.	26,250	238	191°	1202	397	111°	MISS	—	—	—	—	—	—	
68	VI	5/ 6/46	B-17 H	10A08 72	2000 S.A.P.	DROPPED IN TRAIN			1202	440	106°	MISS	—	—	—	—	—	—	
69	VI	5/ 6/46	B-17 D	6A08 71	2000 S.A.P.	26,850	224	215°	1216	192	299°	MISS	—	—	—	—	—	—	
70	VI	5/ 6/46	B-17 D	9A08 71	2000 S.A.P.	DROPPED IN TRAIN			1216	104	243°	MISS	—	—	—	—	—	—	
X_1	VI	5/ 6/46	B-17 J	5A08 71	2000 S.A.P.	ACCIDENTAL RELEASE			1137	12 MILES	132°	MISS	—	—	—	—	—	—	ACCIDENTAL
X_2	VI	5/ 6/46	B-17 J	7A08 71	2000 S.A.P.	DROPPED IN TRAIN			1137	12 MILES	132°	MISS	—	—	—	—	—	—	RELEASE
71	VI	5/ 7/46	B-17 E	25A08 71	2000 S.A.P.	20,000	220	149°	1135	94	374°	MISS	OK.	BOOSTERS OK.	NONE	3'-0"	5'-0"	7'-0"	HIT ON FOOTING OF BUILDING
72	VI	5/ 7/46	B-17 E	39A08 71	2000 S.A.P.	20,000	220	144°	1149	34	337°	HIT ON 4 1/2 METER ROOF	OK.	OK.	NONE	3'-10"	10'-0"	13'-0"	BOMB HIT AT EDGE OF OLD CRATER
73	VI	5/ 7/46	B-17 O	37A08 72	2000 S.A.P.	20,000	220	156°	1151	80	194°	HIT ON 4 1/2 METER ROOF	OK. DENTED	OK.	NONE	3'-8"	12'-0"	7'-0"	HIT AT EDGE OF OLD CRATER. RICOCHETED 40'
74	VI	5/ 7/46	B-17 G	30A08 71	2000 S.A.P.	20,000	220	180°	1209	112	076°	MISS	—	—	—	—	—	—	
75	VI	5/ 7/46	B-17 F	32A08 72	2000 S.A.P.	20,000	205	164°	1210	157	320°	MISS	—	—	—	—	—	—	
76	VI	5/ 7/46	B-17 D	35A08 71	2000 S.A.P.	20,000	220	298°	1224	124	238°	MISS	—	—	—	—	—	—	
77	VI	5/ 7/46	B-17 F	28A08 71	2000 S.A.P.	20,000	205	175°	1234	245	093°	MISS	—	—	—	—	—	—	BOMB WOBBLED IN FLIGHT
78	VI	5/ 7/46	B-17 D	40A08 72	2000 S.A.P.	20,000	220	300°	1240	40	194°	HIT ON 4 1/2 METER ROOF	BROKE UP	EXPLODER BURNED	NONE	2'-8"	8'-8"	8'-8"	NOSE PORTION OF BOMB RICOCHETED 350', TAIL SECTION 50
79	VI	5/ 7/46	B-17 F	34A08 71	2000 S.A.P.	20,000	205	170°	1320	410	106°	MISS	—	—	—	—	—	—	
80	XII	5/ 7/46	B-17 J	VA1099	4500 CP/RA	20,000	216	285°	1502	143	099°	HIT ON WEST TOWER. PERF. 3 1/2 METERS	BROKE UP	ONE MISSING ONE DUMMY	PISTOLS MISSING	4'-0"	9'-8"	9'-8"	
81	XII	5/ 7/46	B-17 M	VA1477	4500 CP/RA	20,000	221	285°	1504	57	156°	HIT ON 4 1/2 METER ROOF	NOSE BROKEN OFF	BOTH DETONATED	MISSING PROBABLY BLOWN OUT	5'-0"	13'-0"	10'-8"	ROCKETS DID NOT FUNCTION. ARMING WIRE IN FUZE POT JACKET. BOMB REBOUNDED AND NOSE BROKE OFF
82	XII	5/ 7/46	B-17 J	VA518	4500 CP/RA	20,000	216	284°	1524	56	316°	MISS	—	—	—	—	—	—	
83	XII	5/ 7/46	B-17 E	VA1473	4500 CP/RA	20,000	225	290°	1534	234	099°	MISS	—	—	—	—	—	—	ROCKETS DID NOT FUNCTION. BOMB TUMBLED AND LANDED FLAT
84	XII	5/ 8/46	B-17 H	VA356	4500 CP/RA	20,000	220	285°	1507	250	109°	HIT ON 7 METER ROOF	OK.	ONE EXPLODER OK. ONE PARTIALLY BURNED	BOTH PISTOLS MISSING	4'-10"	11'-3"	12'-3"	

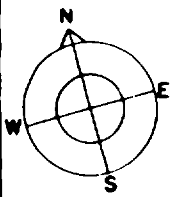
PLOT NO.	TRIAL NO.	DATE	AIRCRAFT NUMBER	BOMB NUMBER	BOMB TYPE	TRUE ALTITUDE	TRUE AIRSPEED	MAG. HEADING	TIME OF RELEASE	SCORE: DISTANCE IN YARDS FROM BULLSEYE	SCORE: TRUE BEARING FROM BULLSEYE	TYPE OF IMPACT	CASE STRENGTH	INSENSITIVITY OF EXPLODER SYSTEM	RELIABILITY OF PISTOLS AND FUZES	CRATER DATA: DEPTH OF SPALLING	CRATER DATA: DIAMETERS LENGTH	CRATER DATA: DIAMETERS WIDTH	REMARKS
85	XII	5/ 8/46	B-17 E	VA478	4500 CP/RA	20,000	220	320°	1341	242	101°	HIT ON EAST TOWER. 5 METERS	OK.	ONE EXPLODER OK. ONE DETONATED	ONE PISTOL WITH ARMING WIRE. LIVE DETONATORS	4'-4"	11'-0"	11'-0"	ROCKETS DID NOT FUNCTION
86	XII	5/ 9/46	B-17 D	VA350	4500 CP/RA	20,000	220	300°	1213	66	174°	MISS	—	—	—	—	—	—	ROCKETS DID NOT FUNCTION
87	XII	5/ 9/46	B-17 D	VA347	4500 CP/RA	20,000	220	310°	1258	19	143°	PERFORATED 4 1/2 METERS	OK.	NOT ASSESSABLE	NOT ASSESSABLE	5'-0"	12'-6"	13'-0"	ALSO PERFORATED GROUND FLOOR
88	XII	5/ 9/46	B-17 F	VA349	4500 CP/RA	20,000	220	008°	1417	95	201°	HIT ON 4 1/2 METER ROOF	OK.	OK.	ONE PISTOL OK. ONE SHEARED OFF	5'-5"	12'-4"	10'-6"	
89	XII	5/ 9/46	B-17 F	VA346	4500 CP/RA	20,000	220	[illegible]	1439	41	115°	PERFORATED 4 1/2 METERS	BROKE IN HALF	OK.	MISSING	4'-3"	13'-0"	13'-0"	BOMB STUCK IN GROUND FLOOR AND BROKE IN HALF
90	XXI	5/23/46	LANC S	[illegible]	12,000 T.B.	16,000	207	055°	1016	31	255°	HIT ON 4 1/2 METER ROOF	BROKE UP	BROKEN OFF NOT OK.	NONE	3'-6"	19'-0"	11'-0"	NOSE RICOCHETED 200 FEET
91	XXI	5/23/46	LANC S	[illegible]	12,000 T.B.	16,250	210	[illegible]	1052	94	054°	MISS	—	—	—	—	—	—	
92	XXI	5/24/46	LANC S	—	12,000 T.B.	10,000	207	025°	1126	[illegible]	108°	HIT ON 4 1/2 METER ROOF	BROKE UP	BROKEN OFF NOT OK.	NONE	4'-0"	17'-6"	16'-0"	
93	XXIa	6/19/46	LANC R	NO1099	12,000 T.B.	5,000	185	291°	0551		05°	HIT ON 4 1/2 METER ROOF	BROKE UP	OK.	FUNCTIONED OK.	3'-4"	14'-0"	13'-3"	BASE PLATE REBOUNDED 300 FEET
94	XXIa	6/19/46	LANC S	6	12,000 T.B.	5,000	185	291°	0551	67	280°	HIT ON 4 1/2 METER ROOF	BROKE UP	OK.	NOT RECOVERED	2'-7"	12'-0"	11'-6"	NOSE NOT LOCATED. BASE PLATE FOUND 350' FROM CRATER
95	XVIII	6/21/46	B-29 C	10511	22,000 T28	17,900	274	[illegible]	1008	[illegible]	078°	PERFORATED 4 1/2 METERS	BROKE UP	NONE	NOT RECOVERED	5'-9"	21'-8"	19'-0"	BROKE UP AFTER PERFORATION
96	XXIa	6/22/46	LANC S	E-189	22,000 G.S.	4,750	185	306°	0519	55	078°	HIT ON 4 1/2 METER ROOF	BOMB DENTED	OK.	NONE	5'-2"	17'-6"	14'-6"	
97	XXIc	6/22/46	LANC S	E-185	22,000 G.S.	4,750	185	308°	0549	48	308°	HIT ON 4 1/2 METER ROOF	BROKE UP	OK.	NONE	4'-0"	21'-6"	13'-4"	NOSE RICOCHETED 200 FEET OFF ROOF
98	XVIII	6/22/46	B-29 C	[illegible]	22,000 T28	17,500	265	281°	1136	104	294°	MISS	—	—	—	—	—	—	
99	XVIII	6/26/46	B-29 B	[illegible]	22,000 T28	17,500	275	290°	0923	127	144°	MISS	—	—	—	—	—	—	
100	XVIII	6/26/46	B-29 A	[illegible]	22,000 T28	17,500	260	295°	0942	180	106°	PERFORATED 4 1/2 METERS	BROKE UP ON SECD. IMPACT	NONE	SENT TO PICATINNY	5'-0"	18'-0"	15'-0"	BASE PLATE FOUND 400' FROM SECONDARY IMPACT
101	XVIII	6/28/46	B-29 C	A0010	22,000 T28	17,500	265	290°	1012	239	097°	HIT CORNER OF EAST TOWER	BROKE UP	NONE	NOT RECOVERED	HIT ON CORNER OF EAST PERISCOPE TOWER			BOUNCED TO GROUND AND BROKE UP
102	XXIb	6/29/46	LANC S	PT-1	12,000 CR PAR	5,000	175	328°	0525	73	076°	HIT ON 4 1/2 METER ROOF	BROKE UP	NONE	NONE	3'-1"	14'-3"	12'-6"	HAD EXTERNAL WELD REINFORCEMENT. NOSE NOT FOUND
103	XXIb	6/29/46	LANC S	PT-2	12,000 CR PAR	5,000	175	270°	0601	216	078°	MISS	—	—	—	—	—	—	MANUAL RELEASE
104	XXIb	6/29/46	LANC T	PT-3	12,000 CR PAR	5,000	175	335°	1317	90	120°	HIT ON 7 METER ROOF	DENTED	NONE	NONE	3'-9"	—	—	RICOCHETED ABOUT 75 FEET
105	XVIII	6/30/46	B-29 A	[illegible]	22,000 T28	17,500	270	281°	0951	142	094°	MISS	—	—	—	—	—	—	
106	XVIII	6/30/46	B-29 B	[illegible]	22,000 T28	17,500	[illegible]	290°	0958	55	128°	HIT ON 4 1/2 METER ROOF	BROKE UP	NONE	SENT TO PICATINNY	7'-4"	21'-6"	16'-0"	BROKE ONE STEEL BEAM ON UNDERSIDE
107	XVIII	6/30/46	B-29 C	[illegible]	22,000 T28	17,500	270	274°	1016	264	104°	HIT ON 7 METER ROOF	OK.	NONE	SENT TO PICATINNY	10'-0"	30'-0"	20'-0"	LEVELED OUT IN CRATER
108	XVIII	6/30/46	B-29 A	[illegible]	22,000 T28	17,500	280	285°	1431	200	141°	MISS	—	—	—	—	—	—	
109	XVIII	6/30/46	B-29 C	[illegible]	22,000 T28	17,500	265	265°	1559	156	094°	HIT ON CORNER OF W. TOWER	BROKE UP	NONE	TWO SENT TO PICATINNY	HIT ON CORNER OF WEST PERISCOPE TOWER			SOME FRAGMENTS FLEW MORE THAN 700 YARDS
110	XIX	7/ 5/46	LANC B	A-46	1850 NOBEL	9,800	196	206°	0727	101	317°	HIT ON SIDE OF WALL	BASE PLATE OFF-BENT	NONE	NONE	—	—	—	GLANCED FROM WALL, HIT FOOTING AND RICOCHETED 300 FEET
111	XIX	7/ 6/46	LANC [illegible]	A-18	1850 NOBEL	9,800	196	215°	0701	34	131°	HIT ON 4 1/2 METER ROOF	BENT	NONE	NONE	3'-3"	8'-10"	9'-0"	BOUNCED OUT OF CRATER
112	XIX	7/ 6/46	LANC [illegible]	A-35	1850 NOBEL	9,400	196	[illegible]	0750	30	219°	HIT ON 4 1/2 METER ROOF	BENT	NONE	NONE	3'-2"	10'-6"	8'-0"	BOUNCED OUT OF CRATER
113	XXIa	7/ 7/46	LANC T	135	22,000 G.S.	10,000	204	320°	0605	28	340°	HIT ON 4 1/2 METER ROOF	BROKE UP	OK.	NONE	5'-2"	20' APPROX	17' APPROX	NOSE NOT LOCATED. HIT AT EDGE OF OLD T.B. CRATER
114	[illegible]	7/ 7/46	LANC R	PT-4	12,000 LB PAR	10,000	190	310°	0615	36	322°	HIT ON 4 1/2 METER ROOF	OK.	NONE	NONE	5'-6"	—	15'-0"	HIT AT EDGE OF OLD CRATER

PLOT NO.	TRIAL NO.	DATE	AIRCRAFT NUMBER	BOMB NUMBER	BOMB TYPE	TRUE ALTITUDE	TRUE AIRSPEED	MAG. HEADING	TIME OF RELEASE	SCORE: DISTANCE IN YARDS FROM BULLSEYE	SCORE: TRUE BEARING FROM BULLSEYE	TYPE OF IMPACT	CASE STRENGTH	INSENSITIVITY OF EXPLODER SYSTEM	RELIABILITY OF PISTOLS AND FUZES	CRATER DATA: DEPTH OF SPALLING	CRATER DATA: DIAMETERS LENGTH	CRATER DATA: DIAMETERS WIDTH	REMARKS
115	XIId	7/ 8/46	LANC S	F-5	12,000 T.B.PAR	10,000	210	316°	1831	125	214°	MISS	--	--	--	--	--	--	
116	XVIII	7/ 9/46	B-29 B	A0813	22,000 T28	17,500	276	260°	1142	61	071°	PERFORATED 4 1/2 METERS	BROKE UP	AUXILIARY BOOSTER OK.	NONE	7'-0"	19'-4"	23'-0"	FELL IN WATER OF LOCK CHAMBER
117	XVIII	7/ 9/46	B-29 C	A0815	22,000 T28	17,500	265	295°	1452	43	090°	PERFORATED 4 1/2 METERS	BROKE UP	NOT RECOVERED	NONE	6'-6"	17'-0"	20'-0"	FELL IN WATER OF LOCK CHAMBER
118	XVIII	7/ 9/46	B-29 A	A0812	22,000 T28	17,500	270	295°	1505	134	100°	HIT ON WEST TOWER & FELL TO MAIN ROOF	SLIGHTLY DENTED	OK	NONE	KNOCKED 11' 6" TOP LAYER OFF PERISCOPE TOWER			HIT ON 7 METERS BREAKING AWAY 3-1/2 METERS AND FELL TO MAIN ROOF
119	XII	7/11/46	B-29 B	A0814	22,000 T28	17,500	280	260°	1549	131	115°	HIT ON 7 METER ROOF	OK	OK	NONE	8'-6"	35'-0"	22'-6"	BOMB LEVELED OUT IN CRATER
120	XIX	7/13/46	LANC Z	A-6	1,650 MODEL	15,600	204	300°	0633	112	219°	MISS	—	—	—	—	—	—	
121	XIX	7/13/46	LANC B	A-11	1,650 MODEL	15,600	204	275°	0705	98	168°	MISS	—	—	—	—	—	—	
122	XIX	7/13/46	LANC B	A-38	1,650 MODEL	15,600	204	296°	0738	57	191°	MISS	—	—	—	—	—	—	
123	XIX	7/26/46	LANC B	A-31	1,650 MODEL	15,800	204	[illegible]	0932	98	235°	MISS	—	—	—	—	—	—	
124	XIX	7/26/46	LANC B	A-16	1,650 MODEL	15,600	207	298°	0942	77	266°	HIT ON 4-1/2 METER ROOF	BENT	NONE	NONE	4'-4"	10'-0"	10'-0"	REBOUNDED 50 FEET
125	XIX	7/26/46	LANC B	—	1,650 MODEL	15,300	207	310°	1717	91	206°	MISS	—	—	—	—	—	—	
126	XIX	7/26/46	LANC B	—	1,650 MODEL	15,400	207	295°	1804	67	182°	MISS	—	—	—	—	—	—	
127	XIX	7/28/46	LANC B	A-9	1,650 MODEL	15,900	207	310°	0600	262	10°	MISS	—	—	—	—	—	—	UNSTABLE IN EARLY FLIGHT
128	XIX	7/28/46	LANC B	A-36	1,650 MODEL	15,900	207	216°	0634	155	339°	MISS	—	—	—	—	—	—	

FARGE BOMB PLOT



TRIAL	TYPE OF BOMB	A/C	SV (FT/SEC)	PLOT NUMBERS
IX	FABRICATED GRAND SLAM	B29	1180	4,13,30,31
XXIE	" " "	LANC.	880	113
XXIC	" " "	"	810	96,97
XXID	FABRICATED TALLBOY	LANC.	840	114
XXIB	" "	"	810	102,104
XXI	CAST TALLBOY	"	880	90,92
XXIA	" "	"	820	93,94
XVIII	AMAZON	B29	1140	98,100,101,106,107,109,116,117,118,119
X	4500 LB CP/NON-RA	B17	1120	2,3,9,10,26,28,29,39,59,61,65
XII	4500 LB CP/RA	"	1450	37,60,80,84,87,88,89
VI	2000 LB SAP	"	1100	43,55,61
	" " "	"	1030	71,72,73,78
XIX	1000 LB MODEL CP/RA	LANC.	800	110,111,112
	" " " "	"	1080	124
	" " " "	"	1100	129



- NOTES -

ALL MEASUREMENTS ARE IN METRES

SHADING INDICATES THE BOUNDARY OF THE 7 M. ROOF

THE EAST TOWER HAS A 5 M. ROOF

THE EAST HALF OF THE WEST TOWER HAS A 3.5 M. ROOF

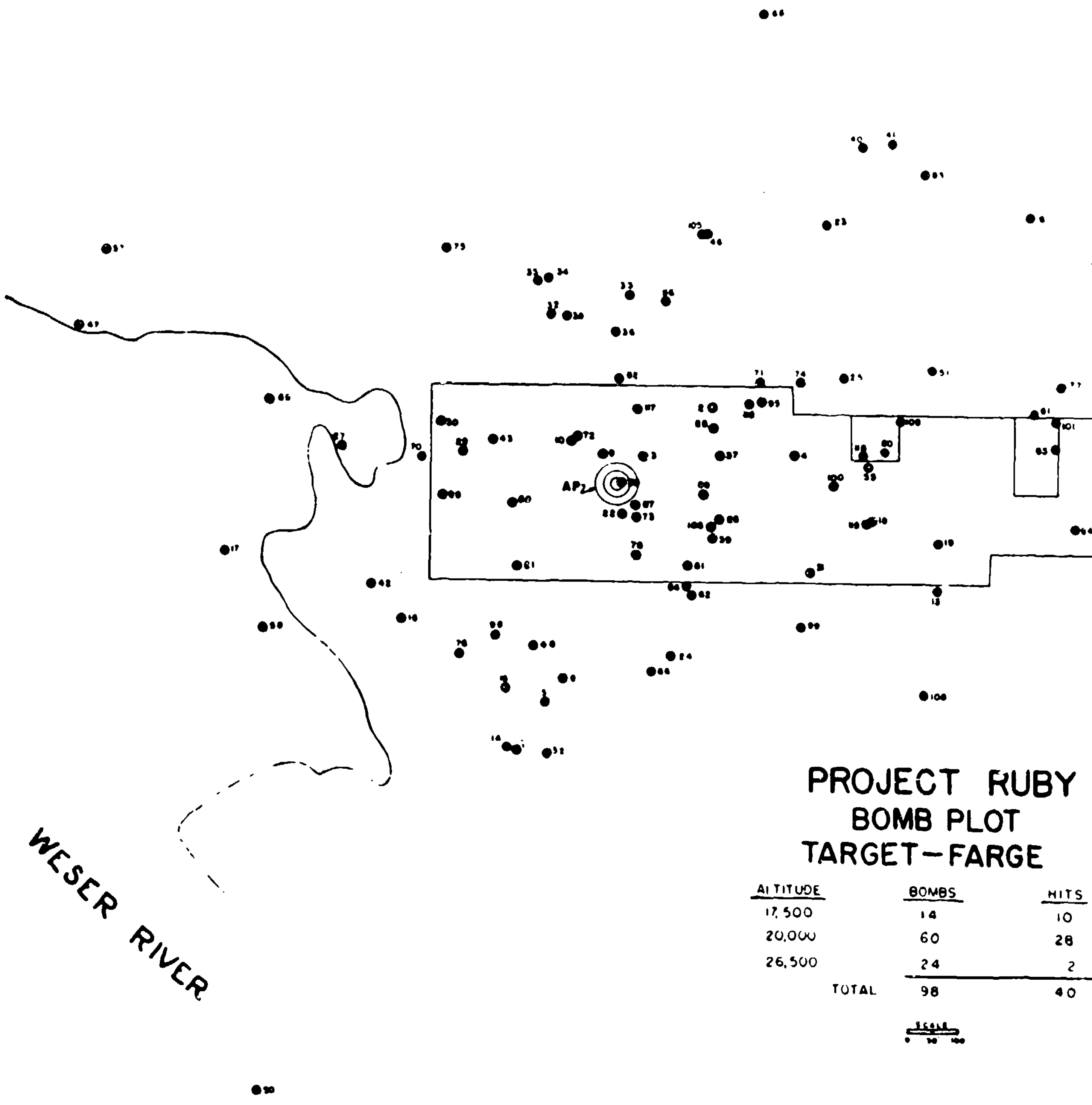
A= PRE-STRESSED REINFORCED CONCRETE TRUSSES

B=60 CM. I-BEAMS, B'= 100 CM. I-BEAMS

C= SHORT REINFORCED CONCRETE BEAMS

D= STEEL TRUSSES

SCALE-METERS 10 20 30 40 50 60 70 80 90

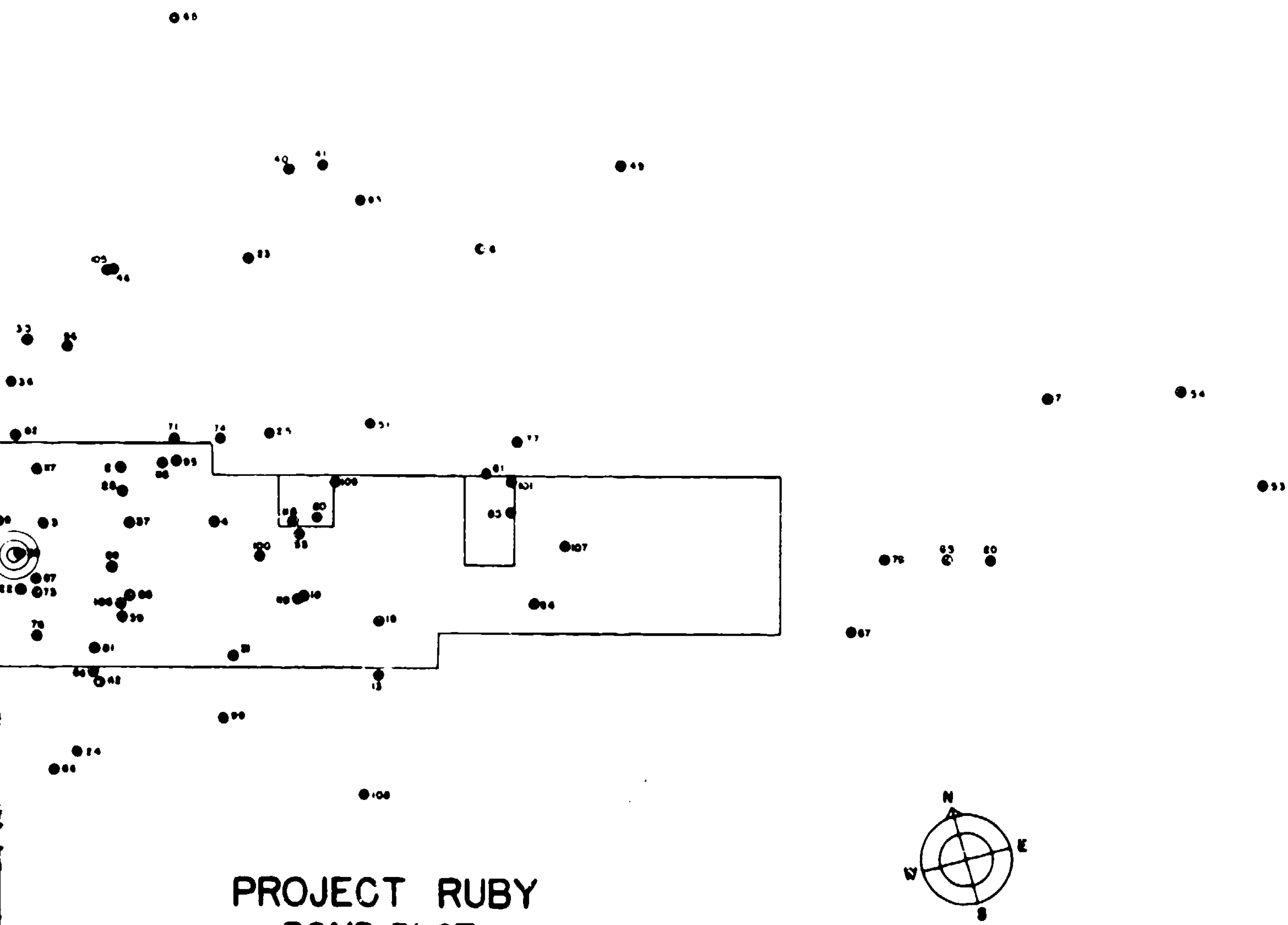


PROJECT RUBY
BOMB PLOT
TARGET—FARGE

ALTITUDE	BOMBS	HITS
17,500	14	10
20,000	60	28
26,500	24	2
TOTAL	98	40

ENCLOSURE 6, PAGE 2

~~CONFIDENTIAL~~



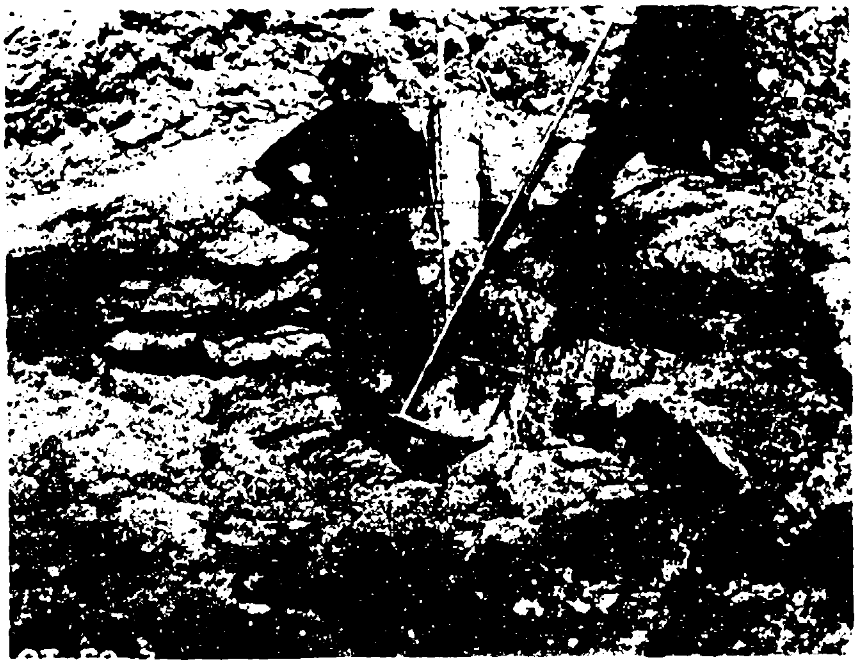
PROJECT RUBY
BOMB PLOT
TARGET—FARGE

ALTITUDE	BOMBS	HITS
17,500	14	10
20,000	60	28
26,500	24	2
TOTAL	98	40

~~CONFIDENTIAL~~

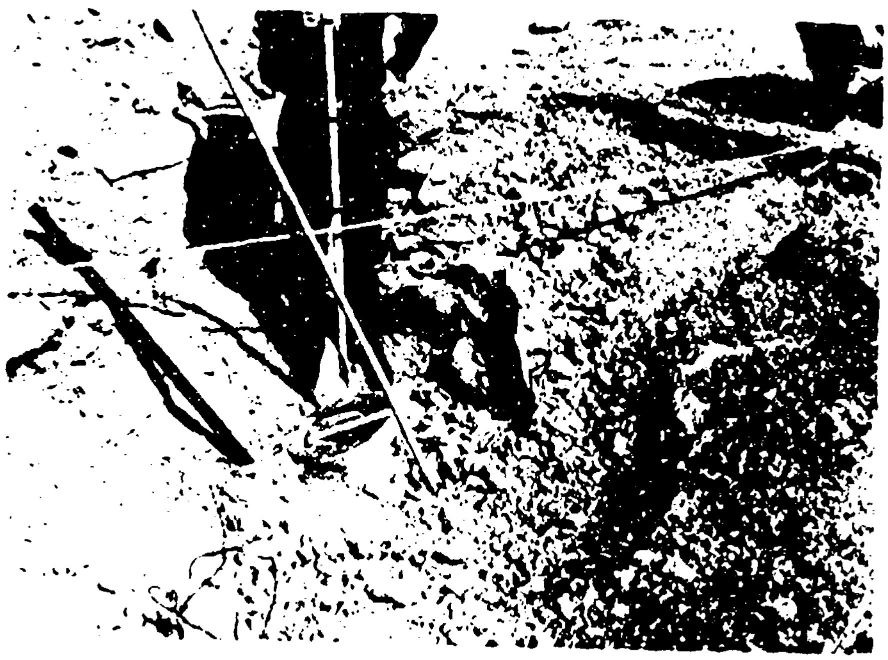
2

British 12,000-lb MC cast Tall Boy crater resulting from 20,000' release. Note shattered nose and base.



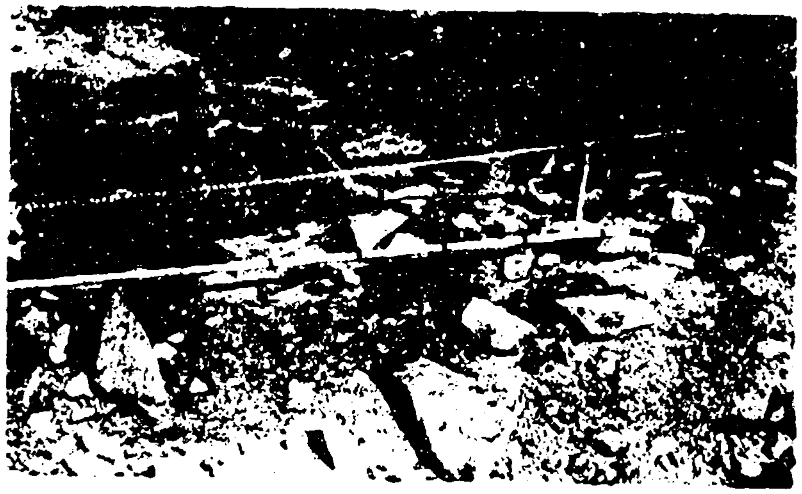
Photograph showing 4500-lb Disney bomb (Plot No. 2) lodged in roof of target. Bomb was dropped from 20,000 feet without rocket assist. Upper chord of a bowstring girder is visible in crater.

View showing scabbing of ceiling produced by 4500-lb. Disney bomb (Plot NO. 2). Lower chords of three bowstring girders have been scabbed.

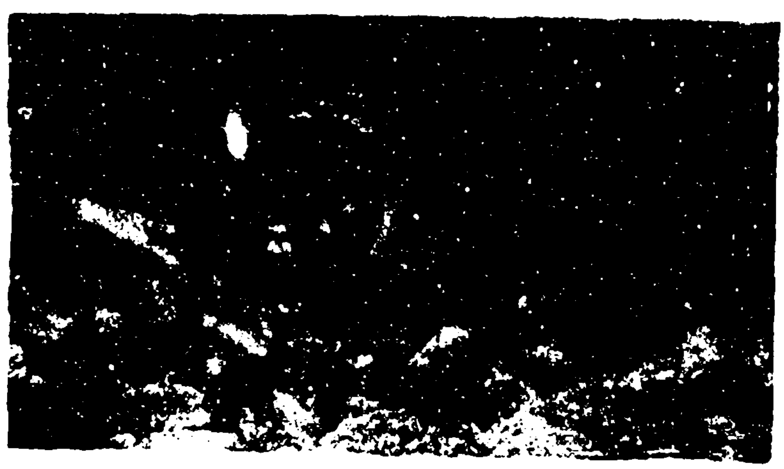


Photograph showing 4500-lb Dismey bomb (Plot No. 3) lodged in roof of target. Bomb was dropped from 20,000 feet without rocket assist.

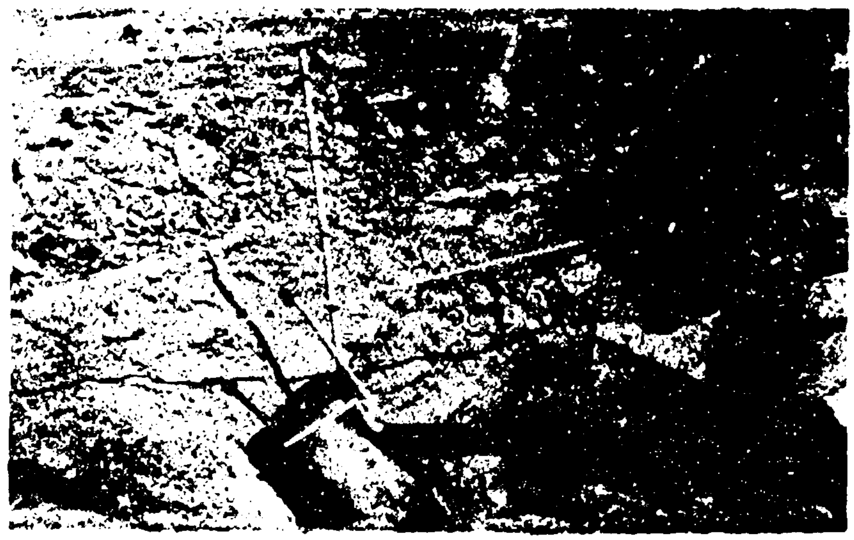
View of crater of 4500-lb. Disney bomb (Plot No. 9) dropped from 20,000 feet. Bomb struck at intersection of four roof slabs. Bomb broke up, leaving nose section lodged in crater.



View showing the fragments recovered from the rear portion of the 4500-lb Disney bomb (Plot No. 9) which broke up when dropped from 20,000 feet without rocket assist.



View of crater of 4500-lb Disney bomb (Plot No. 9) before removal of debris. Note base of bomb in crater.

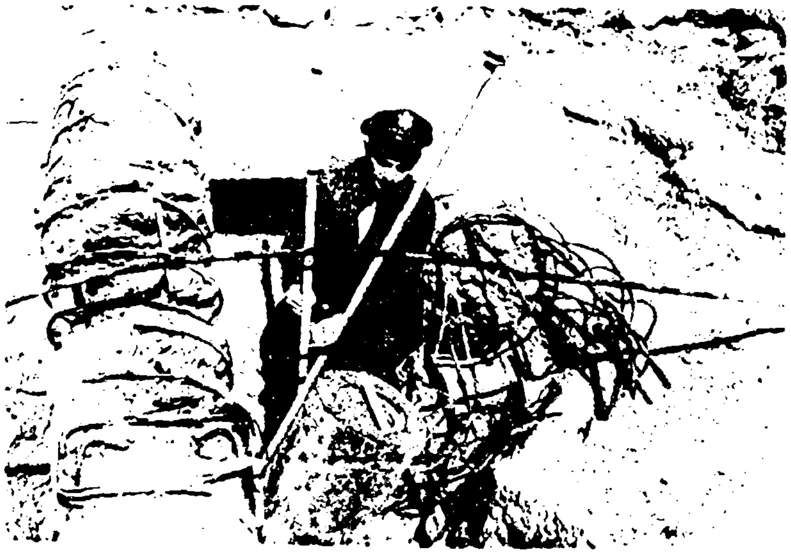


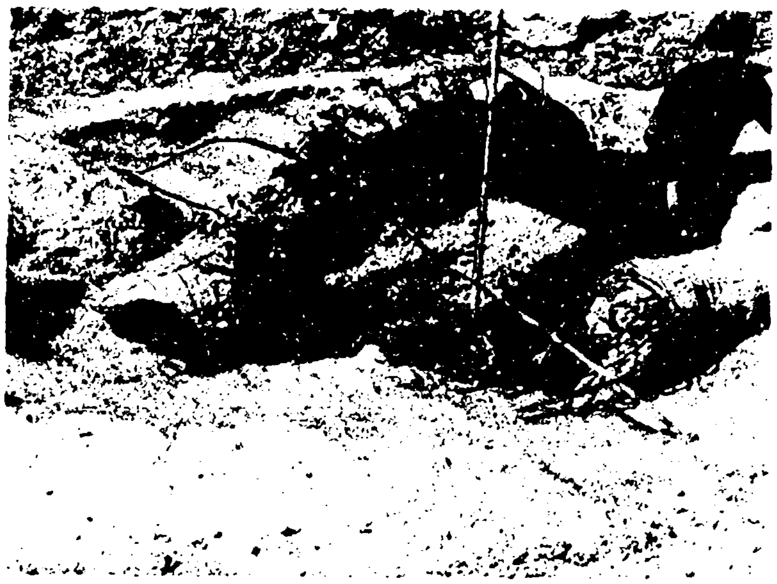
Two views of crater formed by 4500-lb. Disney bomb (Plot No. 10) dropped from 20,000-feet without rocket assist.

View of crater of 4500-lb Disney bomb (Plot No. 26) dropped from 20,000 feet. Bomb bounced out of crater and nose broke off due to internal flaws.

View showing location of bomb case and nose fragments of Disney bomb (Plot No. 26) on roof of target after bouncing out of crater. Man is standing at crater.

Upper view shows nose separated from bomb case (Plot No. 26).
Lower view shows how nose broke up due to internal flaws.
The dark areas on each piece represent the flaws. The fresh breaks have been covered with chalk to make them stand out.





Two views of crater formed by 4500-lb. Disney bomb (Plot No. 23) dropped from 20,000 feet without rocket assist. Bomb has damaged two bowstring girders.

Upper view shows crater of 4500-lb Disney bomb (Plot No. 29) dropped from 20,000 feet without rocket assist. Lower view shows where bomb came to rest after bouncing out of crater. Man is standing in crater.

View showing condition of bomb (Plot No. 29) after impact. Notice slight curvature of bomb case.

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Crater of rocket assisted 4500-lb Disney bomb (Plot No. 37) dropped from 20,000 feet. This bomb struck at junction of four roof slabs. Bomb broke up leaving nose section lodged in crater. Break-up is similar to that of unassisted Disney bomb, Plot No. 9, striking at junction of four roof slabs.

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Views showing fragments and base of bomb recovered from rocket assisted 4500-lb Disney hit (Plot No. 37). Bomb was dropped from 20,000 feet. Lower view shows one exploder tube blown and one intact.

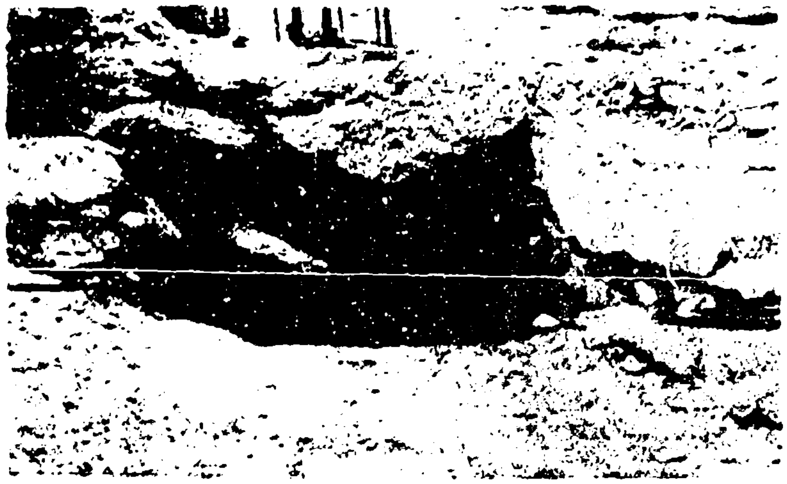
Views of crater of 4500-lb Disney bomb (Plot No. 39) dropped from 20,000 feet. Rockets did not function.

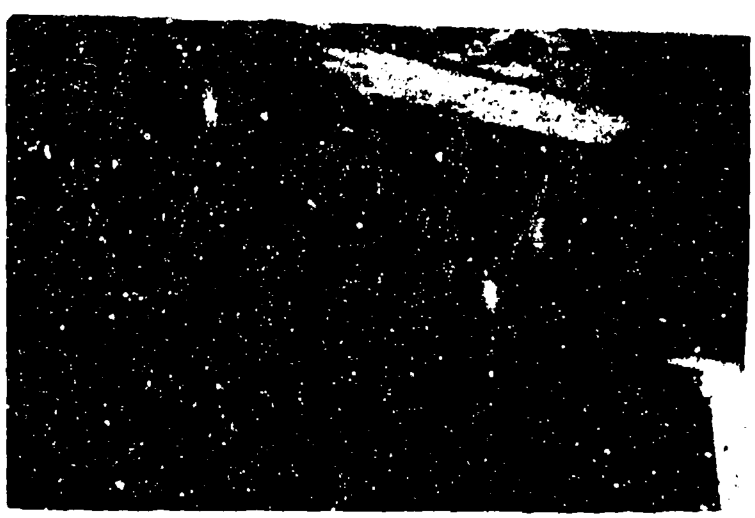
[redacted]

Views of crater of 4500-lb. Disney bomb (Plot No. 59) dropped from 20,000 feet. Rocket assist failed to function. Lower photograph shows bent condition of bomb case.

[redacted]

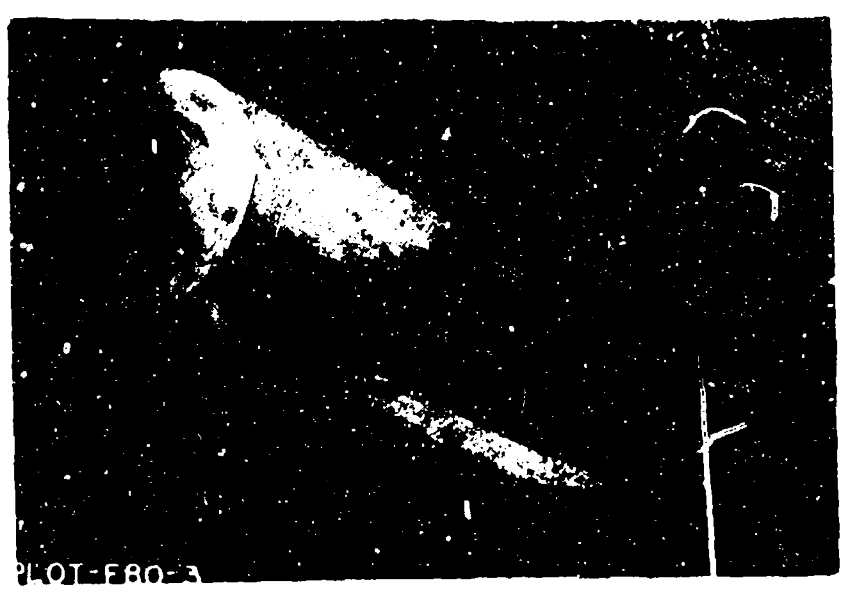
View showing crater of 4500-lb Disney bomb (Plot No. 60) dropped from 20,000 feet with rocket assist. Base of bomb is approximately seven feet below roof surface. Vertical face of adjacent roof slab is seen in background.





Upper view shows crater of 4,500-lb Disney bomb (Plot No. 60) dropped from 20,000 feet with rocket assist. Lower view shows scabbing of ceiling produced by this bomb. Lower chord of concrete bowstring girder has been deflected downward approximately 18 inches.

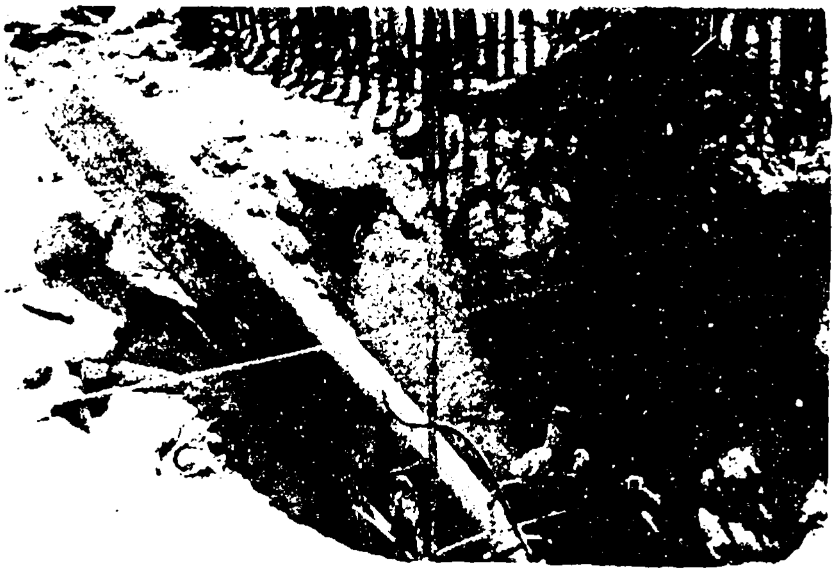
[redacted]



Upper view shows crater of 4500-lb Disney bomb (Plot No. 80) dropped from 20,000 feet with rocket assist. Bomb perforated 3 1/2 meter roof and broke up on floor of building. Lower view shows rear half of bomb as it was found in building after striking H-beam at right.

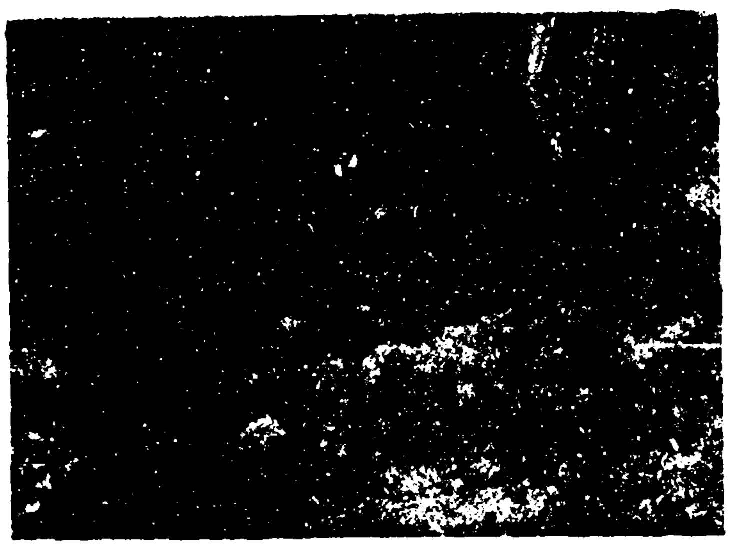
[redacted]

Views showing front half of Disney bomb (Plot No. 80) which broke up on floor of building after perforating West periscope tower roof. Upper view shows front end with nose broken off. Lower view shows circumferential break at other end of front half of bomb.



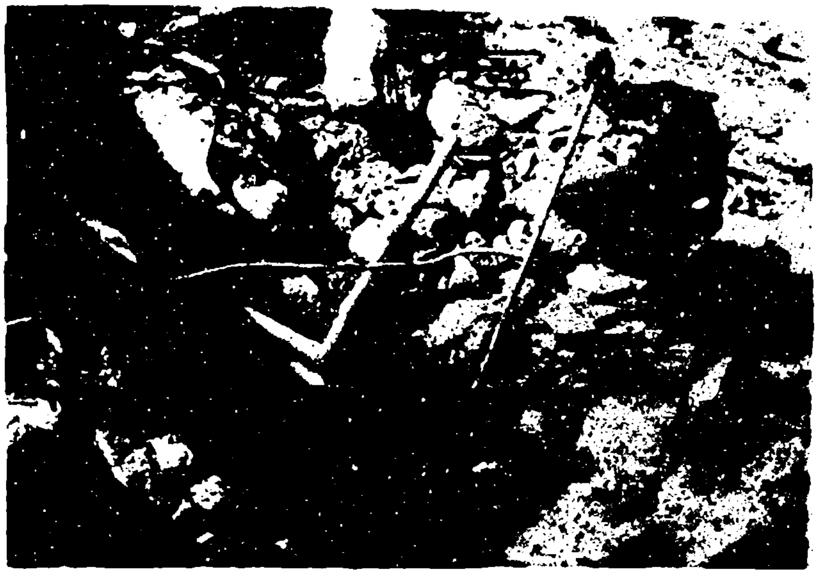
View of crater of 4500-lb Disney bomb (Plot No. 81) dropped from 20,000 feet. Rocket assist failed to function. Nose of bomb broke off due to a flaw.

CONFIDENTIAL

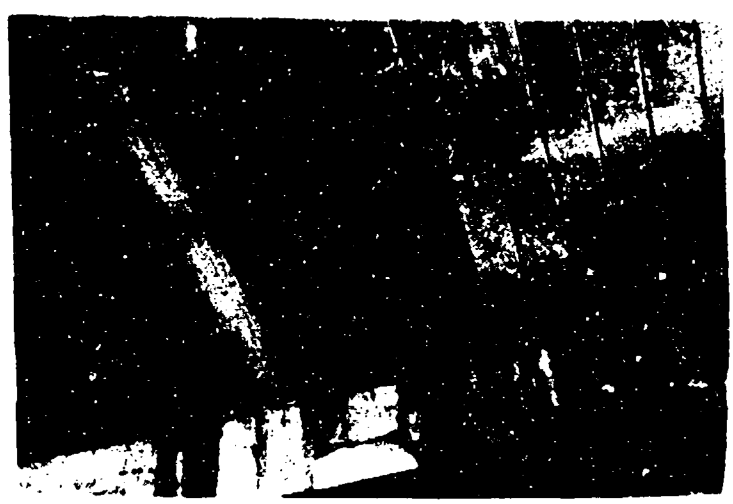


Views of crater of 4500-lb Disney bomb (Plot No. 84) dropped from 20,000 feet with rocket assist. Bomb struck on seven meter roof thickness and penetrated 15'-2". Base of bomb is visible in lower photograph.

View of crater of 4500-lb. Disney bomb (Plot No. 84) before removal of rubble. Rocket tube in crater bears evidence that rocket assist functioned properly. Intense heat at nozzle end produces characteristic markings which are clearly visible in photograph. End of tube has grey ash deposit between two narrow blued bands; rest of tube is blackened. If rocket assist fails to function in flight and tubes ignite upon impact, the markings at the nozzle end are much less pronounced, as the propellent burns from both ends of tube. For an example of burning after impact see Inclosure 7 , page. 25.

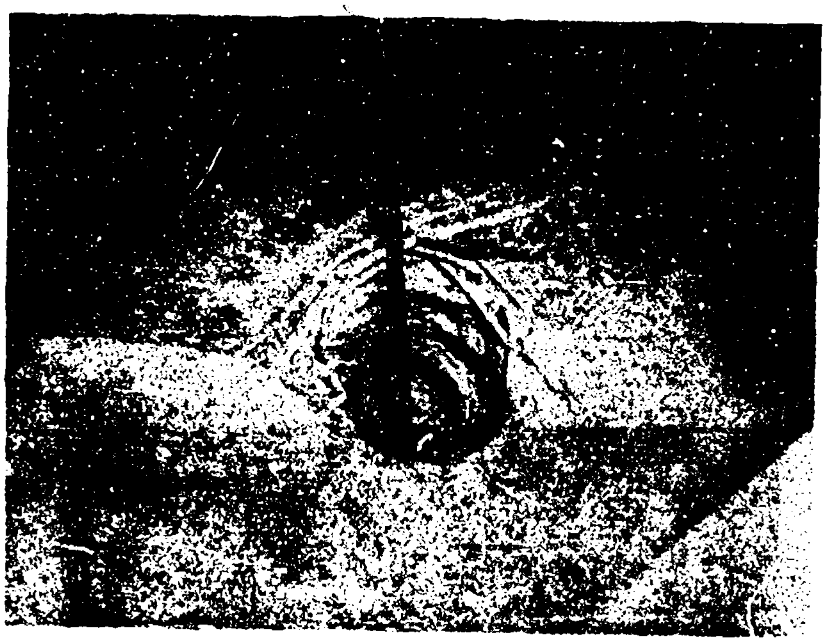


View of crater of 4500-lb. Disney bomb (Plot No. 85) dropped from 20,000 feet. Rocket assist failed to function as indicated by rocket tubes in lower view. Upper view shows trusses deflected laterally.

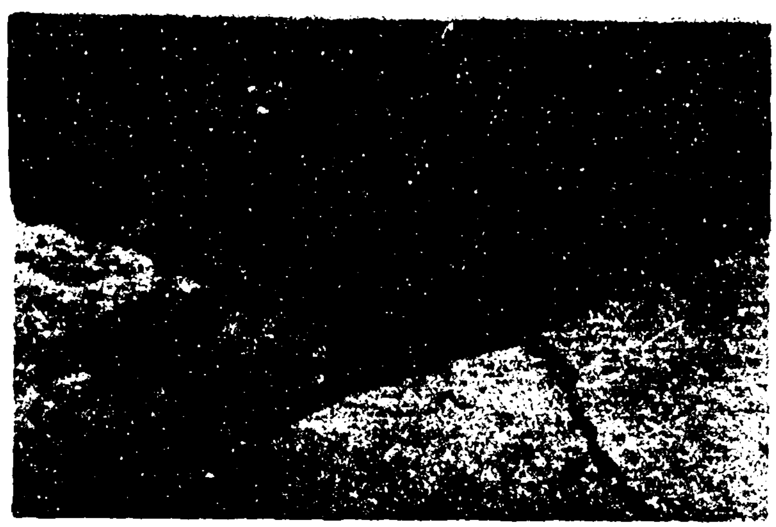


Views of roof perforation of 4500-lb. Disney bomb (Plot No. 87) dropped from 20,000 feet with rocket assist. The bomb passed through ceiling between two bowstring girders, damaging both, and scabbing a third girder.

CONFIDENTIAL



View of perforation hole in floor of building produced by 4500-lb. Disney bomb (Plot No. 87) dropped from 20,000 feet with rocket assist. Bomb buried in sand beneath floor after perforating 4 1/2 meter roof.



Views of crater of rocket assisted Disney bomb hit (Plot No. 58) obtained from 20,000 feet altitude. The bomb penetrated 13'-2" into roof slab.

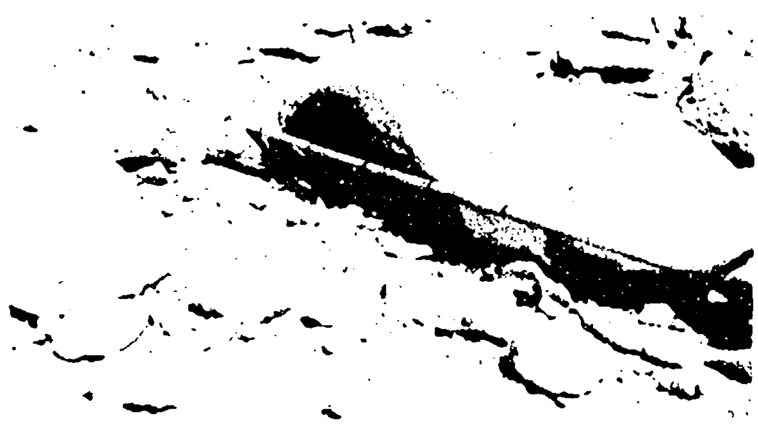
Upper view shows crater of 4500-lb. Disney bomb (Plot No. 89) dropped with rocket assist from 20,000 feet. Bomb perforated 4 1/2 meter roof and lodged in floor of building, breaking into two pieces as shown below.

Upper view shows crater of 2000-lb. SAP bomb (Plot No. 43) dropped from 26,250 feet. Bomb ricocheted off roof to ground. Lower view shows bomb intact but dented near rear lug.

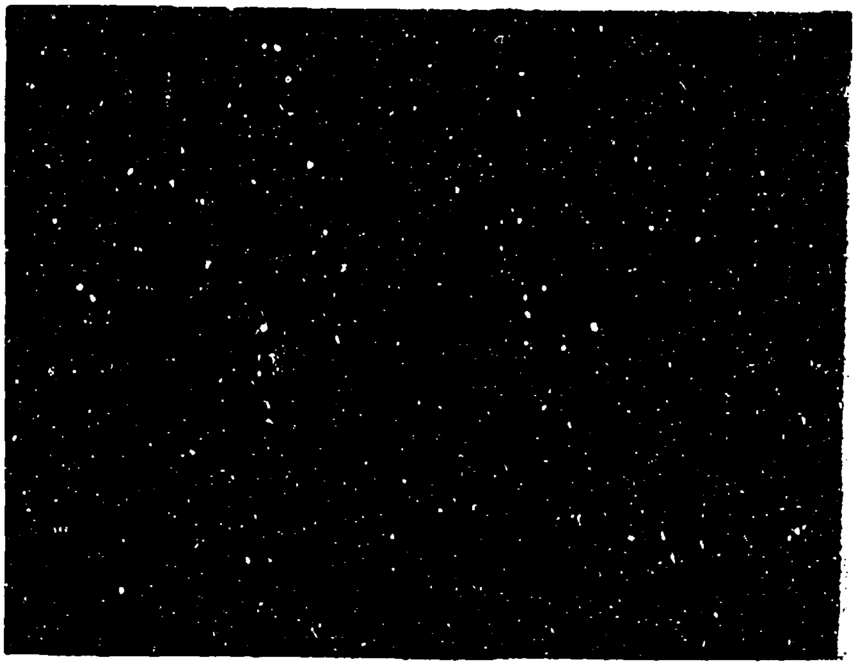
Upper view shows crater of 2000-lb. SAP bomb (Plot No. 55) dropped from 26,250 feet. Lower view shows recovered parts of the bomb. Adapter booster is missing from base plate.

Upper view shows nose section of broken 2000-lb. SAP bomb (Plot No. 55) as found in crater. Lower view shows lengthwise crack extending beyond front lug.

Views of crater of 2000-lb. SAP bomb (Plo. No. 72) dropped from 20,000 feet. Bomb bounced and fell back into crater with nose pointing opposite to heading.

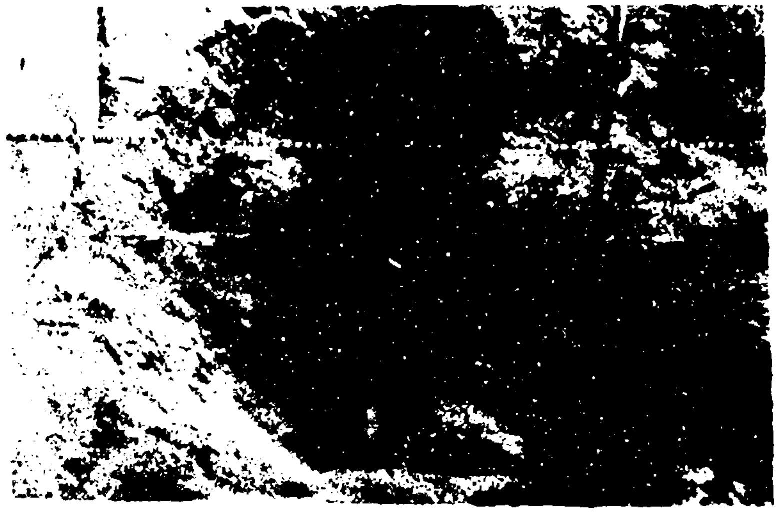


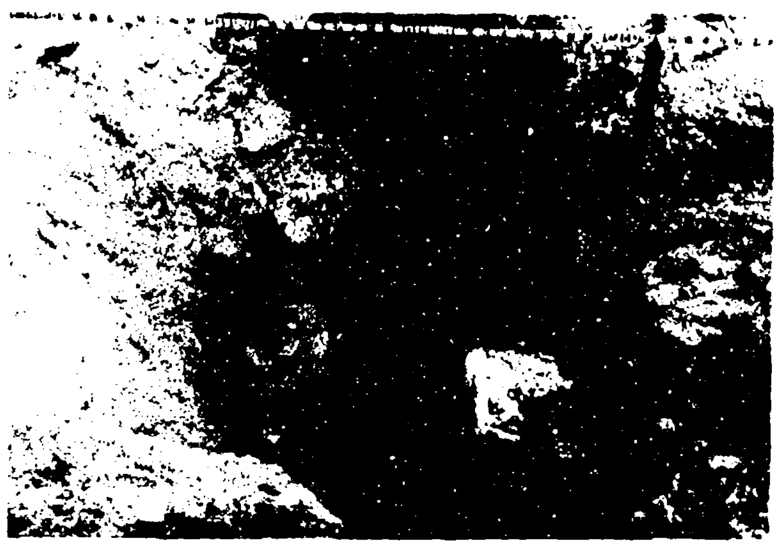
Upper view shows crater of 2000-lb. SAP bomb (Plot No. 73) dropped from 20,000 feet. Crater overlaps old Tall Boy crater. Lower view shows bomb after ricocheting 40 feet.



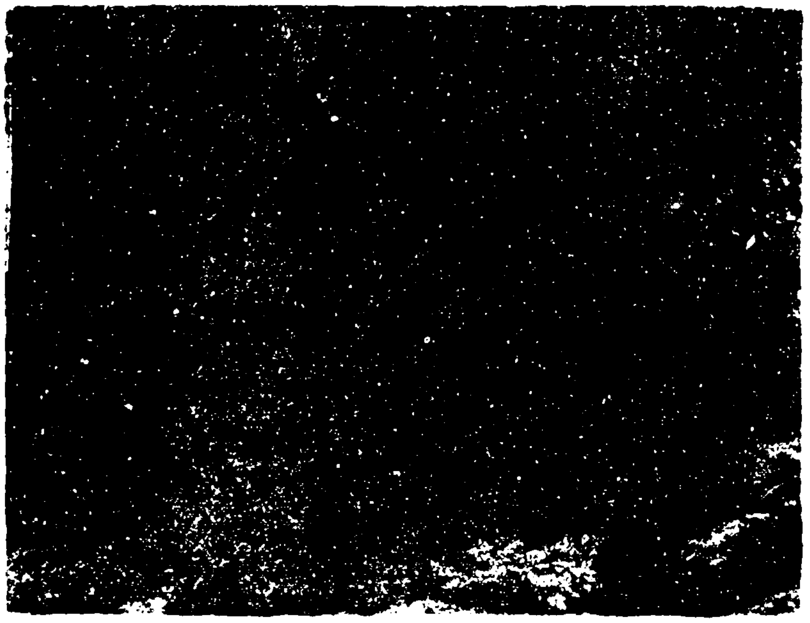
View of crater of 2000-lb. SAP bomb (Plot No. 78)
dropped from 20,000 feet. Bomb broke up and ricocheted.

Photographs of 2000-lb. SAP bomb (Plot No. 78) that broke up on impact. Nose ricocheted 350 feet. Bomb dropped from 20,000 feet.



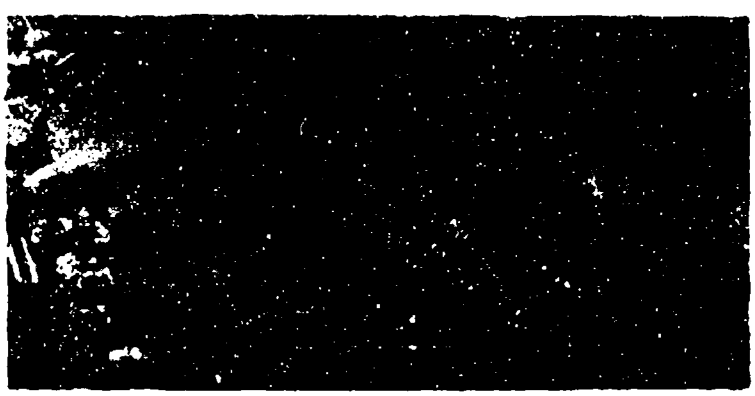


Views of crater of 2000-lb. SAP bomb (Plot No. 61) dropped from 26,250 feet. Bomb struck concrete footing at base of North wall of target. Bomb case was cracked and dented.



Views of crater and nose section of 22,000-lb. T 14 bomb (Plot No. 4) dropped from 20,000 feet. Bomb side swiped vertical face of second roof layer.

Views of concrete displaced by 22,000-lb. T 14 bomb (Plot No. 4) which struck at base of a slab of second roof layer.



Upper view shows inside of nose section of 22,000-lb. T 14 bomb (Plot No. 4). Note cracks running up to solid part of nose. Lower view shows base of bomb with circumferential break at rear weld.

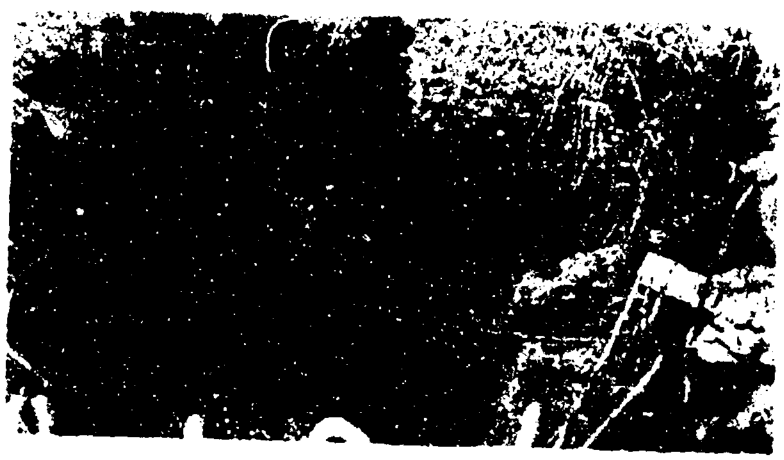
View of crater of 22,000-lb. T 14 bomb (Plot.No. 30) dropped from 20,000 feet. Bomb struck close to west edge of building and broke up.

View of recovered fragments of 22,000-lb. T 14 bomb (Plot No. 30). Nose section is seen at lower right.

[redacted]

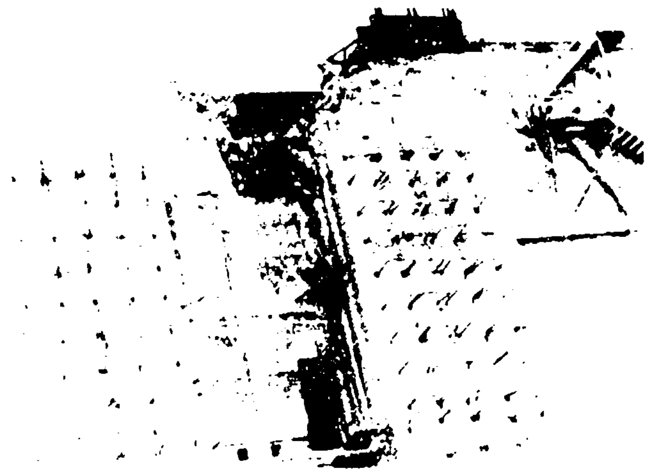
View showing bulge at top of west wall of Farge target, resulting from impact of 22,000-lb. T 14 bomb (Plot No. 30).

[redacted]



Views of crater of 22,000-lb. T 14 bomb (Plot No. 31) before and after cleaning out debris. Lower view shows nose of bomb with break extending into solid part of nose.

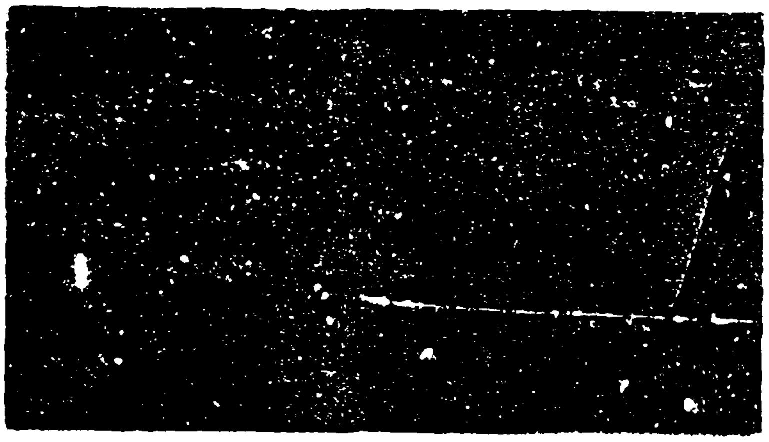
CONFIDENTIAL

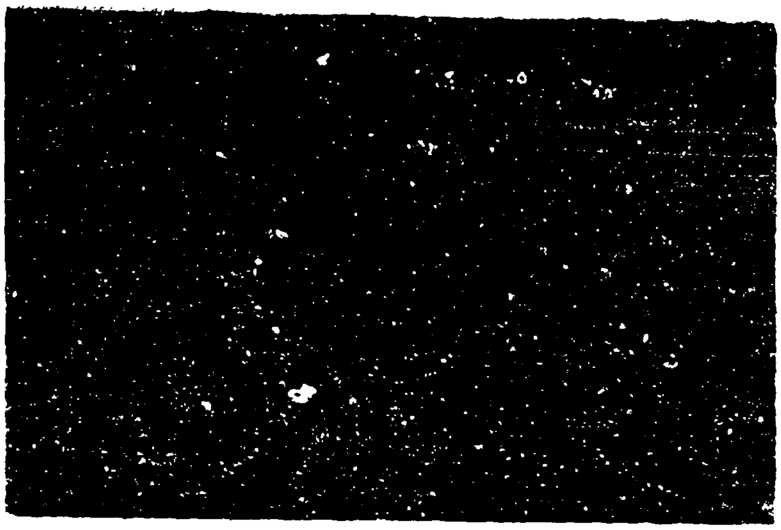


Upper view shows damage to south wall of building caused by 22,000-lb. T 14 bomb (Plot No. 31) dropped from 20,000 feet. Recess in wall is unfinished ventilator shaft. Lower view shows base plate found on ground.

Upper view shows base plate and ring of 22,000-lb. T 14 bomb (Plot No. 31). Finger points to groove where ring had been welded to bomb body. Lower view shows fragment which fits into groove of base ring. Note welding material partly stripped off of fragment.

Upper view shows crater of 12,000-lb. cast Tall Boy bomb (Plot No. 90) dropped from 10,000 feet. Lower view shows broken nose of this bomb found 225 feet ahead of crater. Note the exposed threads of nose plug.





Upper view shows some fragments recovered from 12,000-lb. cast Tall Boy bomb (Plot No. 90). Lower view shows base plate with two attached fragments bulged outward.

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Upper view shows crater of 12,000-lb. cast Tall Boy (Plot No. 92) dropped from 10,000 feet. Base of bomb is at crater edge. Lower view shows broken nose, cracked up to nose plug.

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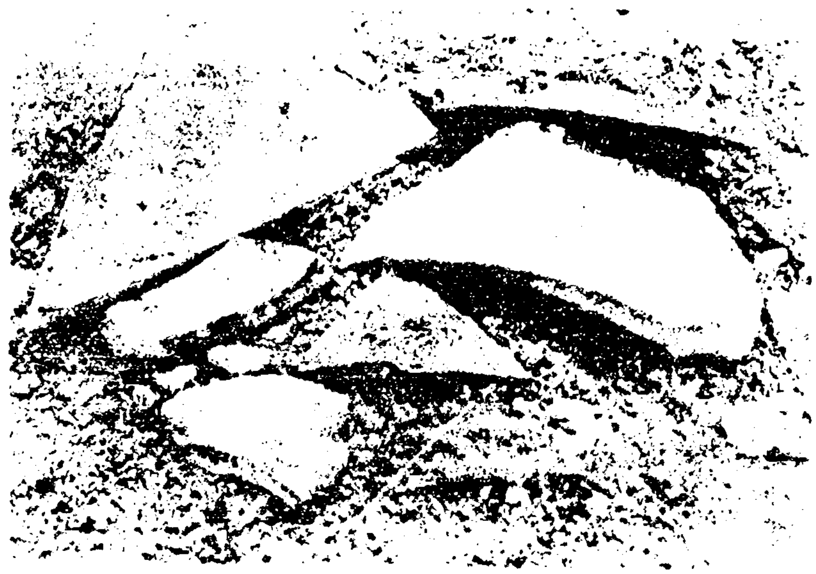
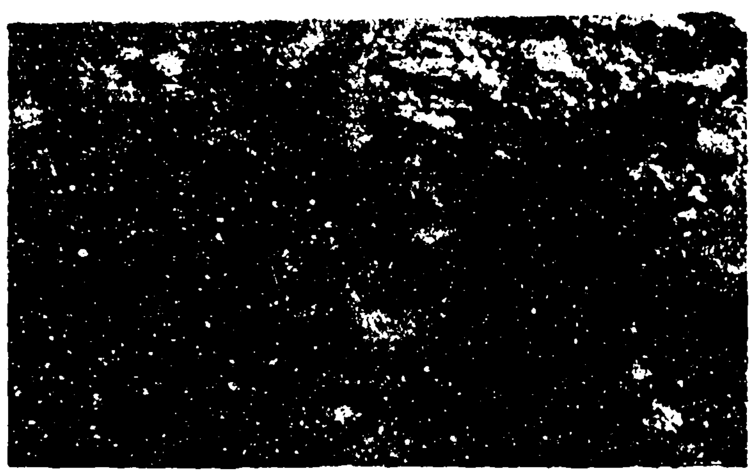


Fragments of various sizes recovered from 12,000-lb. cast Tall Boy (Plot No. 92). Lower view shows 4'-6" fragment from nose end.

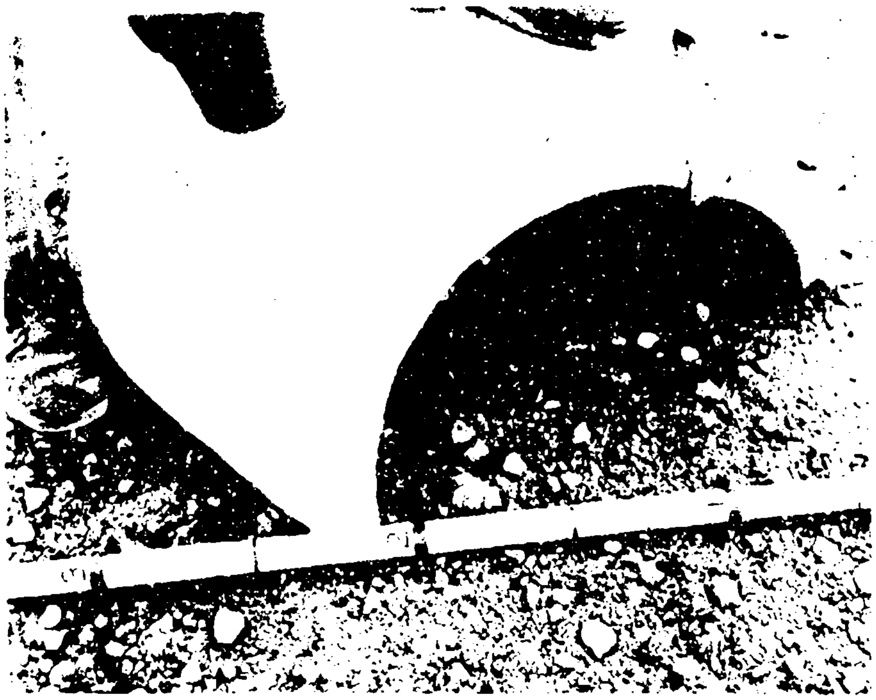
View of crater of 12,000-lb. cast Tall Boy bomb (Plot No. 93) dropped from 5000 feet. Nose section remained in crater. Lower view shows large nose fragment found near crater.



Lower view shows base of 12,000-lb. cast Tall Boy bomb (Plot No. 93). Attached fragment is three feet long. Upper view shows fragment which broke away from base plate.

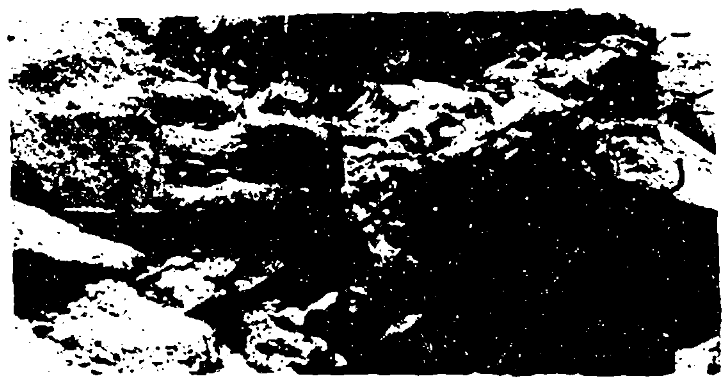
View of crater of 12,000-lb. cast Tall Boy bomb (Plot No. 94) dropped from 5000 feet. Lower view shows large fragment recovered. Note reverse curvature of projection.

Upper view shows crater of modified 12,000-lb. T 10 bomb (Plot No. 102) dropped from 5000 feet. Lower view shows broken base plate. Note the circumferential separation of the rear weld.



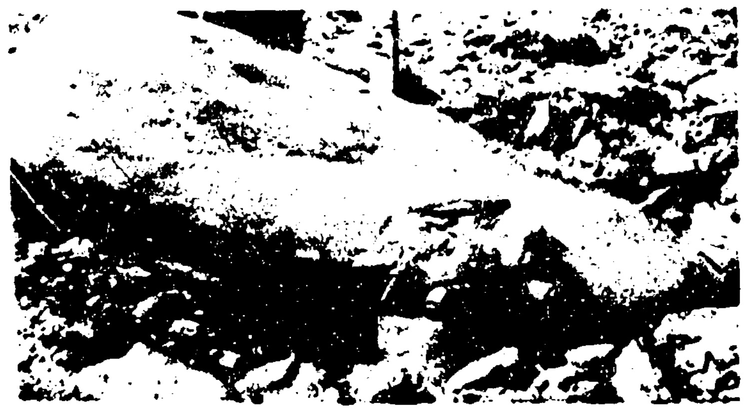
Fragment of modified 12,000-lb. T 10 bomb (Plot No. 102) showing circumferential separation at rear weld. This bomb had been strengthened by externally welding several beads over the original rear weld. Finger at right points to strip of external weld, adhering to original weld. Finger at left points to external weld on bomb body.

Fragment from body of modified 12,000-lb. T 10 bomb (Plot No. 102). Reverse curvature at bottom of fragment indicates bomb body had been dented near base.



Upper view shows crater of modified 12,000-lb. T 10 bomb (Plot No. 104) dropped from 5000 feet. Bomb struck on 7 meter roof and ricocheted into old crater on $4\frac{1}{2}$ meter roof, as shown in lower view.

[redacted]

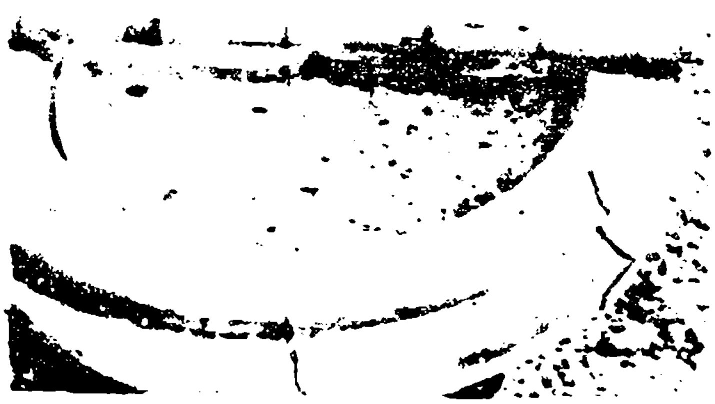


Views of 22,000-lb. T 14 bomb (Plot No. 96) dropped from 4750 feet. Lower view shows dent in bomb body.

[redacted]

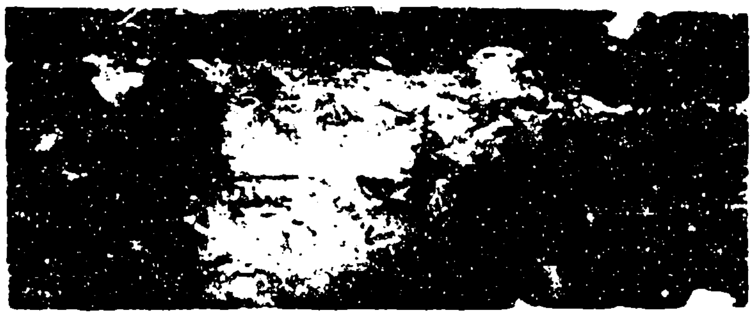
View of 22,000-lb. T 14 bomb (Plot No. 96) with base plate removed. Officer is pointing to broken RDX pellet of auxiliary exploder.

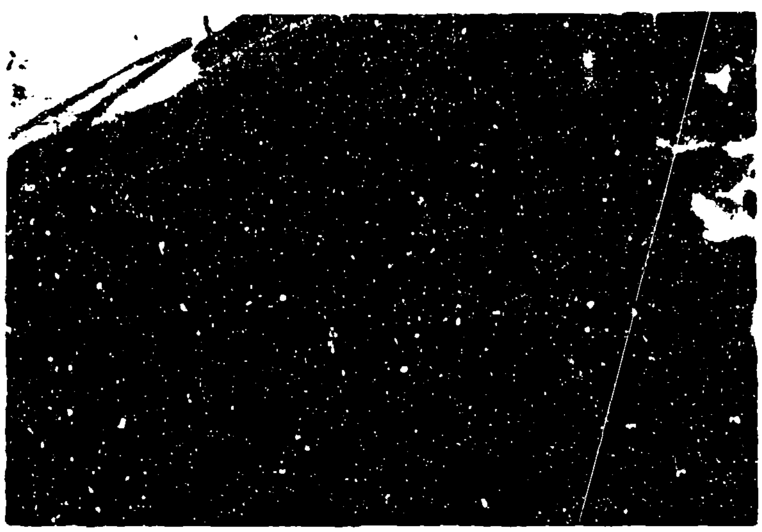
Upper view shows crater of 22,000-lb. T 14 bomb (Plot No. 97) dropped from 4750 feet. Lower view shows broken base of bomb, with break along rear circumferential weld.



Upper view shows crater of 22,000-lb. T 14 bomb (Plot No. 113) dropped from 10,000 feet. Lower view shows broken base of bomb, with break along rear circumferential weld.

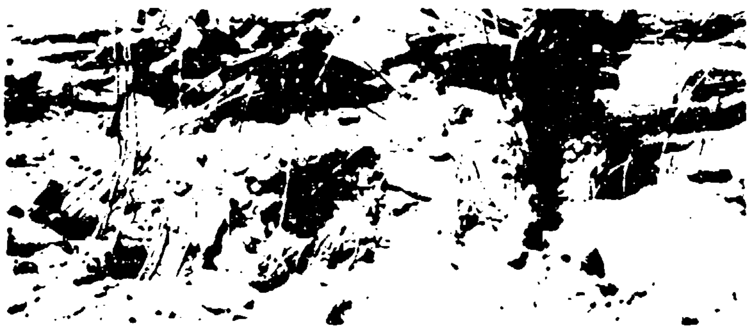
Views of crater of modified 12,000-lb. T 10 bomb (Plot No. 114) dropped from 10,000 feet. This bomb had been internally strengthened at the rear weld.

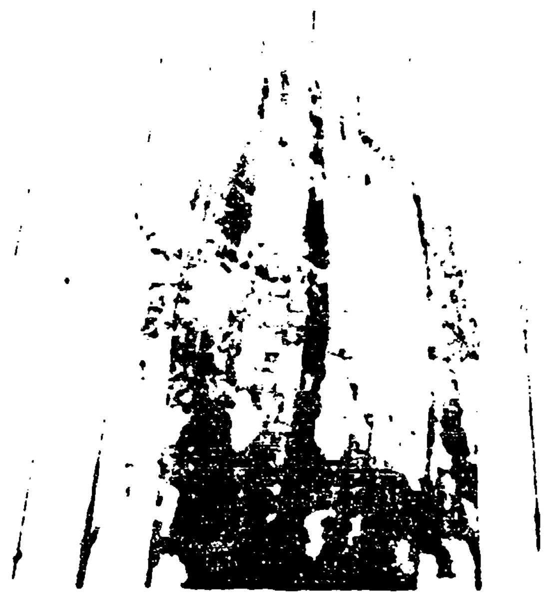




View of the crater and perforation hole made by 22,000-lb. SAP Amazon bomb (Plot No. 95.)

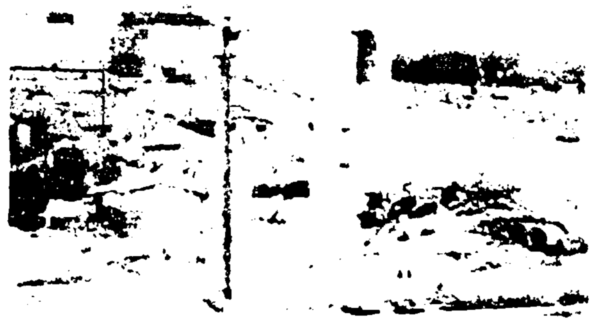
Inside view of perforation made by Amazon bomb.
(Plot No. 95)





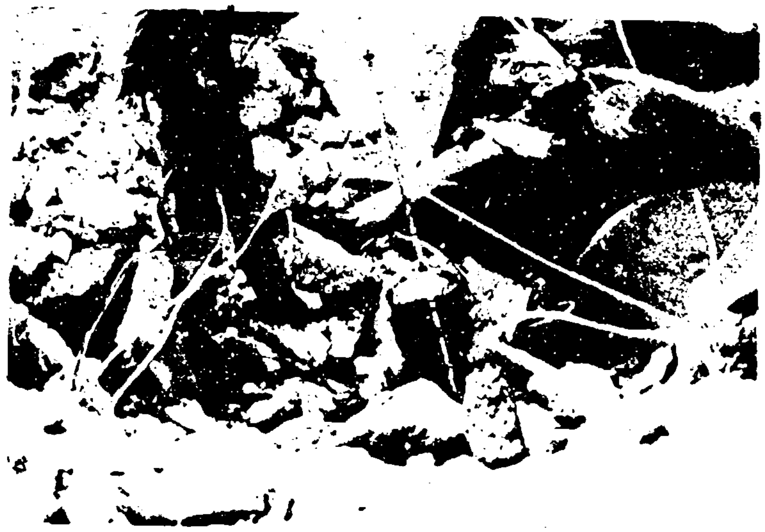
Views of crater and perforation of 22,000-lb. SAP Amazon bomb (Plot No. 100) dropped from 17,500 feet.

Views of nose and base of Amazon bomb (Plot No. 100) which perforated 4 1/2 meter roof and broke up on floor. Finger points to crack in bomb body.

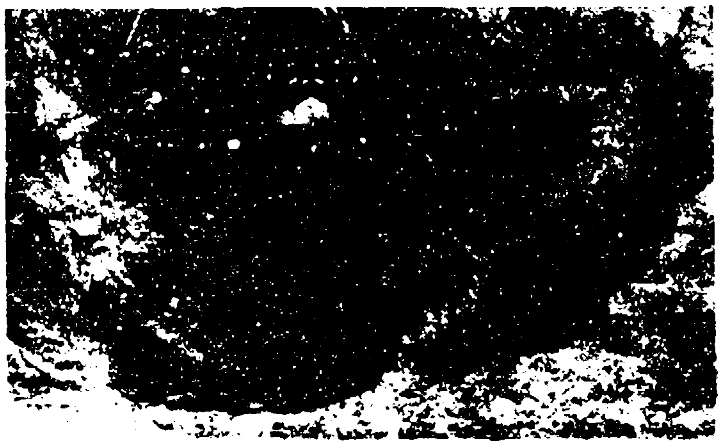


Upper view shows 22,000-lb RAF Amazon bomb (Plot No. 101) striking on corner of east periscope tower. Lower view shows concrete dislodged by bomb.

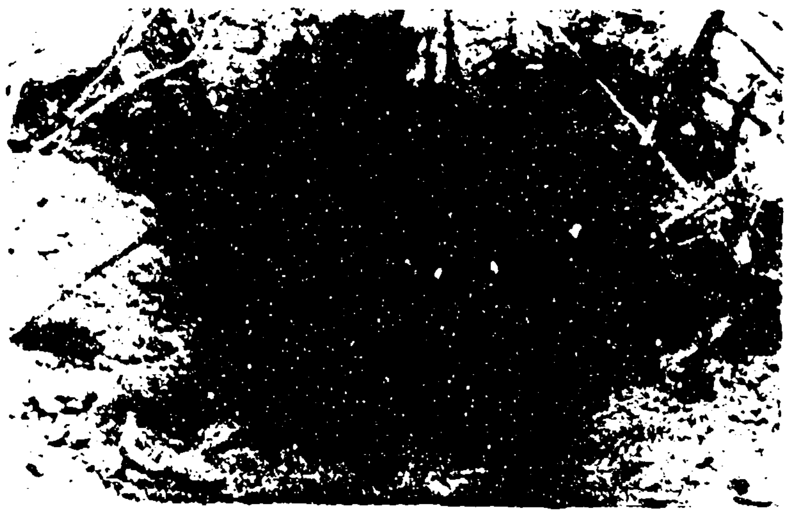
Upper view shows corner of east periscope tower where Amazon bomb (Plot No. 101) struck. Lower view shows some of the fragments recovered from crater in ground beneath tower.



Upper view shows crater of 22,000-lb. SAP Amazon bomb (Plot No. 106) before removal of debris. Bomb was dropped from 17,500 feet. Lowerview shows large body fragment found beside crater.



Upper view shows crater and some of the fragments of Amazon bomb (Plot 106.) Lower view shows scabbing of roof. One I-Beam was cracked by the impact.



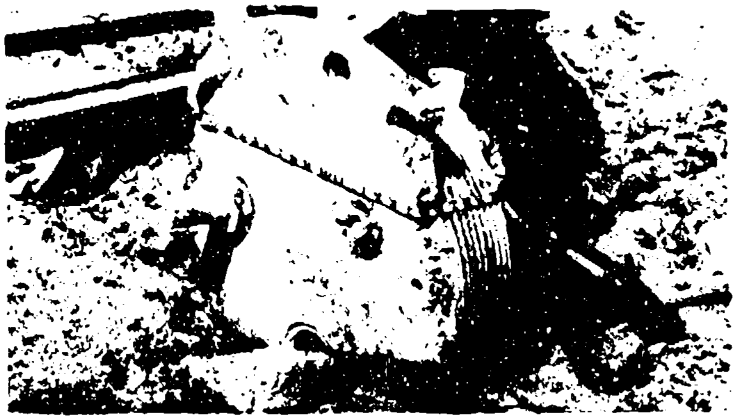
Upper view shows nose of Amazon bomb (Plot No. 106) being lifted out of crater. Lower view shows fragment with part of base ring attached. Finger points to break extending through rear weld.

[redacted]

Views of crater of 22,000-lb. SAP Amazon bomb (Plot No. 107) dropped from 17,500 feet. Tail assembly has telescoped into base of bomb body.

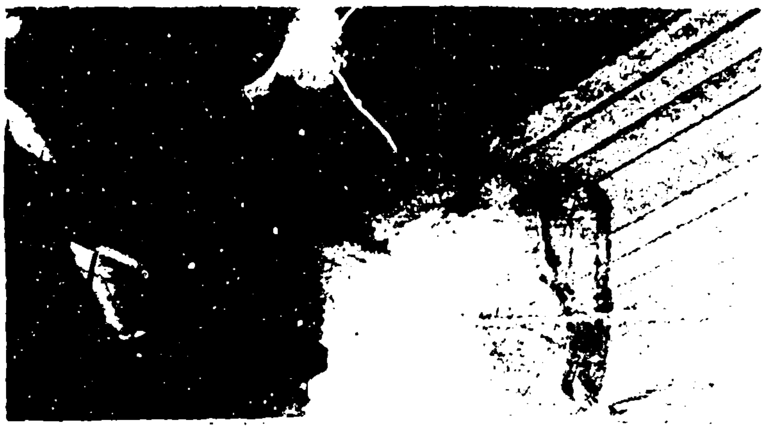
[redacted]

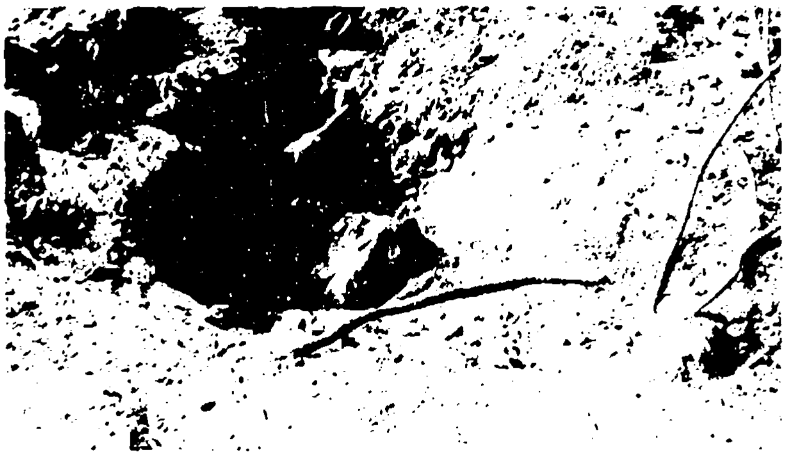
Views of the point of strike of 22,000-lb. SAP Amazon bomb (Plot No. 109) dropped from 17,500 feet. Pointer shows where bomb body struck against I-beam.



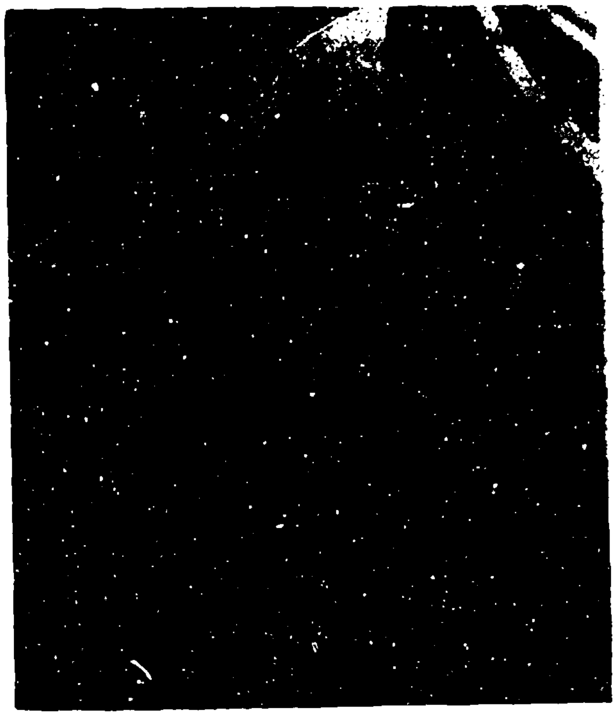
Parts of base plate and base ring recovered from Amazon bomb. (Plot No. 109.)

View of crater and perforation produced by 22,000-lb. SAP Amazon bomb (Plot No. 116) dropped from 17,500 feet.

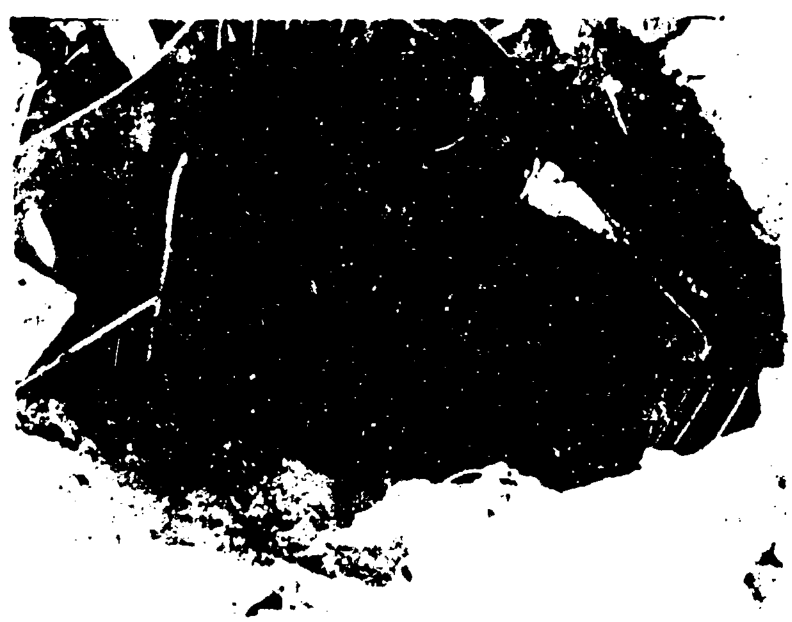




Upper view shows two perforations in roof over lock chamber made by Amazon bombs. (Plot No. 116 at left, Plot No. 95 at right). Lower view shows crater made by No. 116 on secondary impact in lock chamber.



Upper view shows base of broken Amazon bomb (Plot No. 116) in Lock chamber. Rear weld held in this instance. Lower view shows auxiliary booster from this bomb.



Crater perforation made by 22,000-lb. SAP Amazon bomb (Plot No. 117) dropped from 17,500 feet.

Two views of roof perforated by Amazon bomb (Plot No. 117)

Point of secondary impact of Amazon bomb (Plot No.117) Large fragment of bomb can be seen at bottom of photograph.

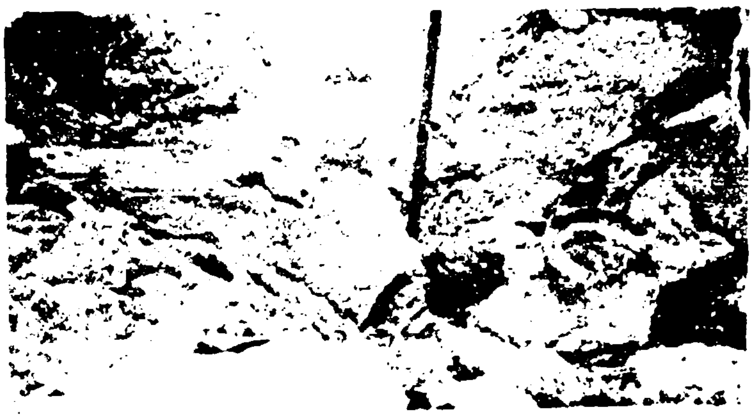
Amazon bomb (Plot No. 115) Struck on 7 meter roof of west periscope tower and ricocheted to main roof below.

[redacted]

Crater of 22,000-lb. Amazon Bomb (Plot No. 119) dropped from 17,500 feet, before and after debris is removed.

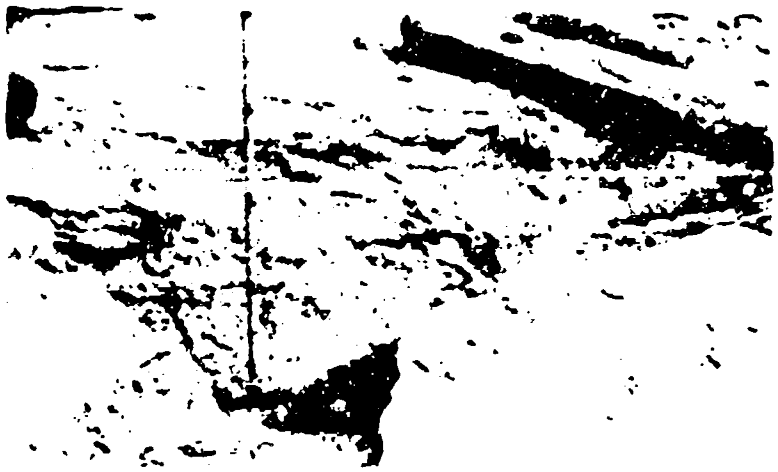
View of Amazon bomb (Plot No. 119) buried in crater.

[redacted]



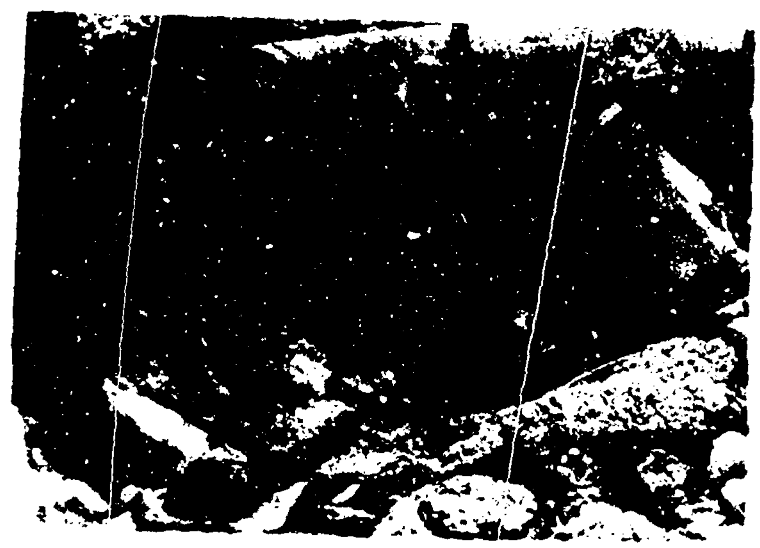
Point of impact of 1650-lb Model bomb (Plot No. 110) Dropped from 9800 feet. Bomb glanced off wall and struck footing, making crater shown below.

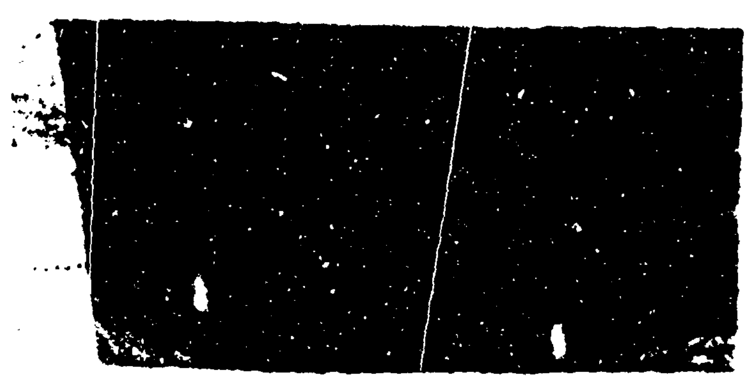
Views of Model bomb (Plot No. 110) after striking vertical wall of target.



Crater of 1650-lb. Model bomb (Plot No. 111) before and after removal of debris. Bomb was dropped from 9600 feet.

View of model bomb (Plot No. 111) showing the curvature of the bomb body.





Views of crater of 1650-lb. Model bomb (Plot No. 112) before and after removal of debris. Bomb dropped from 9600 feet.

Upper view shows crater of 1650-lb. Model bomb (Plot No.124) dropped from 15,600 feet. Lower view shows bent bomb resting in adjacent crater.

SUMMARY OF TRIAL X
1600-lb CT/MA DISNEY BOMBS DROPPED FROM 20,000 FEET WITH ROCKETS "SAFE"
(AVERAGE STRIKING ANGLE 15°)

PLOT NO.	CONCRETE		BOMB CASE		BOMB COMPONENTS				VERTICAL PENETRATION	CRATER DATA				T.A.S. MPH	STRIKING VELOCITY FT/SEC.	REMARKS
					FUNCTIONING		INSENSITIVITY			ANGLE OF PENETRATION	CRATER DIMENSIONS					
	ROOF THICKNESS	TYPE OF ROOF REINFORCING	BEHAVIOUR ON IMPACT	CONDITION OF BOMB	PISTOLS	ROCKETS	EXPLODERS	FILLER			DEPTH OF SPALLING	LENGTH	WIDTH			
2	14'-9"	CONCRETE BOWSTRING GIRDER	LODGED IN ROOF	INTACT	OK. DETONATORS & CAPS NOT FITD STRIKERS FLATTENED ON DET. HOLDER	DROPPED SAFE	DUMMY WOOD EXPLODERS FITTED	INERT	11'-0"	28°	4'-3"	9'-10"	13'-6"	222	1121	ROOF SLIGHTLY SCABBED
5	14'-9"	CONCRETE BOWSTRING GIRDER	LODGED IN ROOF	INTACT	OK. DETONATORS & CAPS NOT FIYD STRIKERS FLATTENED ON DET. HOLDER	DROPPED SAFE	DUMMY WOOD EXPLODERS FITTED	INERT	11'-1"	21°	3'-2"	12'-0"	14'-3"	222	1121	BOMB HIT NEAR JUNCTION OF FOUR ROOF SLABS
9	14'-9"	CONCRETE BOWSTRING GIRDER	NOSE SECTION LODGED IN ROOF	BROKE UP	OK. DETONATORS & CAPS NOT FITD STRIKERS FLATTENED ON DET. HOLDER	DROPPED SAFE	DUMMY WOOD EXPLODERS FITTED	INERT	10'-7"	32°	4'-6"	14'-0"	11'-4"	220	1120	BOMB HIT ON JUNCTION OF FOUR ROOF SLABS AND BROKE UP
10	16'-0"	SHORT SPAN CONCRETE GIRDER	LODGED IN ROOF	INTACT	OK. DETONATORS & CAPS NOT FITD STRIKERS FLATTENED ON DET. HOLDER	DROPPED SAFE	DUMMY WOOD EXPLODERS FITTED	INERT	9'-5"	29°	6'-0"	16'-6"	14'-3"	220	1120	BOMB STRUCK ADJACENT TO OLD TALL BOY CRATER OF TRIAL VII
26	14'-9"	60 CM. STEEL I-BEAM	BOUNCED OUT OF CRATER	NOSE BROKE OFF	OK. DUMMY DETONATORS AND LIVE CAPS FITTED. BOTH CAPS FIRED	DROPPED SAFE	DUMMY WOOD EXPLODERS FITTED	INERT	8'-7"	26°	4'-9"	12'-3"	12'-1"	218	1119	BOMB HIT NEAR JUNCTION OF FOUR ROOF SLABS. BOMB BOUNCED OUT OF CRATER 55 FEET. NOSE FRACTURED DUE TO INTERNAL FLAWS
28	14'-9"	CONCRETE BOWSTRING GIRDER	LODGED IN ROOF	INTACT	OK. DUMMY DETONATORS AND LIVE CAPS FITTED. BOTH CAPS FIRED	DROPPED SAFE	DUMMY WOOD EXPLODERS FITTED	INERT	10'-6"	25.5°	4'-6"	13'-9"	15'-4"	218	1119	ROOF SLIGHTLY SCABBED
29	16'-4"	SHORT SPAN CONCRETE GIRDER	BOUNCED OUT OF CRATER	INTACT BUT BENT	OK. DUMMY DETONATORS AND LIVE CAPS FITTED. BOTH CAPS FIRED	DROPPED SAFE	DUMMY WOOD EXPLODERS FITTED	INERT	9'-3"	34°	5'-6"	14'-6"	14'-3"	219	1120	BOMB HIT ON JUNCTION OF TWO ROOF SLABS, OVER SUPPORTING WALL. BOMB BOUNCED OUT OF CRATER 15 FEET
							AVERAGE		10'-5"	27°	4'-6"	13'-0"	13'-5"	220	1120	AVERAGE FOR 5 BOMBS (NOS. 26 AND 29 OMITTED)
							STANDARD DEVIATION		8"	4°	12"	30"	14"			STANDARD DEV. $\sqrt{\frac{(X-\bar{X})^2}{n-1}}$

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SUMMARY OF RESULTS OF TRIAL XII
4500-lb CP/RA DISNEY BOMBS WITH ROCKET ASSIST
DROPPED FROM 20,000 FEET ALTITUDE (STRIKING ANGLE 16°)

PLOT NO.	ROOF: ROOF THICKNESS	ROOF: TYPE OF ROOF CONSTRUCTION	BOMB CASE: BEHAVIOR ON IMPACT	BOMB CASE: CONDITION OF BOMB	BOMB COMPONENTS: FUNCTIONING: PISTOLS	BOMB COMPONENTS: FUNCTIONING: ROCKETS	BOMB COMPONENTS: SENSITIVITY: EXPLODERS	BOMB COMPONENTS: SENSITIVITY: FILLER	VERTICAL PENETRATION	CRATER DATA: ANGLE OF PENETRATION	CRATER DATA: CRATER DIMENSIONS: DEPTH OF SPALLING	CRATER DATA: CRATER DIMENSIONS: LENGTH	CRATER DATA: CRATER DIMENSIONS: WIDTH	T.A.S. MPH	STRIKING VELOCITY FT/SEC.	REMARKS
57	14'-9"	60 CM. STEEL I-BEAM	NOSE SECTION LODGED IN ROOF	BROKE UP	OK.	PARTIAL	ONE OK. OTHER BLEW ON SECONDARY IMPACT	INERT	9'-1"	37°	5'-3"	14'-3"	12'-3"	220	1447	BOMB STRUCK AT JUNCTION OF FOUR ROOF SLABS OVER SUPPORTING WALL. BREAK-UP OF BOMB SIMILAR TO #9 TRIAL X. ROCKET ACTION INCOMPLETE
59	14'-9"	CONCRETE BOWSTRING GIRDER	LODGED IN ROOF	INTACT	DROPPED SAFE. LIVE CAPS DUMMY DETS.	DID NOT FUNCTION	OK.	INERT	10'-9"	30°	4'-4"	15'-0"	16'-0"	220	1447	BOMB STRUCK NEAR CENTER OF ROOF SLAB. SAFETY .DX3 BR" NOT BEEN REMOVED FROM PISTOLS
59	14'-9"	60 CM. STEEL I-BEAM	RESTING IN CRATER	INTACT BUT BENT	BOTH MISSING	DID NOT FUNCTION	BOTH BLEW	INERT	6'-8"	41°	6'-8"	16'-6"	11'-6"	220	1447	BOMB CASE BENT OUT OF LINE 5 INCHES. PISTOLS & DETONATORS MISSING. ONE DETONATOR HOLDER IN POSITION, BULGED FROM UNDERSIDE AND BLACKENED
60	16'-7"	CONC. TIE BOWSTRING GIRDER	LODGED IN ROOF	INTACT	ONE OK OTHER SHEARED OFF	OK.	BOTH BLEW	INERT	15'-3"	36°	5'-6"	12'-6"	16'-4"	220	1447	ROOF SCABBED. TWO BOWSTRING GIRDERS BULGED DOWNWARD 18 INCHES. (LIVE DETONATORS SUSPECTED)
80	11'-9"	100 CM. STEEL I-BEAM	PERFORATED WEST PERISCOPE TOWER, STRUCK STEEL I-BEAM ON FLOOR	BROKE UP ON SECONDARY IMPACT	BOTH MISSING	OK.	ONE WOOD DUMMY, OTHER MISSING	INERT	PERFORATED 3 1/2 METER ROOF	23°	4'-0"	9'-6"	9'-9"	216	1446	BOMB BROKE CIRCUMFERENTIALLY AT MIDDLE AND NOSE BROKE OFF ON SECONDARY IMPACT. NOSE HAD INTERNAL FLAW. ROCKET BASE PLATE LODGED IN PERFORATION HOLE
61	14'-9"	60 CM. STEEL I-BEAM	BURIED IN CRATER	NOSE BROKEN OFF	BOTH MISSING	DID NOT FUNCTION. (DROPPED SAFE)	BOTH BLEW	INERT	5'-0"	39°	5'-0"	13'-6"	10'-6"	221	1447	NOSE FELL 130 FEET BEHIND CRATER. NOSE HAD INTERNAL FLAW. ARMING WIRE FOUND IN ROCKET FUZE POT.
64	14'-6"	CONCRETE BOWSTRING GIRDER	LODGED IN ROOF	INTACT	BOTH MISSING	OK.	ONE OK. ONE PARTIALLY BURNED	INERT	13'-2"	21°	4'-10"	11'-9"	12'-3"	220	1447	BOMB HIT ON 7 METER ROOF. ONE PIECE OF STRIKER FOUND, ONE DETONATOR HOLDER IN POSITION, OTHER MISSING
65	16'-9"	STEEL TRUSS	LODGED IN ROOF OF EAST PERISCOPE TOWER	INTACT	DROPPED SAFE. LIVE CAPS, LIVE DETS. ONE STRIKER DRIVEN BACKWARDS	DID NOT FUNCTION (DROPPED SAFE)	ONE OK. OTHER BLEW	INERT	17'-1"	23°	4'-4"	11'-0"	11'-0"	220	1447	HIT ON 5 METER ROOF NEAR EDGE (OVER TOWER WALL). TWO TRUSSES DEFLECTED LATERALLY. ARMING WIRE FOUND IN PISTOLS. BROKEN ARMING WIRE ON AIRPLANE. LIVE DETONATORS WITH BLACK POWDER PELLETS USED BY MISTAKE
67	14'-9"	CONCRETE BOWSTRING GIRDER	PERFORATED ROOF AND ONE CONCRETE FLOOR	INTACT(?)	NO DATA	OK.	NO DATA	INERT	PERFORATED 4 1/2 METER ROOF	17°	5'-0"	12'-6"	13'-0"	220	1447	BOMB PERFORATED 3' CONCRETE FLOOR AT GROUND LEVEL, BURYING IN SAND BENEATH. BOMB NOT RECOVERED
68	16'-9"	SHORT SPAN CONCRETE GIRDER	LODGED IN ROOF	INTACT	ONE OK. LIVE CAP, DUMMY DET. OTHER PISTOL SHEARED OFF	OK.	OK.	INERT	13'-2"	31°	5'-5"	12'-4"	10'-6"	220	1447	ROOF SLIGHTLY SCABBED. HEAD OF SECOND PISTOL SHEARED OFF FLUSH WITH CONTAINER AND COULD NOT BE REMOVED FOR INSPECTION
69	14'-9"	60 CM. STEEL I-BEAM	PERFORATED ROOF & LODGED IN FLOOR	BROKE UP ON SECONDARY IMPACT	BOTH MISSING	OK.	OK.	INERT	PERFORATED 4 1/2 METER ROOF	21°	4'-5"	13'-0"	13'-0"	220	1447	BOMB PENETRATED FLOOR AT GROUND LEVEL. BOMB BROKE CIRCUMFERENTIALLY ON SECONDARY IMPACT
							AVERAGE		13'-10"	25°	4'-10"	11'-11"	12'-6"	220	1447	AVERAGE PENETRATION BASED ON THREE BOMBS (60, 64, AND 68). AVERAGE CRATER DIMENSIONS BASED ON SIX BOMBS (60, 80, 64, 67, 68 AND 69)
							STANDARD DEVIATION		14"	7°	7"	19"	28"	—	—	STANDARD DEV. $\sqrt{\frac{(x-\bar{x})^2}{n-1}}$

SUMMARY OF RESULTS OF TRIAL VI
2000-lb SAP (M103) BOMBS DROPPED FROM 26,250 FEET AND 20,000 FEET

	26,250'	20,000'
STRIKING ANGLE	12°-30'	14°-30'

	CONCRETE		BOMB CASE		BOMB COMPONENTS				CRATER DATA							
						SERVICEABILITY OF				CRATER DIMENSIONS						
FLAG NO.	ROOF THICKNESS	TYPE OF ROOF REINFORCING	BEHAVIOR ON IMPACT	CONDITION OF BOMB	FUNCTIONING OF FUZE	ADAPTER BOOSTER	FILLER	VERTICAL PENETRATION	ANGLE OF PENETRATION	DEPTH OF SPALLING	LENGTH	WIDTH	RELEASE ALTITUDE	T.A.S. MPH	STRIKING VELOCITY FT/SEC.	REMARKS
43	16'-0"	SHORT SPAN CONCRETE GIRDER	RICOCHETED 200'	INTACT BUT DENTED NEAR REAR LUG	NOT FITTED	OK.	INERT	2'-7"	—	2'-7"	14'-6"	8'-6"	26,250'	[illegible]	1100	BOMB RICOCHETED TO GROUND. DENTED 5" DEEP, 51 INCHES FROM NOSE
55	14'-9"	CONCRETE [illegible] GIRDER	NOSE SECTION LYING IN CRATER	BROKEN UP	NOT FITTED	MISSING	INERT	2'-10"	—	2'-10"	12'-0"	10'-0"	26,250'	238	1102	BOMB STRUCK 4 FEET IN FRONT OF VERTICAL FACE OF WEST PERISCOPE TOWER. NOSE SECTION LYING CROSSWISE IN CRATER. BASE OF BOMB NEAR CRATER EDGE
72	16'-0"	SHORT SPAN CONCRETE GIRDER	BOMB IN CRATER	INTACT UNDENTED	NOT FITTED	OK.	INERT	3'-10"	—	3'-10"	10'-0"	13'-0"	20,000'	220	1090	BOMB HIT ON EDGE OF OLD CRATER. BOMB UNDEFORMED, LYING FLAT IN CRATER WITH NOSE POINTING OPPOSITE TO HEADING, TAIL CONE IN PLACE
73	14'-9"	60 CH. STEEL I-BEAM	RICOCHETED 40'	INTACT BUT DENTED NEAR REAR LUG	NOT FITTED	OK.	INERT	3'-6"	—	3'-6"	12'-0"	7'-0"	20,000'	220	1090	BOMB HIT ON EDGE OF OLD CRATER. SPALLED MATERIAL SQUEEZED OUT AROUND BASE PLATE. BOMB DENTED 5" DEEP, 55" FROM NOSE
70	14'-9"	60 CH. STEEL I-BEAM	NOSE RICOCHETED 350'	BROKEN UP	NOT FITTED	BLEW ON SECONDARY IMPACT	INERT	2'-6"	—	2'-6"	8'-6"	8'-6"	20,000'	220	1090	NOSE SECTION RICOCHETED TO WEST EDGE OF TARGET. BASE OF BOMB RICOCHETED 85 FEET. BOOSTER CUP CRACKED WITH CHARRED EDGES. TETRYL POWDER ON INNER SURFACE OF BASE
						AVERAGE		3'-1"	—	3'-1"	11'-5"	9'-5"	22,500'	225	1094	AVERAGE BASED ON ALL 5 BOMB HITS
						STANDARD DEVIATION		7"	—	7"	27"	27"	—	—	—	STANDARD DEV. $\sqrt{\frac{(x-\bar{x})^2}{n-1}}$
								NEAR MISSES								
61	HIT ON CONCRETE FOOTING OF WALL		LODGED IN CRATER	CASE DENTED & CRACKED	NOT FITTED	OK.	INERT	4'-0" APPROX	—	4'-0" APPROX	8'-0"	7'-0"	26,250	245	1103	NOSE OF BOMB POINTING IN DIRECTION OPPOSITE TO HEADING, AT ANGLE OF 45° TO VERTICAL
71	HIT ON CONCRETE FOOTING OF WALL		BOUNCED 70'	INTACT BUT BULGED AT SHOULDER	NOT FITTED	OK.	INERT	3'-0" APPROX	—	3'-0" APPROX	5'-0"	7'-0"	20,000	220	1090	BOMB HIT AT JUNCTION OF NORTH WALL AND CONCRETE FOOTING. DIAMETER INCREASED 1/8" AT SHOULDER

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SUMMARY OF FABRICATED GRAND SLAM HITS
AMERICAN 22,000-lb GP (T14) BOMB

PLOT NO.	CONCRETE: ROOF THICKNESS	CONCRETE: TYPE OF ROOF REINFORCING	BOMB CASE: BEHAVIOUR ON IMPACT	BOMB CASE: CONDITION OF BOMB	BOMB COMPONENTS: FUNCTIONING OF PISTOLS	BOMB COMPONENTS: SENSITIVITY: EXPLODERS	BOMB COMPONENTS: SENSITIVITY: FILLER	VERTICAL PENETRATION	CRATER DATA: ANGLE OF PENETRATION	CRATER DATA: CRATER DIMENSIONS: DEPTH OF SPALLING	CRATER DATA: CRATER DIMENSIONS: LENGTH	CRATER DATA: CRATER DIMENSIONS: WIDTH	T.A.S. MPH	ALTITUDE FEET	STRIKING VELOCITY FT/SEC.	TRIAL NO.	REMARKS
4	14'-9"	CONCRETE BOWSTRING GIRDER	SMALL SECTION LYING IN CRATER	BROKE UP, BOMB CRACKED BASE SEPARATED	OK.	BROKEN OFF BUT NOT BLOWN	INERT	7'-0"	—	7'-0"	21'-0"	10'-0"	275	20,000	1180	IX	BOMB HIT AT BASE OF SEAM OF SECOND ROOF THICKENING, CRACKING IT AND DISLODGING SEVERAL HUNDRED TONS OF CONCRETE. BASE OF BOMB SEPARATED AT REAR WELD
30	14'-9"	SHORT SPAN CONCRETE GIRDER	BOMB SECTION LYING IN CRATER	BROKE UP	MISSING	MISSING	INERT	7'-6"	—	7'-6"	31'-2"	27'-6"	275	20,000	1180	IX	BOMB HIT ON ROOF SLAB OVER WEST WALL OF BUILDING. BASE OF BOMB WENT OVER SIDE, NOT RECOVERED
31	14'-9"	CONCRETE BOWSTRING GIRDER	BOMB SECTION LYING IN CRATER	BROKE UP, BASE SEPARATED	OK.	ONE INTACT, ONE BLOWN, ONE MAY HAVE BLOWN	INERT	8'-6"	—	8'-6"	—	18'-6"	273	20,000	1180	IX	BOMB HIT 10 FEET FROM EDGE OF WEST WALL NEAR VENTILATOR SHAFT. 7 METER ROOF ON THREE SIDES OF CRATER. BOMB CRACKED OFF INTO SOLID SECTION. BASE OF BOMB SEPARATED AT REAR WELD
						AVERAGE		7'-4"	—	7'-6"	26'-1"	18'-8"	274	20,000	1180	IX	AVERAGE FOR THREE BOMBS, ALTHOUGH PLOT NO. 4 IS NOT FAIR HIT
115	16'-0"	SHORT SPAN CONCRETE GIRDER	BOMB SECTION RICOCHETED OFF ROOF	BROKE UP, BASE SEPARATED	NOT FITTED	BROKEN OFF BUT NOT BLOWN	INERT	5'-8"	—	5'-8"	20' APPROX	17' APPROX	204	10,000	850	XXIa	BOMB HIT ON EDGE OF OLD WALL NOT CRATER. BOMB SECTION RICOCHETED OFF ROOF, NOT RECOVERED. BASE OF BOMB SEPARATED AT REAR WELD
96	14'-9"	CONCRETE BOWSTRING GIRDER	BOMB LYING IN CRATER	INTACT, BUT DENTED	NOT FITTED	OK.	INERT	5'-8"	80°	5'-8"	17'-4"	14'-6"	185	4,750	610	XXIc	BOMB DENTED 1" DEEP, 4 FEET FROM BASE. EXPLODER TUBES CRACKED AT WELD
97	16'-0"	CONCRETE BOWSTRING GIRDER	BOMB SECTION RICOCHETED 200'	BROKE UP, BASE SEPARATED	NOT FITTED	OK.	INERT	4'-0"	—	4'-0"	21'-6"	13'-4"	185	4,750	610	XXIc	BOMB HALF OF BOMB, 8' LONG, RICOCHETED OFF ROOF TO GROUND. BASE OF BOMB SEPARATED AT REAR WELD
						AVERAGE		4'-7"	—	4'-7"	19'-0"	14'-9"	185	4,750	610	XXIc	AVERAGE FOR TWO BOMBS

SUMMARY OF TALL BOY HITS
BRITISH CAST 12,000-lb M.C. AND AMERICAN FABRICATED 12,000-lb GP (T10)

BRITISH CAST 12,000-lb M.C. BOMB

PLOT NO.	CONCRETE: ROOF THICKNESS	CONCRETE: TYPE OF ROOF REINFORCING	BOMB CASE: BEHAVIOUR ON IMPACT	BOMB CASE: CONDITION OF BOMB	BOMB COMPONENTS: FUNCTIONING OF PISTOLS	BOMB COMPONENTS: SENSITIVITY: EXPLODERS	BOMB COMPONENTS: SENSITIVITY: FILLER	VERTICAL PENETRATION	CRATER DATA: ANGLE OF PENETRATION	CRATER DATA: CRATER DIMENSIONS: DEPTH OF SPALLING	CRATER DATA: CRATER DIMENSIONS: LENGTH	CRATER DATA: CRATER DIMENSIONS: WIDTH	T.A.S. MPH	ALTITUDE FEET	STRIKING VELOCITY FT/SEC.	TRIAL NO.	REMARKS
90	14'-9"	CONCRETE BOWSTRING GIRDER	BOMB RICOCHETED 825 FEET	BROKE UP	NOT FITTED	OK.	INERT	3'-6"	—	3'-6"	19'-0"	11'-0"	207	10,000	850	XXI	NOSE CRACKED OFF, EXPOSING NOSE PLUG THREADS. BASE PLATE FOUND BEHIND CRATER
92	14'-9"	40 CM. STEEL I-BEAM	BOMB RICOCHETED 40 FEET	BROKE UP	NOT FITTED	OK.	INERT	4'-0"	—	4'-0"	17'-4"	16'-0"	207	10,000	850	XXI	NOSE CRACKED OFF. BASE PLATE IN CRATER
						AVERAGE		3'-9"	—	3'-9"	18'-5"	13'-6"	207	10,000	850	XXI	AVERAGE FOR TWO BOMBS
93	14'-9"	CONCRETE BOWSTRING GIRDER	BOMB LYING IN CRATER	BROKE UP	OK.	OK.	INERT	3'-4"	—	3'-4"	14'-0"	13'-5"	185	5,000	620	XXIa	BOMB HIT ON PILE OF SAND BAGS. BASE OF BOMB REBOUNDED 300 FEET
94	17'-0"	CONCRETE BOWSTRING GIRDER	BOMB AND BASE RICOCHETED OFF ROOF	BROKE UP	NOT EXAMINED	OK.	INERT	2'-7"	—	2'-7"	12'-0"	11'-6"	185	5,000	620	XXIa	BASE OF BOMB FOUND NORTH OF BUILDING. NOSE SECTION NOT RECOVERED
						AVERAGE		3'-0"	—	3'-0"	13'-0"	12'-5"	185	5,000	620	XXIa	AVERAGE FOR TWO BOMBS

AMERICAN FABRICATED 12,000-lb GP (T10) BOMB

PLOT NO.	CONCRETE: ROOF THICKNESS	CONCRETE: TYPE OF ROOF REINFORCING	BOMB CASE: BEHAVIOUR ON IMPACT	BOMB CASE: CONDITION OF BOMB	BOMB COMPONENTS: FUNCTIONING OF PISTOLS	BOMB COMPONENTS: SENSITIVITY: EXPLODERS	BOMB COMPONENTS: SENSITIVITY: FILLER	VERTICAL PENETRATION	CRATER DATA: ANGLE OF PENETRATION	CRATER DATA: CRATER DIMENSIONS: DEPTH OF SPALLING	CRATER DATA: CRATER DIMENSIONS: LENGTH	CRATER DATA: CRATER DIMENSIONS: WIDTH	T.A.S. MPH	ALTITUDE FEET	STRIKING VELOCITY FT/SEC.	TRIAL NO.	REMARKS
114	16'-0"	SHORT SPAN CONCRETE GIRDER	LYING IN CRATER	INTACT, UNDEFORMED	NOT FITTED	NOT FITTED	INERT	5'-8"	[illegible]°	5'-8"	— OPEN END	15'-0"	190	10,000	840	XXId	BOMB CAME TO REST WITH NOSE UNDER LEDGE RAISED BY BOMB. BOMB TURNED 15° FROM HEADING
102	14'-9"	CONCRETE BOWSTRING GIRDER	NOSE RICOCHETED OFF ROOF	BROKE UP BASE SEPARATED	NOT FITTED	NOT FITTED	INERT	3'-1"	—	3'-1"	14'-5"	12'-6"	175	5,000	610	XXIb	NOSE SECTION RICOCHETED OFF ROOF, NOT RECOVERED. NOSE SECTION WAS AT LEAST 2 CALIBERS LONG. BODY FRAGMENTS SHOW BOMB WAS DENTED AT REAR. BASE OF BOMB SEPARATED AT REAR WELD
104	16'-0"	CONCRETE BOWSTRING GIRDER	RICOCHETED INTO OLD CRATER	INTACT, DENTED	NOT FITTED	NOT FITTED	INERT	3'-9"	—	3'-9"	—	—	175	5,000	610	XXIb	BOMB HIT ON 7 METER ROOF, RICOCHETED TO 4 1/2 METER ROOF INTO DISNEY CRATER. BODY DENTED 3" DEEP AT END OF CYLINDRICAL SECTION. OPEN CRATER FORMED
						AVERAGE		3'-5"	—	3'-5"	—	—	175	5,000	610	XXIb	AVERAGE FOR TWO BOMBS

[redacted]

SUMMARY OF RESULTS OF TRIAL XVIII

22,000-lb S.A.P. (T28) AMAZON BOMBS DROPPED FROM 17,500 FEET (STRIKING ANGLE 21°)

PLOT NO.	CONCRETE: ROOF THICKNESS	CONCRETE: TYPE OF ROOF REINFORCING	BOMB CASE: BEHAVIOUR ON IMPACT	BOMB CASE: CONDITION OF BOMB	BOMB COMPONENTS: FUNCTIONING OF FUZES	BOMB COMPONENTS: INSENSITIVITY: BOOSTER	BOMB COMPONENTS: INSENSITIVITY: FILLER	VERTICAL PENETRATION	CRATER DATA: ANGLE OF PENETRATION	CRATER DATA: CRATER DIMENSIONS: DEPTH OF SPALLING	CRATER DATA: CRATER DIMENSIONS: LENGTH	CRATER DATA: CRATER DIMENSIONS: WIDTH	T.A.S. MPH	STRIKING VELOCITY FT/SEC.	REMARKS
95	14'-9"	CONCRETE BOWSTRING GIRDER	PERFORATED ROOF AND FELL INTO LOCK CHAMBER	BROKE UP ON SECONDARY IMPACT	NOT RECOVERED	NOT FITTED	INERT	PERFORATED 4 1/2 METER ROOF	--	5'-9"	21'-4"	19'-0"	274	1139	DIVER FOUND NOSE SECTION 5' TO 6' LONG AT BOTTOM OF LOCK CHAMBER. BOMB HIT NEAR N. EDGE OF BUILDING
100	14'-9"	CONCRETE BOWSTRING GIRDER	PERFORATED ROOF AND STRUCK GROUND FLOOR	BROKE UP ON SECONDARY IMPACT. BASE SEPARATED		NOT FITTED	INERT	PERFORATED 4 1/2 METER ROOF	—	5'-9"	18'-0"	15'-0"	260	1128	NOSE SECTION MEASURED 68" TO NEAREST BREAK. BASE OF BOMB RICOCHETED 300 FEET, HAD SEPARATED AT REAR WELD. FUZES RECOVERED, SENT TO PICATINNY ARSENAL
101	16'-5"	STEEL TRUSS	FELL TO GROUND AFTER STRIKING CORNER OF E. PERISCOPE TOWER	BROKE UP	NOT RECOVERED	NOT FITTED	INERT	--	--	—	--	--	265	1132	BOMB STRUCK ON CORNER OF EAST PERISCOPE TOWER, BROKE UP AND BOMB PIECES CRATERED IN GROUND BENEATH TOWER. PIECE OF BASE RING RECOVERED SHOWING FAILURE OF REAR WELD
106	14'-9"	40 CM. STEEL I-BEAM	MOST OF BOMB FRAGMENTS IN CRATER	BROKE UP, BASE SEPARATED		NOT FITTED	INERT	13'-5"	—	7'-4"	21'-6"	15'-0"	280	1144	BOMB BROKE UP INTO LARGE PIECES. BASE RING SEPARATED FROM BODY ALONG REAR WELD. FUZES RECOVERED, SENT TO PICATINNY ARSENAL. CONSIDERABLE SCABBING OF ROOF. ONE I-BEAM BROKEN
107	24'-3"	CONCRETE BOWSTRING GIRDER	BOMB TURNED 20° TO RIGHT IN CRATER	INTACT, UNDEFORMED		NOT FITTED	INERT	10'-0"	75°	10'-0"	--	20'-0"	270	1136	BOMB INTACT. TAIL ASSEMBLY TELESCOPED INTO BASE. FUZES RECOVERED, SENT TO PICATINNY ARSENAL. OPEN CRATER FORMED. BOMB HIT NEAR EDGE OF SECOND ROOF LAYER
109	21'-5"	100 CM. STEEL I-BEAM	STRUCK WALL OF W. PERISCOPE TOWER. SCATTERED FRAGMENTS WIDELY	BROKE UP		NOT FITTED	INERT	—	—	—	—	—	265	1132	BOMB STRUCK AGAINST WALL OF WEST PERISCOPE TOWER AND BROKE UP INTO MANY FRAGMENTS WHICH FELL OVER WIDE AREA. STEEL I-BEAM REINFORCING EXPOSED BY IMPACT. TWO FUZES RECOVERED AND SENT TO PICATINNY ARSENAL
116	14'-9"	CONCRETE BOWSTRING GIRDER	PERFORATED ROOF AND FELL TO FLOOR OF LOCK CHAMBER	BROKE UP	NOT FITTED	OK.	INERT	PERFORATED 4 1/2 METER ROOF	--	7'-0"	19'-4"	23'-0"	276	1141	BOMB PRODUCED CRATER IN FLOOR OF UPPER LEVEL OF LOCK CHAMBER. NOSE SECTION FELL INTO WATER. BASE BROKE OFF AHEAD OF REAR WELD
117	14'-9"	CONCRETE BOWSTRING GIRDER	PERFORATED ROOF AND FELL TO FLOOR OF LOCK CHAMBER	BROKE UP	NOT FITTED	MISSING	INERT	PERFORATED 4 1/2 METER ROOF	—	6'-8"	17'-0"	20'-0"	265	1132	BOMB STRUCK ON A STEEL TRUSS IN LOCK CHAMBER. BREAK-UP MORE COMPLETE THAN FOR OTHER PERFORATIONS. BASE PLATE NOT ACCESSIBLE FOR INSPECTION. AUXILIARY BOOSTER FELL IN WATER
118	23'-0"	100 CM. STEEL I-BEAM	STRUCK ON W. PERISCOPE TOWER. RICOCHETED TO ROOF	INTACT, DENTED	NOT FITTED	OK.	INERT	11'-6"	--	11'-9"	--	--	270	1136	BOMB STRUCK ON 7 METER ROOF OF WEST PERISCOPE TOWER AND RICOCHETED TO MAIN ROOF. OPEN CRATER FORMED
119	24'-9"	CONCRETE BOWSTRING GIRDER	BOMB TURNED 90° IN CRATER	INTACT	NOT FITTED	OK.	INERT	12'-0"	90°	8'-0"	--	22'-6"	280	1144	BOMB STRUCK ON SEVEN METER ROOF NEAR EDGE OF SECOND ROOF LAYER. BOMB FLAT AT BOTTOM OF CRATER. OPEN CRATER
					AVERAGE			11'-2"	—	7'-8"	19'-6"	19'-4"	270	1136	AVERAGE PENETRATION FOR 3 BOMBS (107, 118 AND 119). CRATER DIMENSIONS BASED ON ALL BOMBS EXCEPT 101, 109 AND 118
					STANDARD DEVIATION			12"	—	26"	2'-1"	3'-0"	--	—	STD. DEVIATION $\sqrt{\frac{(X-\bar{X})^2}{n-1}}$

Inclosure #, page 6

SUMMARY OF RESULTS OF TRIAL XIX
BRITISH 1650-lb MODEL BOMBS

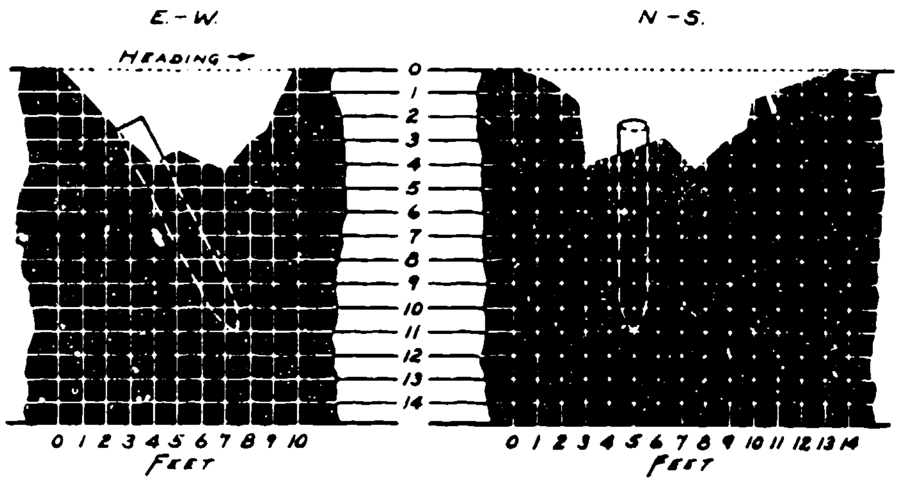
(SCALE MODEL OF A 12,000-lb CP/MA BOMB)

PLOT NO.	CONCRETE: ROOF THICKNESS	CONCRETE: TYPE OF ROOF REINFORCING	BOMB CASE: BEHAVIOUR ON IMPACT	BOMB CASE: CONDITION OF BOMB	BOMB COMPONENTS: FUNCTIONING: PISTOLS	BOMB COMPONENTS: FUNCTIONING: ROCKETS	BOMB COMPONENTS: SENSITIVITY: EXPLODERS	BOMB COMPONENTS: SENSITIVITY: FILLER	VERTICAL PENETRATION	CRATER DATA: ANGLE OF PENETRATION	CRATER DATA: CRATER DIMENSIONS: DEPTH OF SPALLING	CRATER DATA: CRATER DIMENSIONS: LENGTH	CRATER DATA: CRATER DIMENSIONS: WIDTH	T.A.S. MPH	ALTITUDE FEET	STRIKING VELOCITY FT/SEC.	REMARKS
110	—	—	STRUCK WALL, REBOUNDED	BADLY DEFORMED	NOT FITTED	NOT FITTED	NOT FITTED	INERT	—	—	—	—	—	196	9800	800	BOMB STRUCK NORTH WALL, GLANCED OFF, HIT FOOTING, REBOUNDED 300 FEET. BOMB BADLY BENT, DENTED AT REAR, BASE PLATE OFF
111	14'-9"	CONCRETE BOWSTRING GIRDER	BOUNCED OUT OF CRATER	INTACT NOT BENT	NOT FITTED	NOT FITTED	NOT FITTED	INERT	3'-3"	—	3'-3"	8'-10"	9'-0"	196	9600	800	BOMB BENT 3" OUT OF LINE
112	14'-9"	60 CM. STEEL I-BEAM	BOUNCED OUT OF CRATER	INTACT NOT BENT	NOT FITTED	NOT FITTED	NOT FITTED	INERT	3'-2"	—	3'-2"	10'-6"	8'-0"	196	9600	820	BOMB BENT 2" OUT OF LINE
							AVERAGE		3'-3"	—	3'-3"	9'-[illegible]	8'-6"	196	9600	800	AVERAGE FOR BOMBS 111 AND 112
114	[illegible]'-9"	CONCRETE BOWSTRING GIRDER	BOUNCED OUT OF CRATER	INTACT NOT DENTED	NOT FITTED	NOT FITTED	NOT FITTED	INERT	4'-4"	—	4'-4"	10'-0"	10'-0"	204	15,400	1000	BOMB REBOUNDED 50 FEET AND LANDED IN OLD TALL BOY CRATER. BENT 3 3/4" OUT OF LINE

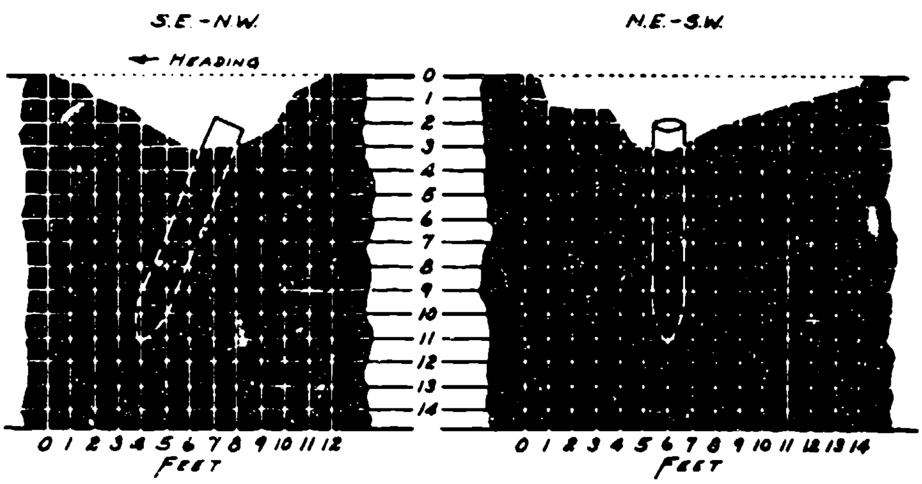
CRATER PROFILES - TRIAL I

4500-LB CP/ROR RA DISNEY BOMBS

PLOT 2



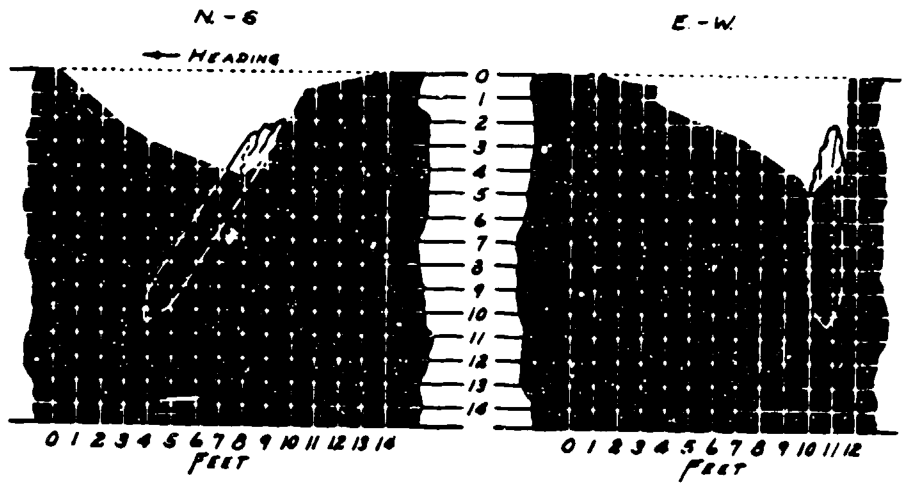
PLOT 3



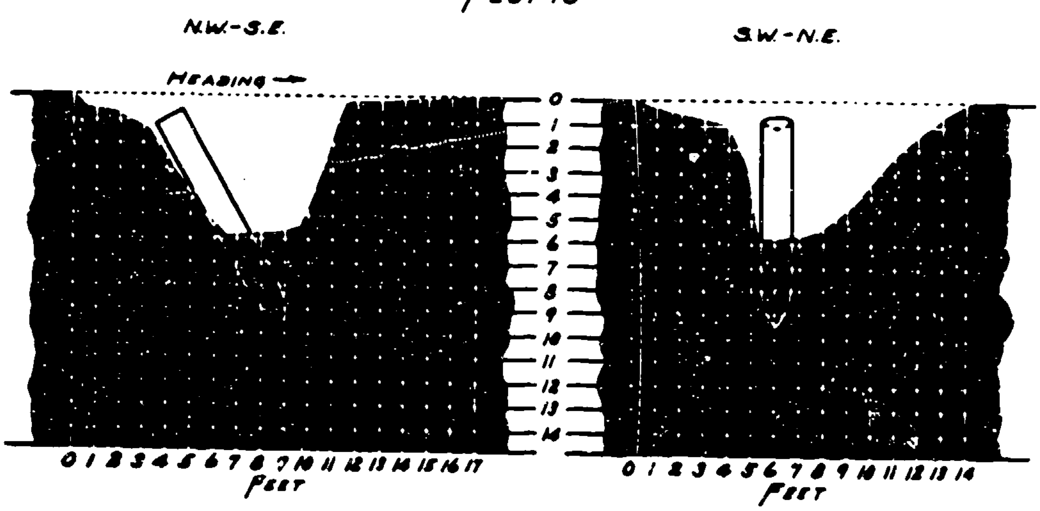
CRATER PROFILES - TRIAL I

[illegible]00-LB GP/[illegible] DIRECT BOMBS

PLOT 9



PLOT 10

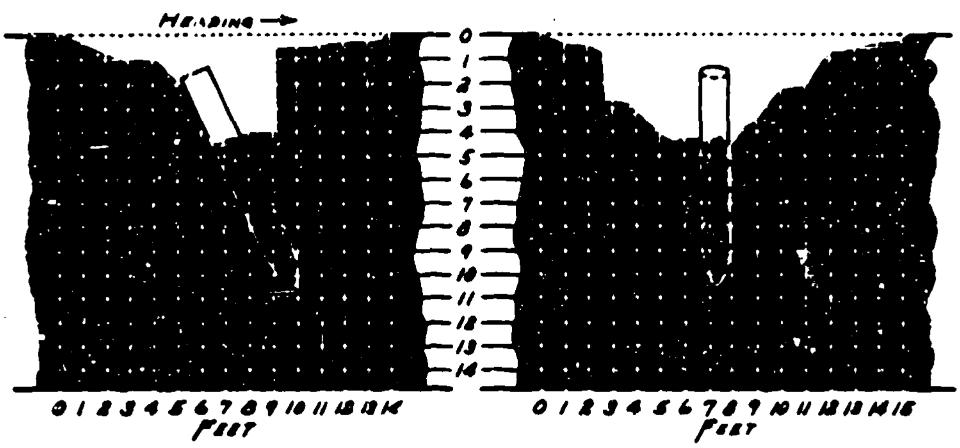


[redacted]

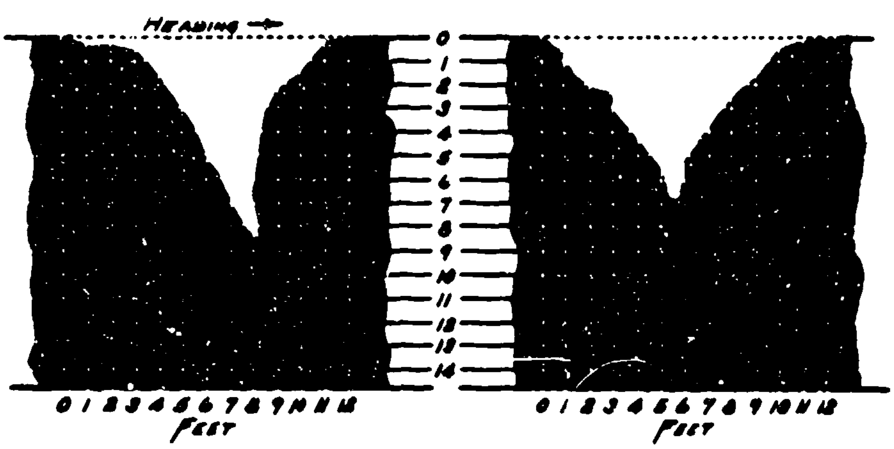
CRATER PROFILES - TRIAL I

4000-LB GP/HC AA DIRECT BOMBS

PLOT 28



PLOT 26



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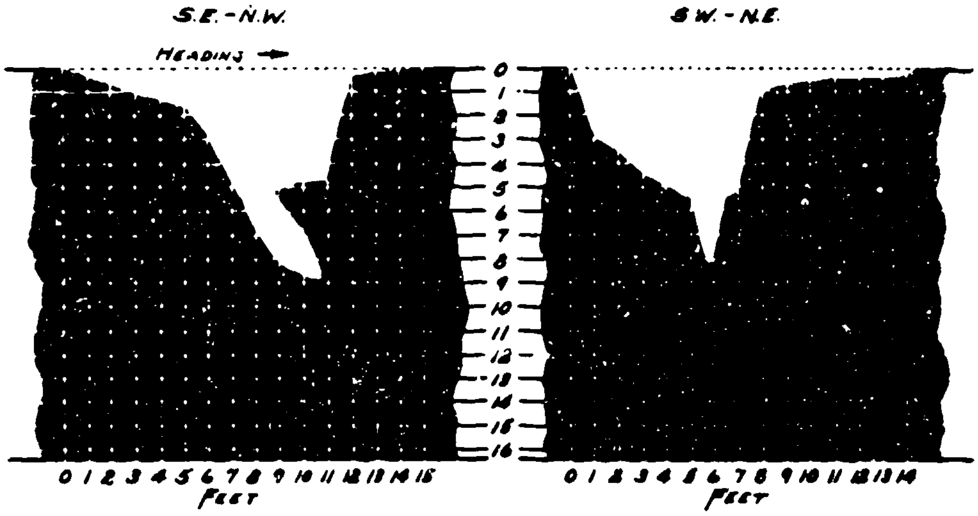
[redacted]

CRATER PROFILES - TRIAL X

4500-LB CP/ROM RA DIRECT BOMB

PLOT 29



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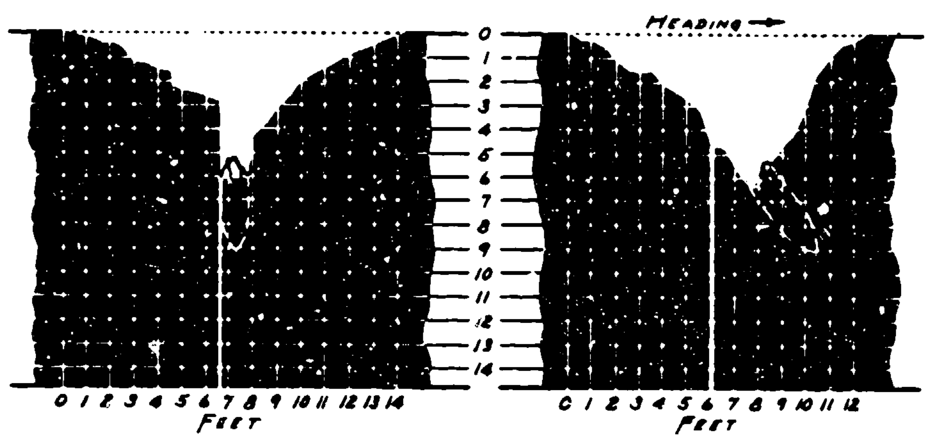
[redacted]

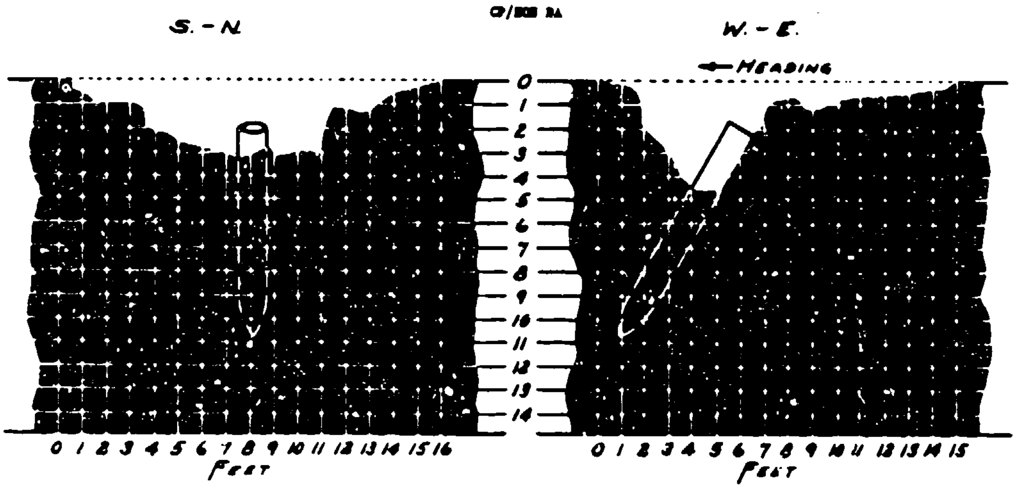
CRATER PROFILES - TRIAL XII

4500-LB DISNEY BOMBS

PLOT 37



PLOT 39



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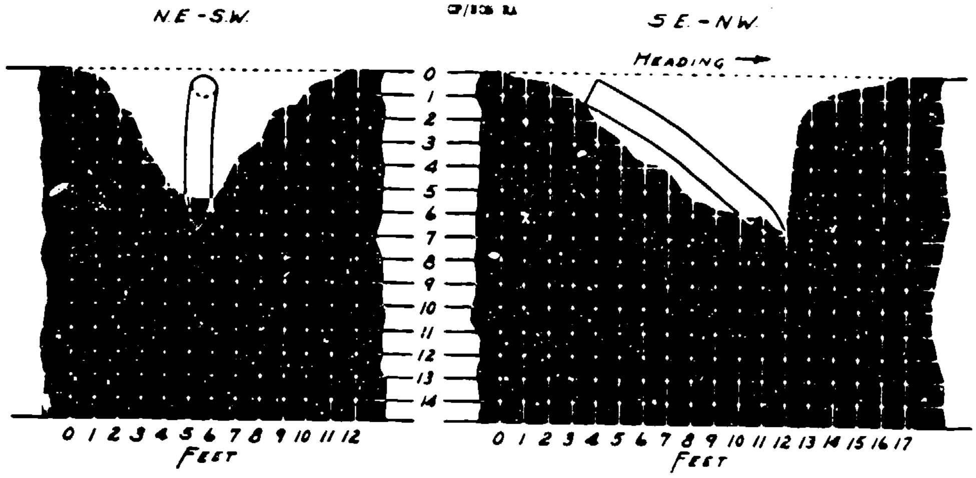
[redacted]

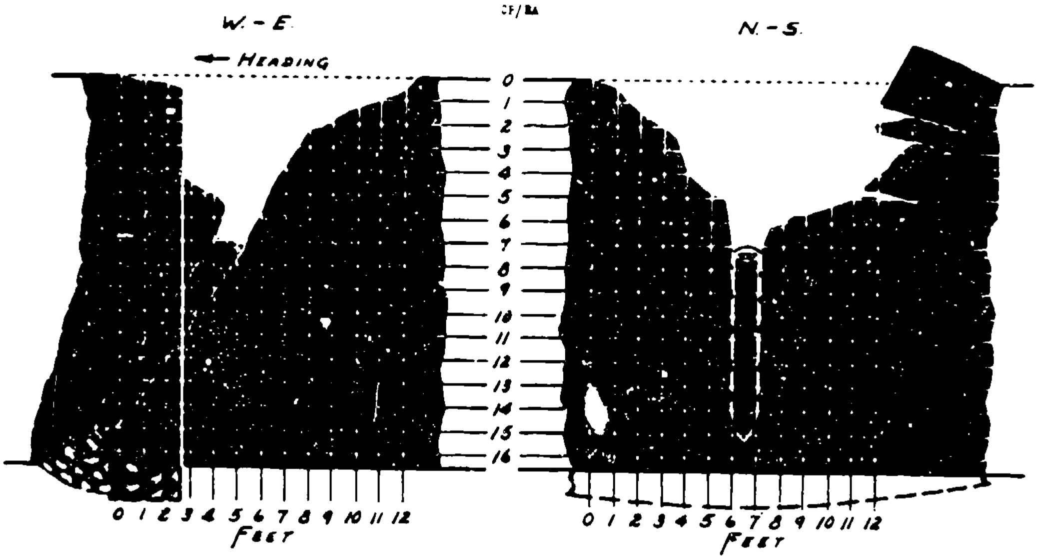
CRATER PROFILES – TRIAL III

[illegible]

PLOT 59



PLOT 60



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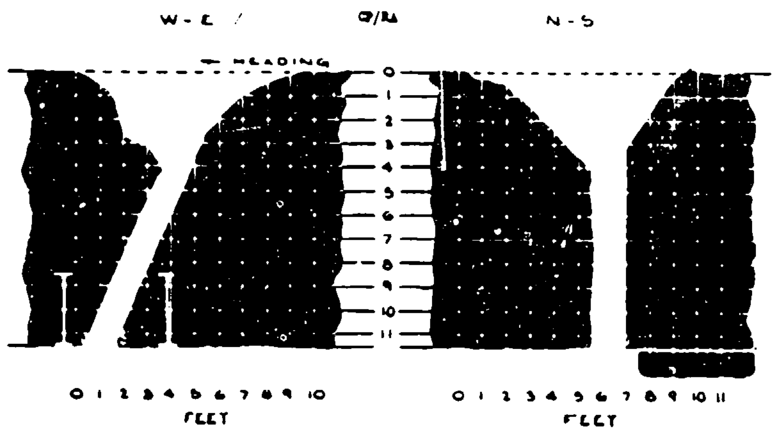
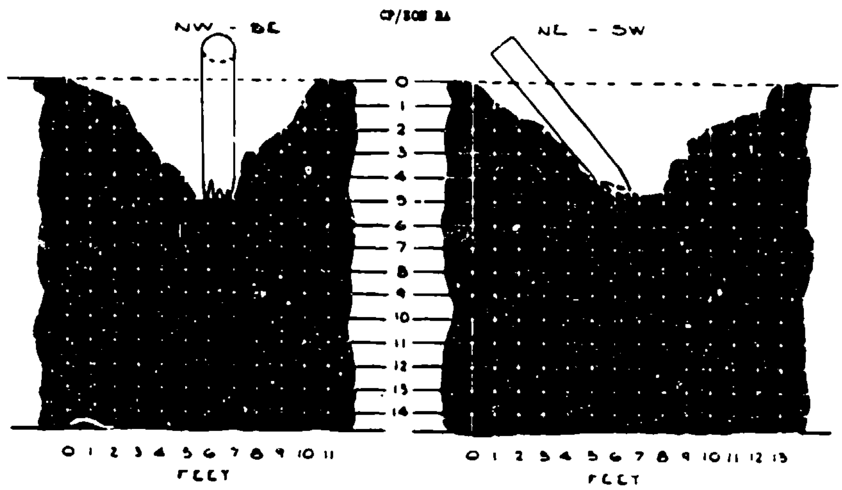
CRATER PROFILES - TRIAL XII

4500-LB DISNEY BOMBS

PLOT 80



PLOT 81



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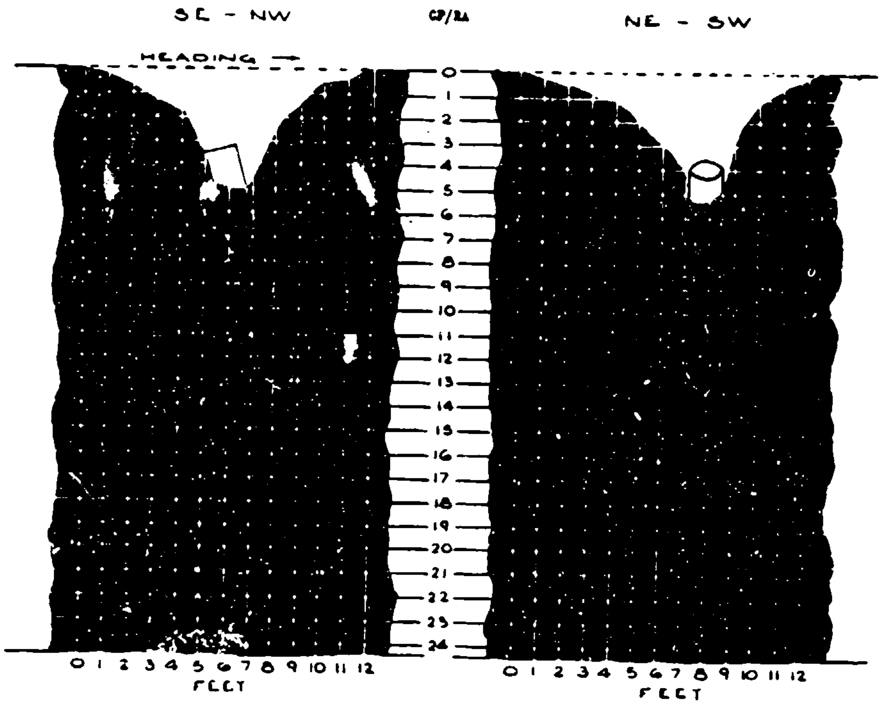
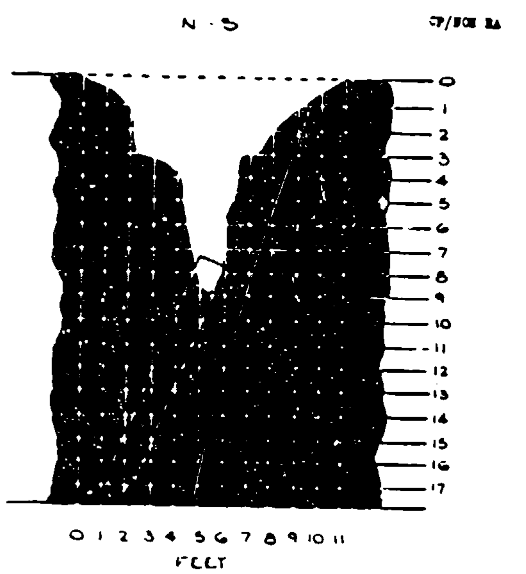
CRATER PROFILES - TRIAL XII

4500-LB DISNEY BOMBS

PLOT 84



PLOT 85



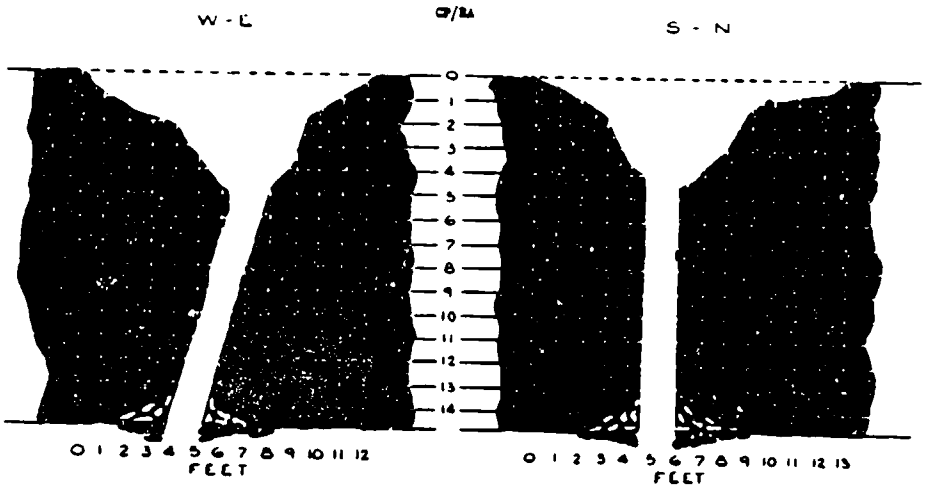
IN PLOT 85 BOMB IS NOT
IN PLANE OF PROFILE.
E-W PROFILE NOT TAKEN.

[redacted]

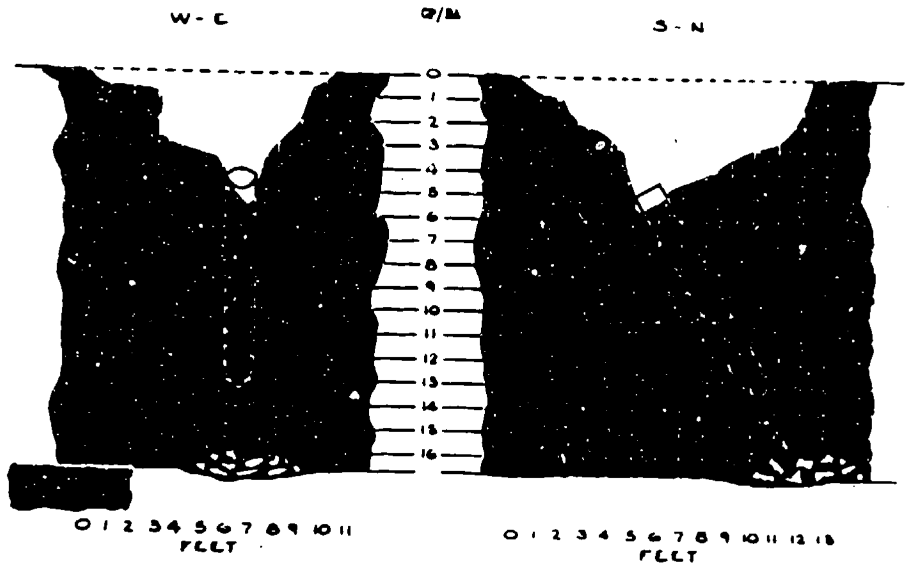
CRATER PROFILES - TRIAL XXI

4500-LB DISNEY BOMBS

PLOT 87



PLOT 88



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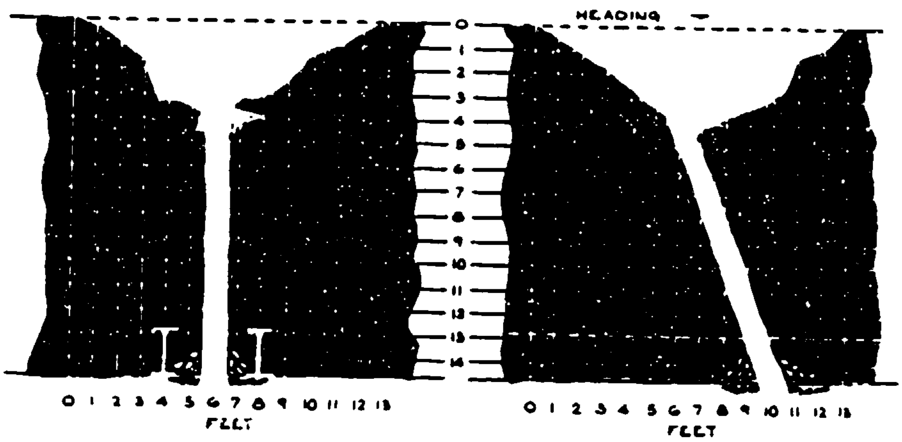
CRATER PROFILES - TRIAL XII

4500-LB DISNEY BOMBS

PLOT 89



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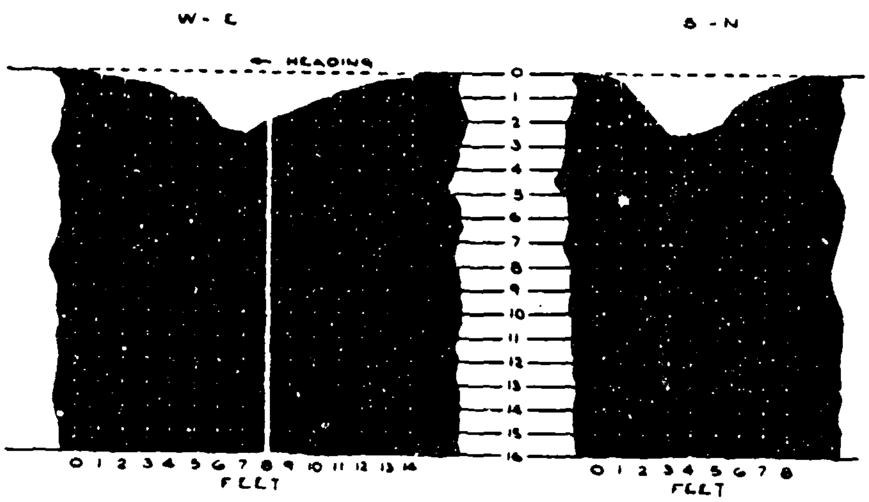
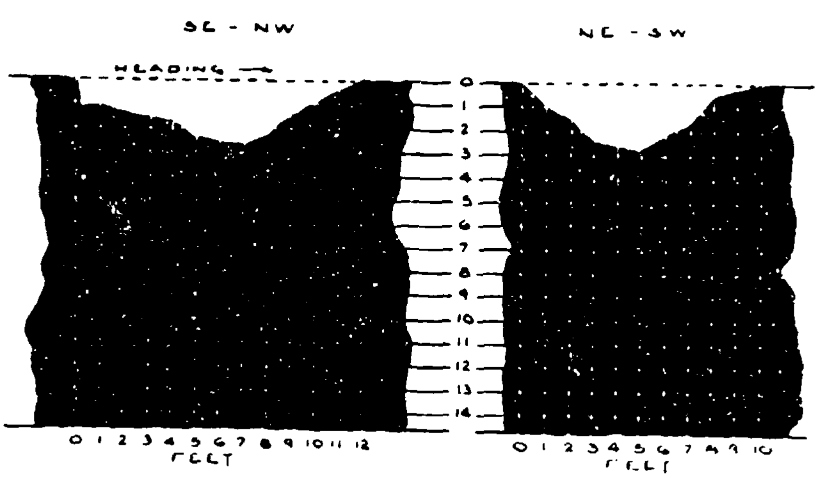
CRATER PROFILES - TRIAL VI

2000-LB SAP (M103) BOMBS

PLOT-43



PLOT-55



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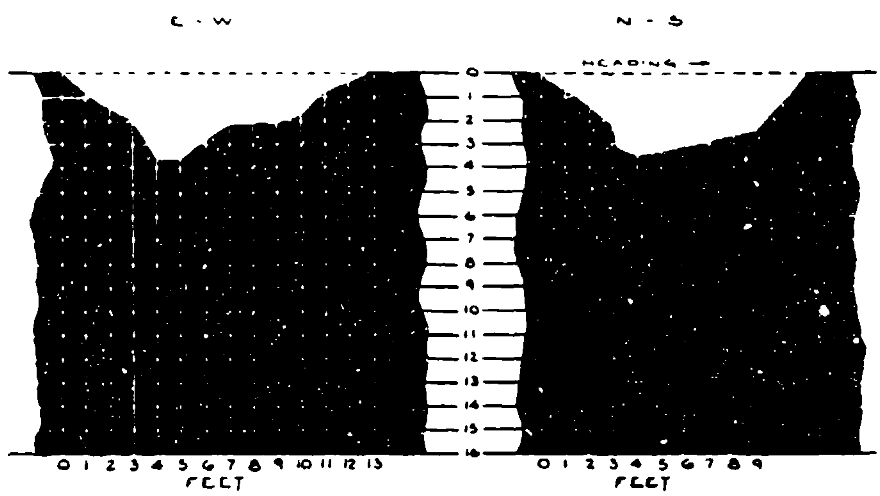
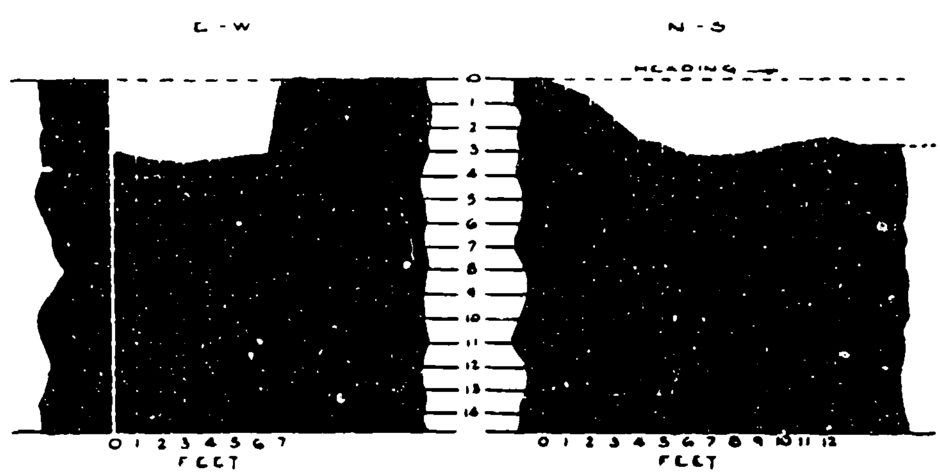
CRATER PROFILES - TRIAL VI

2000-LB SAP (M103) BOMBS

PLOT-72



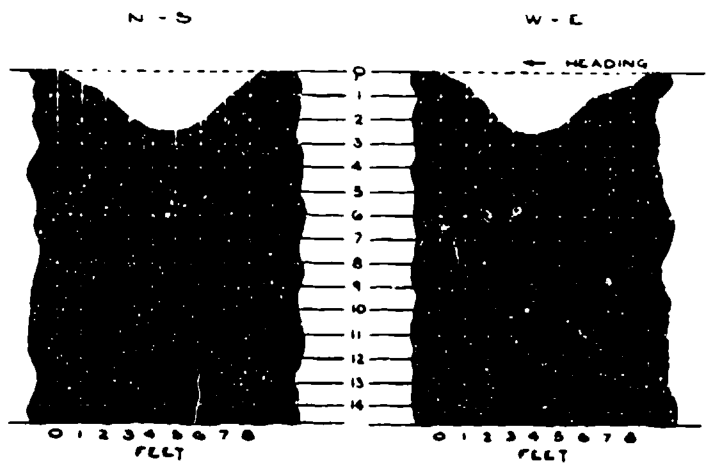
PLOT - 73



CRATER PROFILES - TRIAL VI

2000-LB SAP (M103) BOMB

PLOT-78



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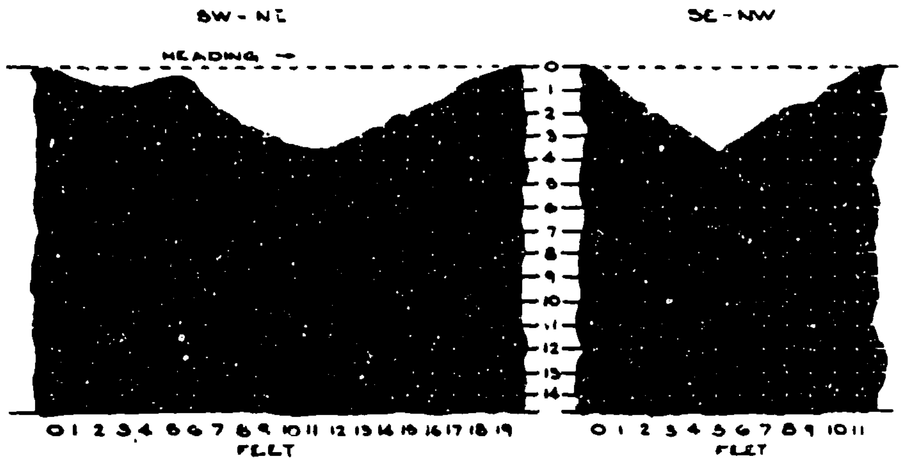
CRATER PROFILES - TRIAL XXI

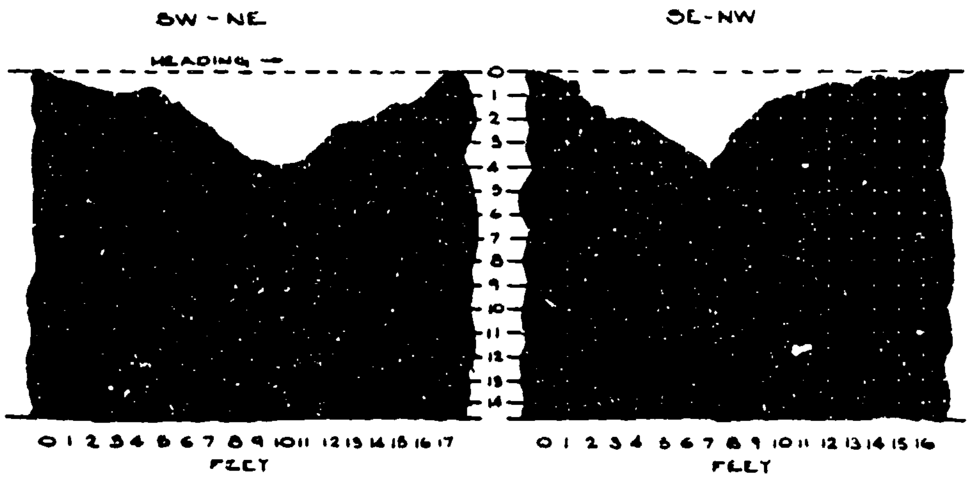
12,000-LB. CAST TALL BOY BOMBS

RELEASE ALTITUDE 10,000 FT.

PLOT 90



PLOT 92



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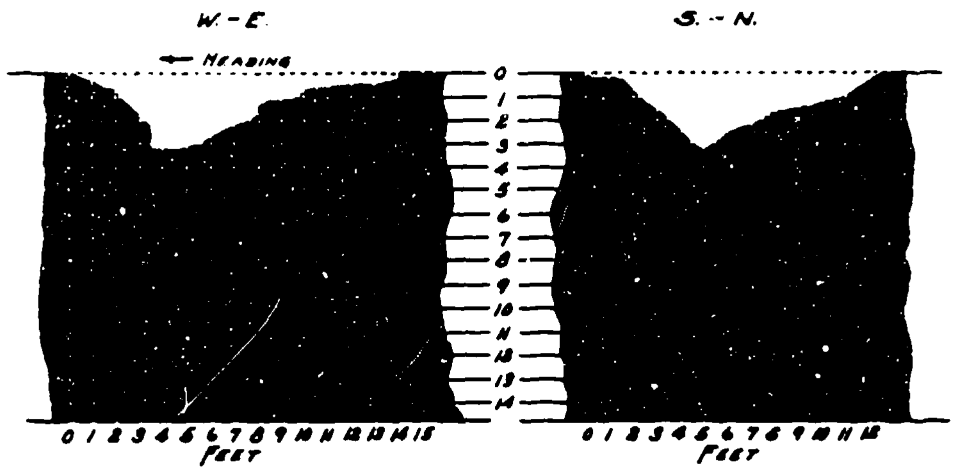
[redacted]

CRATER PROFILES - TYPICAL AREA

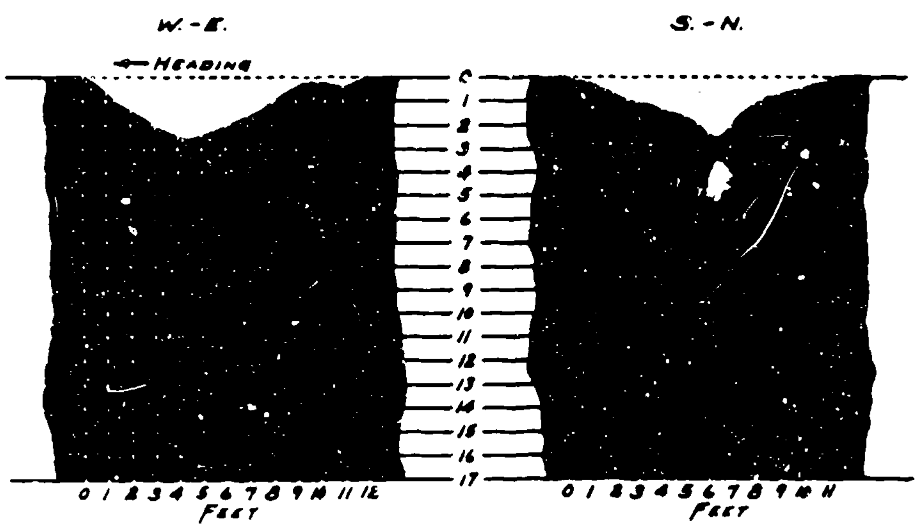
12,000-LB. CAST TALL BOY BOMBS

RELEASE ALTITUDE 5,000 FT.

PLOT 93



PLOT 94



[redacted]

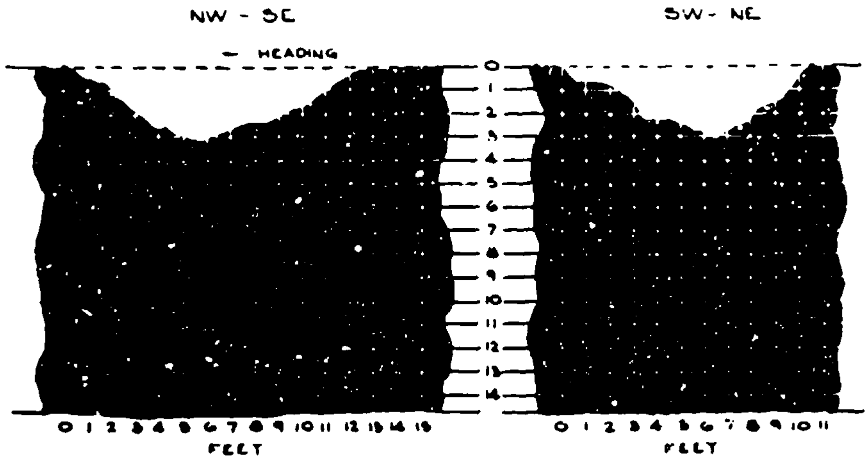
[redacted]

CRATER PROFILES - TRIAL [illegible]

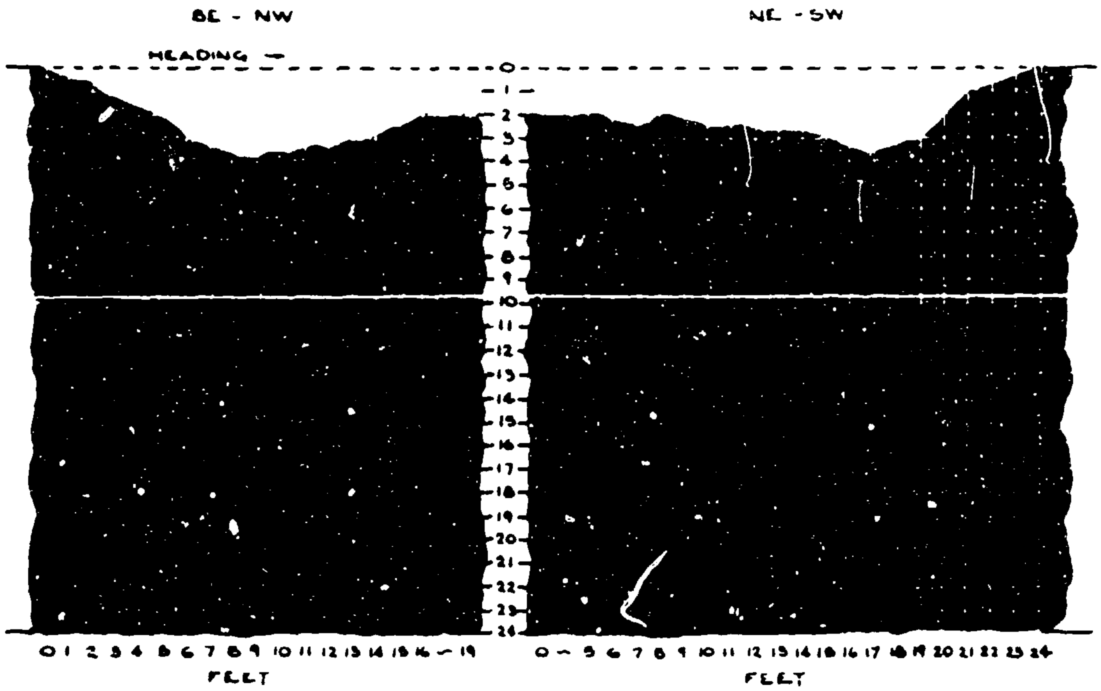
12,000-LB. FABRICATED TALL BOY BOMBS

RELEASE ALTITUDE 5,000 FT.

PLOT 102



PLOT 104



[redacted]

[redacted]

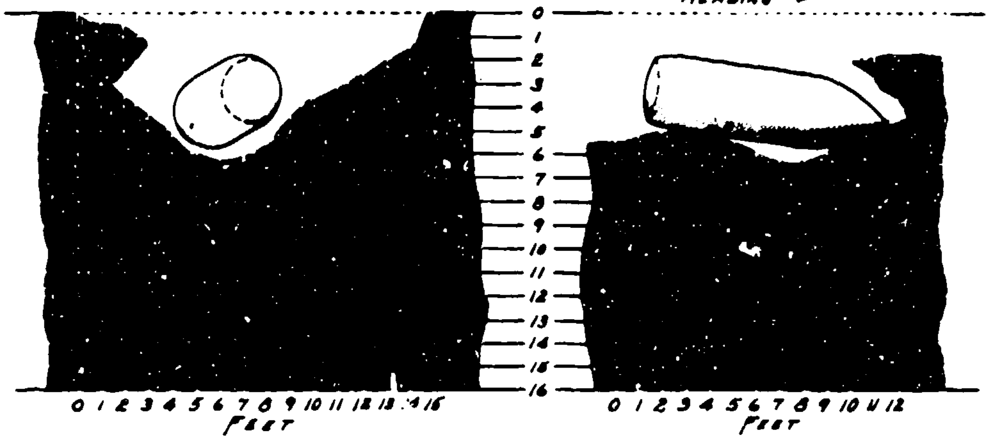
CRATER PROFILES

TRIAL XXIID.

PLOT 114

12,000-LB. FABRICATED TALL BOY

RELEASE ALTITUDE 10,000 FT.

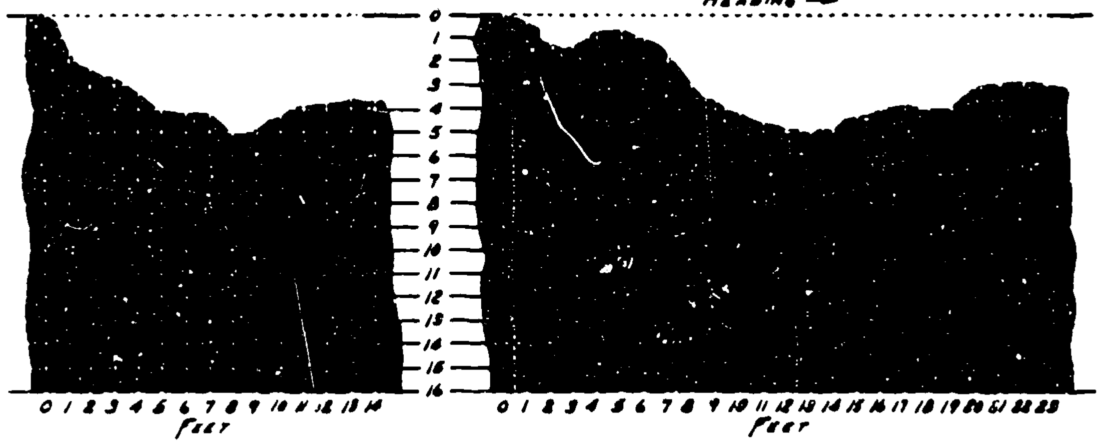


TRIAL XXIII

PLOT 113

22,000-LB. GRAND SLAM.

RELEASE ALTITUDE 10,000 FT.



[redacted]

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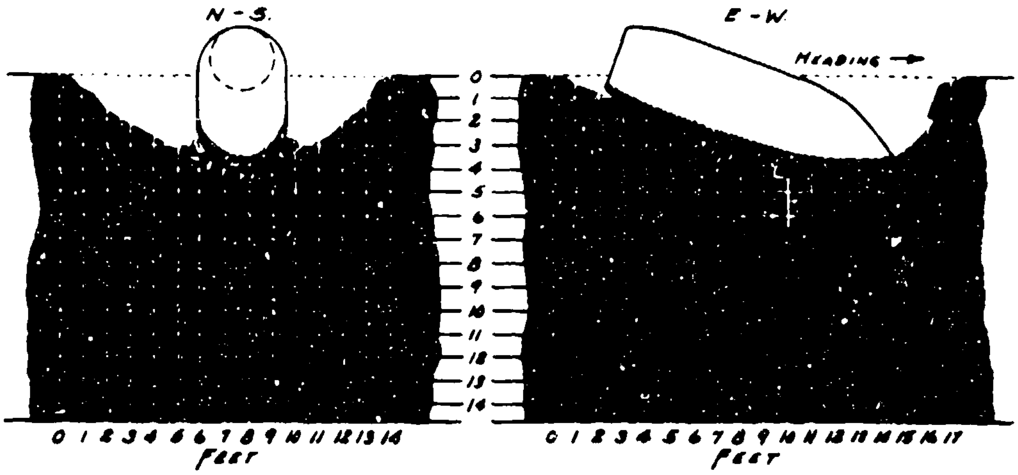
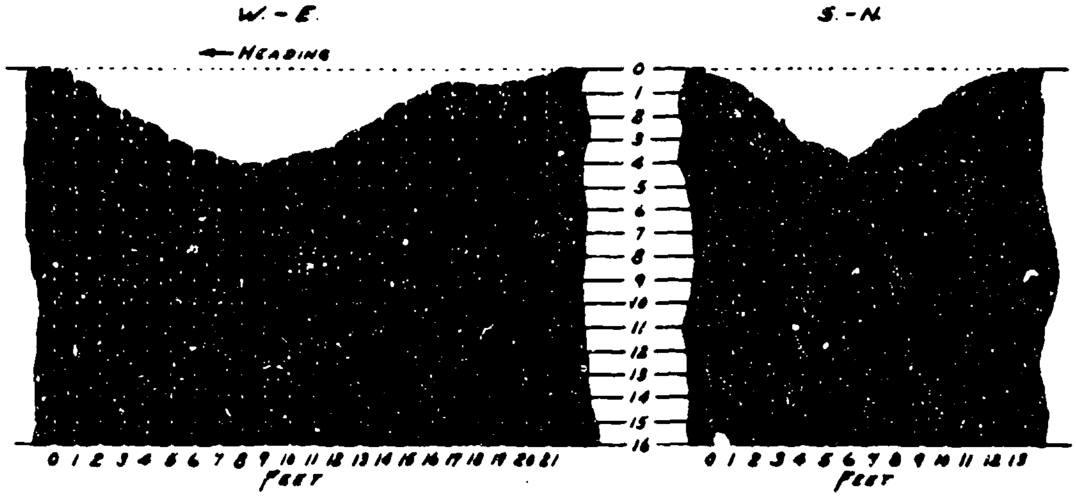
CRATER PROFILES - TRIAL XXIC
22,000 LB. FABRICATED GRAND SLAM BOMBS
RELEASE ALTITUDE - 4750 FEET

PLOT 96



PLOT 97



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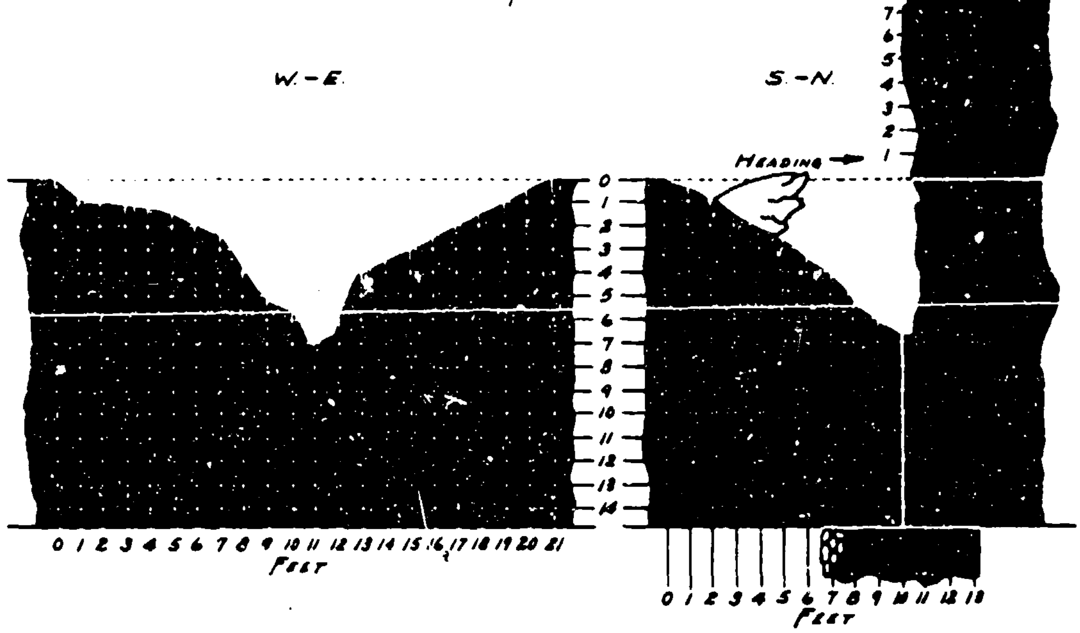
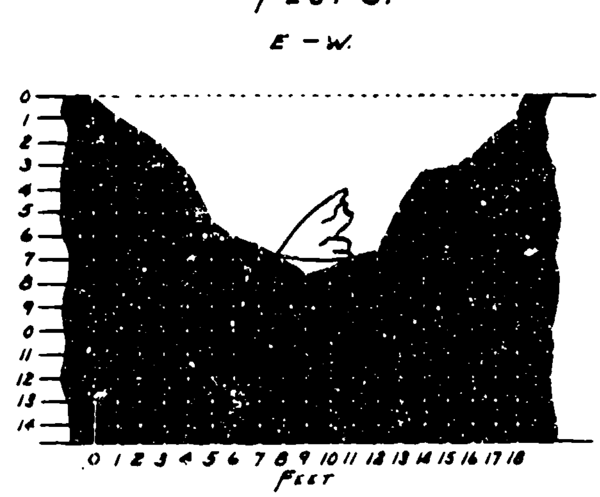
[redacted]

CRATER PROFILES - TRIAL II
22,000 LB. FABRICATED GRAND SLAM BOMBS
RELEASE ALTITUDE 20,000 FT.

PLOT 4



PLOT 31



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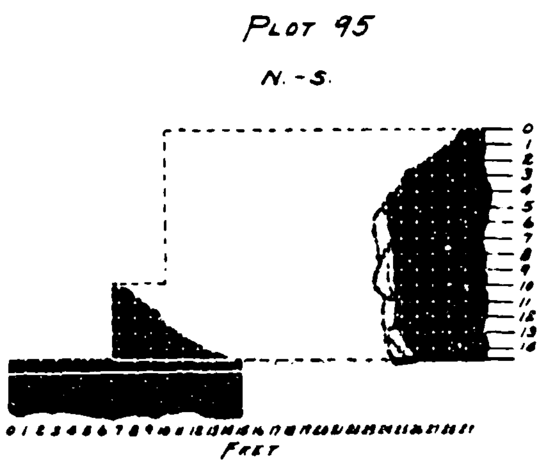
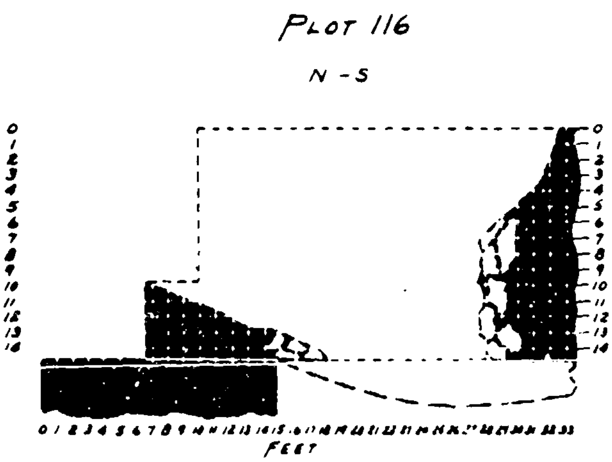
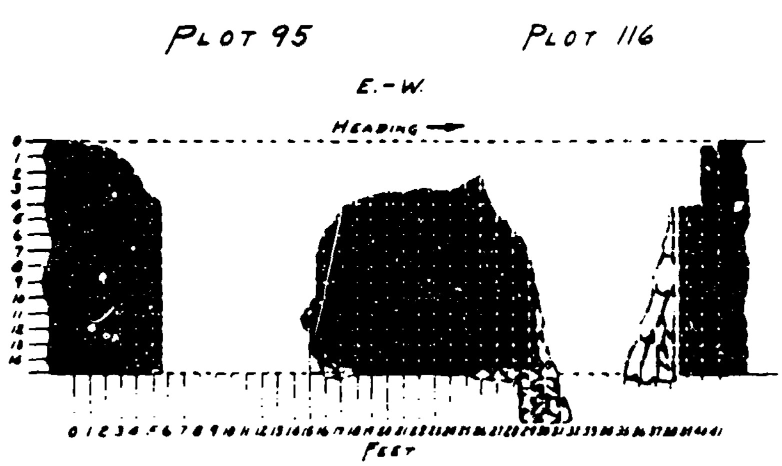
CRATER PROFILES - TRIAL XVIII

22,000-LB. S.A.P AMAZON BOMBS

RELEASE ALTITUDE 17,500 FT.







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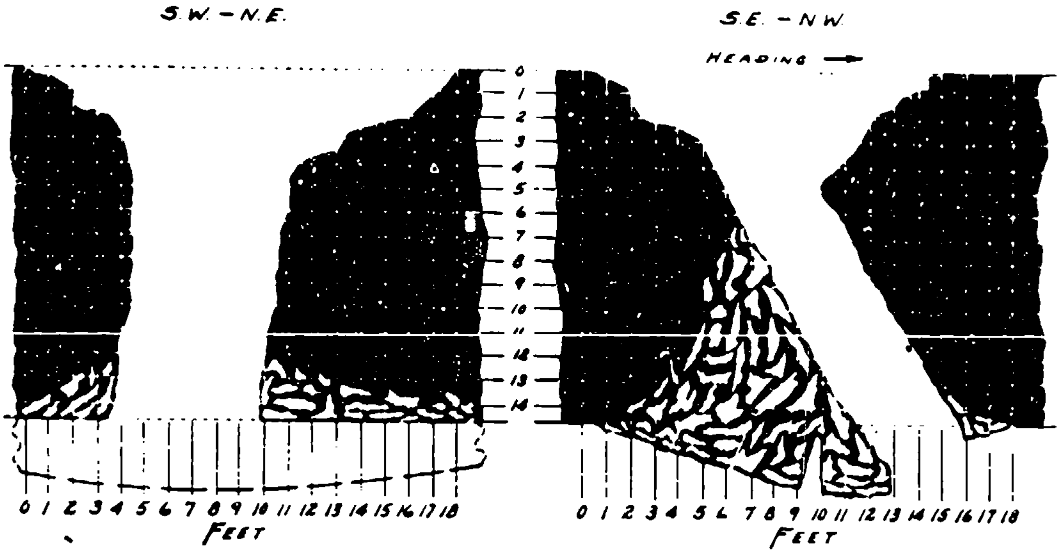
CRATER PROFILES - TRIAL XVIII
20,000 LB. SAP AMAZON BOMB
RELEASE ALTITUDE 17,500 FT.

PLOT 100



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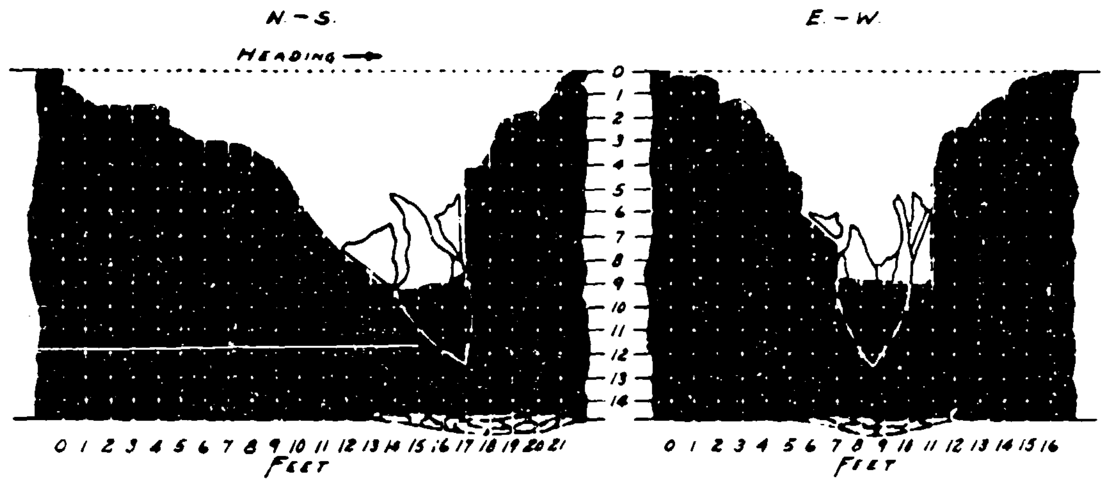
CRATER PROFILES - TRIAL XVIII

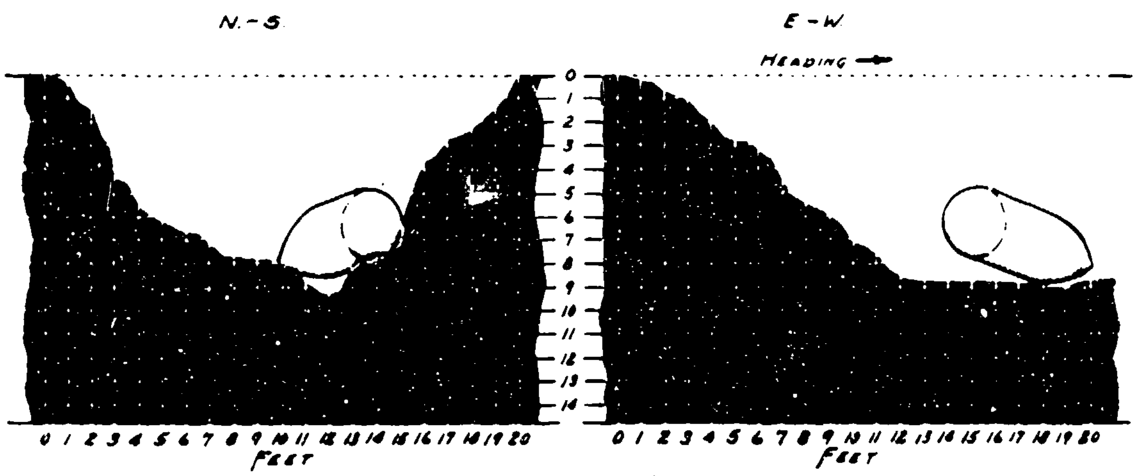
22,000-LB. SAP AMAZON BOMBS

RELEASE ALTITUDE 17,500 FT.

PLOT 106



PLOT 107



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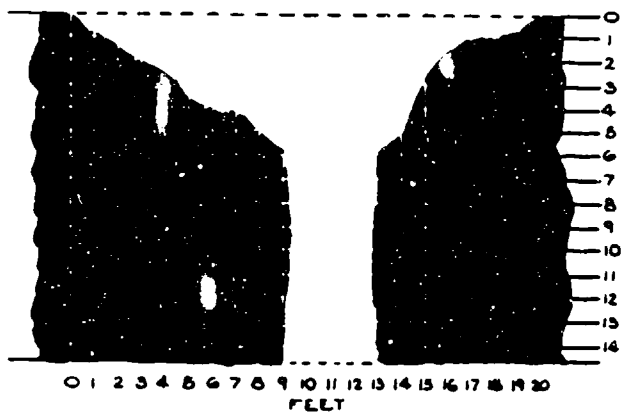
CRATER PROFILES - TRIAL XVIII

22,000-LB. SAP AMAZON BOMBS

PLOT 117

N- S



E-W

[redacted]

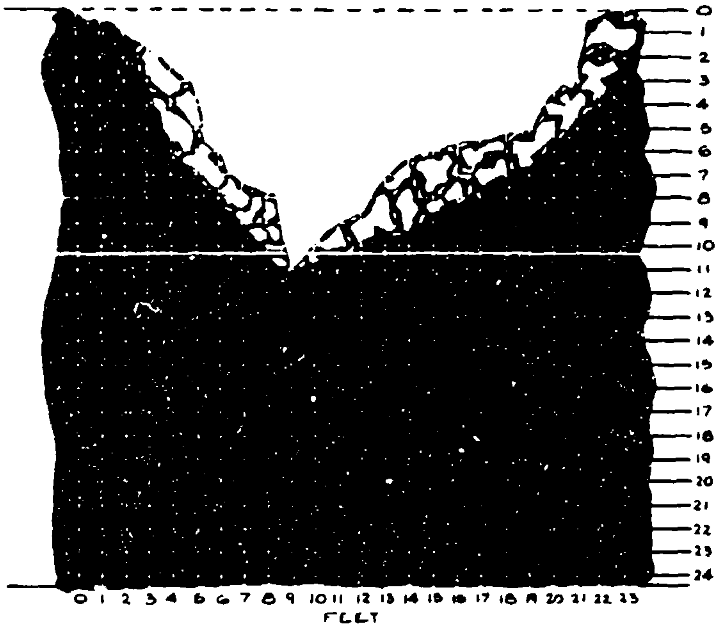
[redacted]

CRATER PROFILES - TRIAL XVIII
22,000-LB. SAP AMAZON BOMB.

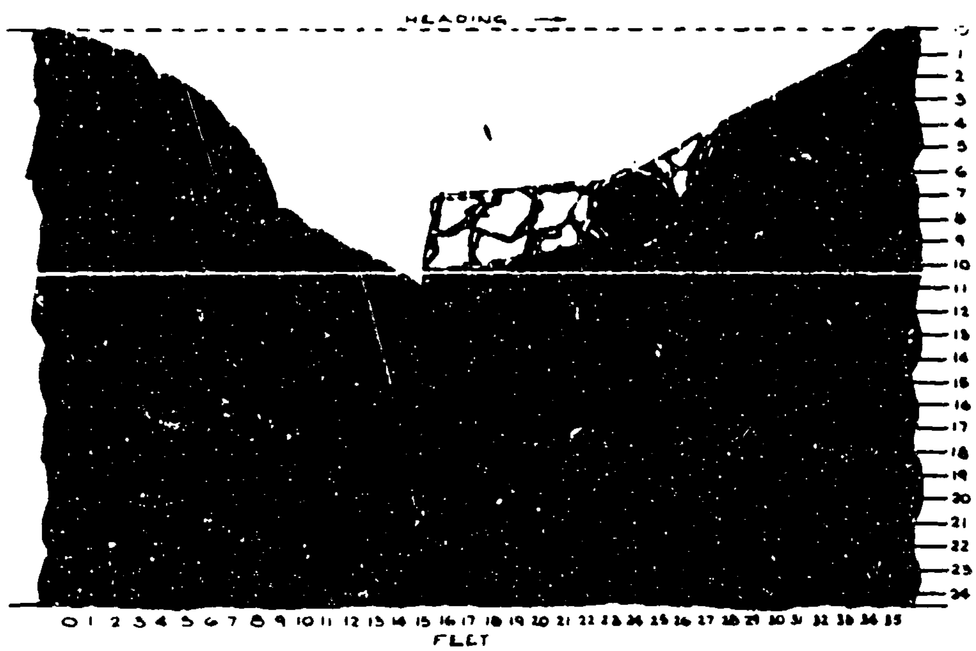
PLOT 119

RELEASE ALTITUDE 17,500 FT.

N - S



E - W



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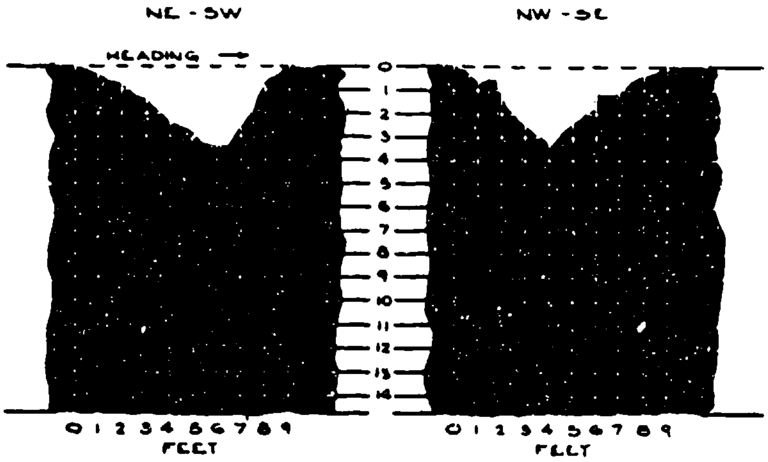
CRATER PROFILES - TRIAL III

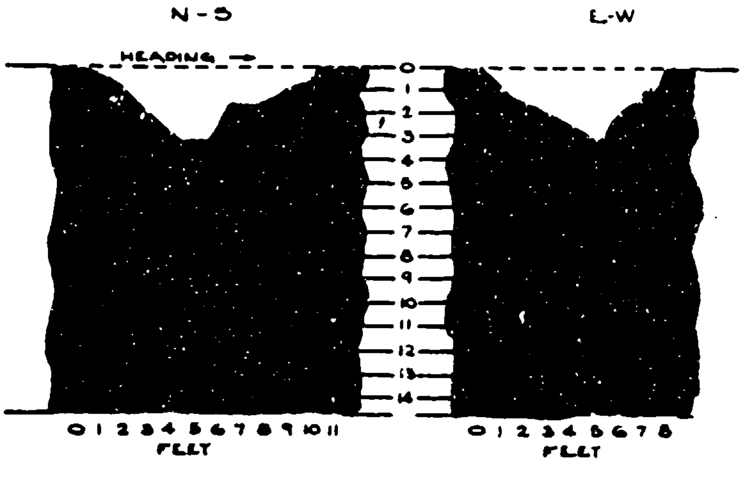
1650-LB. MODEL BOMBS

RELEASE ALTITUDE 9600 FT.

PLOT 111



PLOT 112



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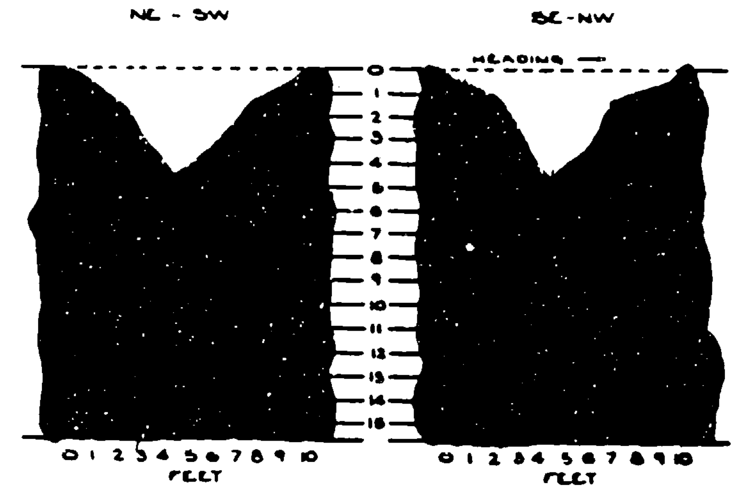
CRATER PROFILES - TRIAL XIX

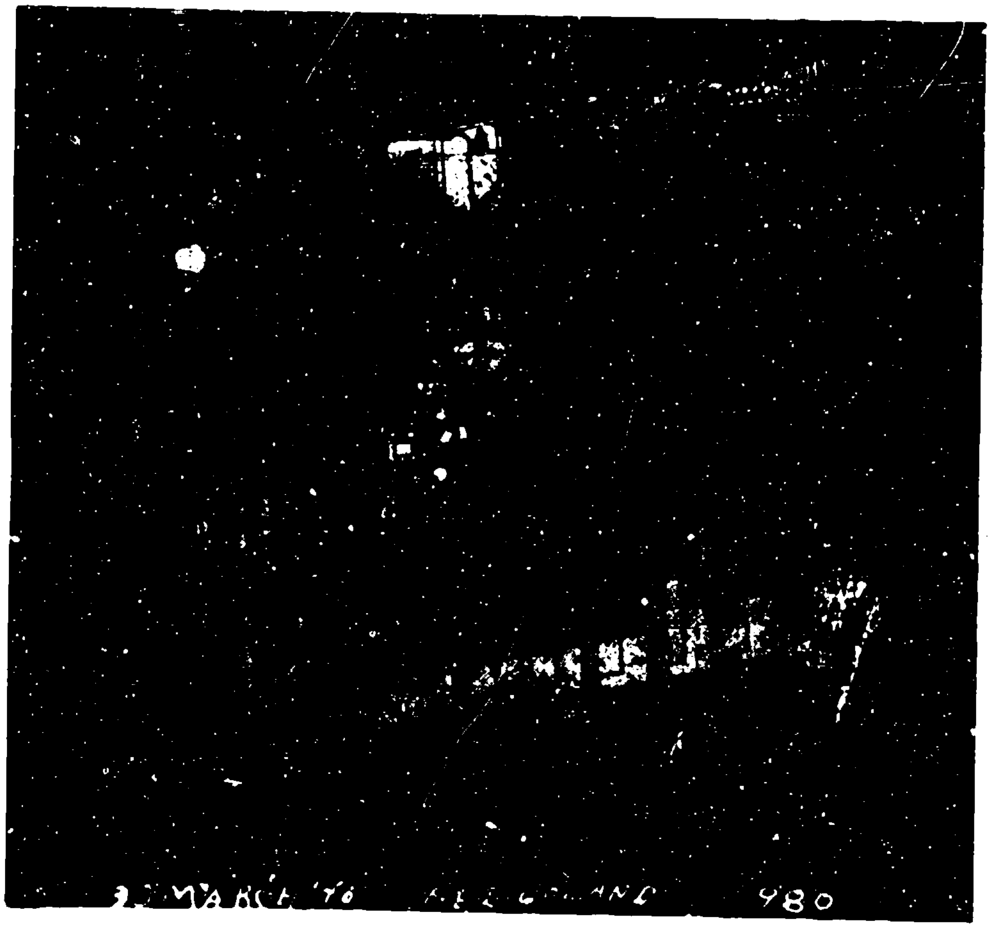
1650-LB. MODEL BOMBS

RELEASE ALTITUDE 15,600 FT.

PLOT 124



View of U-boat Shelter at Heligoland.



Aerial view of roof of Heligoland target. Radar emplacement at center was used as aiming point.

BOMB RELEASE RECORD - HELIGOLAND

PLOT NO. IDENT	PLOT NO. HIT	TRIAL NO.	DATE	AIRCRAFT NUMBER	BOMB NUMBER	BOMB TYPE	TRUE ALTITUDE	TRUE AIRSPEED	MAG. HEADING	TIME OF RELEASE	SCORE: DISTANCE IN FEET FROM WEST EDGE	SCORE: DISTANCE IN FEET FROM SOUTH EDGE	TYPE OF IMPACT	CASE PERFORMANCE	TYPE OF FILLING	INSENSITIVITY OF FILLING	CRATER DATA: DEPTH OF SPALLING	CRATER DATA: DIAMETERS ALONG FLIGHT PATH	CRATER DATA: DIAMETERS TO FLIGHT PATH	REMARKS
1	2	I	3/30/46	B-17 B	FH17	4500 CP/RA	20,000	219	330°	—	122	102	PERFORATED 3 METER	OK	SHELLITE 70-30	OK	4'-4"	9'-0"	7'-6"	DIAMETER OF PERFORATION HOLE WAS 21"
2	1	I	3/30/46	B-17 B	FH305	4500 CP/RA	20,000	219	330°	—	154	169	PERFORATED 3 METER ROOF	OK	SHELLITE 70-30	OK	4'-3"	11'-0"	7'-6"	DIAMETER OF PERFORATION HOLE WAS 16"
3		I	3/30/46	B-17 G	F-3	4500 CP/RA	20,000	224	350°	1336					SHELLITE 70-30					
4	3	I	3/30/46	B-17 D	FH178	4500 CP/RA	20,000	224	325°	1344	89	65	PERFORATED 3 METER ROOF	OK	SHELLITE 70-30	OK	3'-10"	9'-0"	8'-0"	DIAMETER OF PERFORATION HOLE WAS 18"
5		I	3/30/46	B-17 E	FH82	4500 CP/RA	20,000	210	010°	1350					SHELLITE 70-30					
6		I	3/30/46	B-17 E	FH16	4500 CP/RA	20,000	210	356°	1400					SHELLITE 70-30					
7		I	3/30/46	B-17 D	FH174	4500 CP/RA	20,000	224	325°	1404					SHELLITE 70-30					
8	4	I	3/30/46	B-17 G	FH139	4500 CP/RA	20,000	224	347°	1408	138	0	PERFORATED OVERHANG	OK	SHELLITE 70-30	OK	OVERHANG BROKE AWAY NO CRATER DEPTH			
9		I	3/30/46	B-17 F	F111	4500 CP/RA	20,000	220	340°	[illegible]					SHELLITE 70-30					
10		I	3/30/46	B-17 F	F129	4500 CP/RA	20,000	220	330°	1443					SHELLITE 70-30					
11	5	V	4/4/46	B-17 F	27538	4500 CP/RA	20,000	220	010°	1147	249	388	PERFORATED 3 METER ROOF	OK	NEW ALUMINUM WAX 64/20/16	OK	—	8'-0"	8'-0"	BOMB FOUND IN BASEMENT. PERFORATED TORPEDO ROOM FLOOR
12	6	V	4/4/46	B-17 F	[illegible]150	4500 CP/RA	20,000	220	340°	1206	222	197	PERFORATED 3 METER ROOF	OK	NEW ALUMINUM WAX 64/20/16	OK	—	9'-0"	9'-0"	FELL IN WATER
13		V	4/4/46	B-17 G	10P31	4500 CP/RA	20,000	224	240°	1210					NEW ALUMINUM WAX 64/20/16					
14		V	4/4/46	B-17 E	6[illegible]85	4500 CP/RA	20,000	218	240°	1221	MISS				NEW ALUMINUM WAX 64/20/16					
15		V	4/4/46	B-17 G	[illegible]	4500 CP/RA	20,000	224	350°	1228					NEW ALUMINUM WAX 64/20/16					
16	7	V	4/4/46	B-17 E	9-E 436E	4500 CP/RA	20,000	218	217°	1234	125	182	PERFORATED 3 METER ROOF	OK	NEW ALUMINUM WAX 64/20/16	OK	—	8'-0"	8'-0"	SCRAPED EDGE OF QUAY
17		V	4/26/46	B-17 F	E-181	4500 CP/RA	20,000	225	350°	1044					NEW ALUMINUM WAX 64/20/16					
18	6	V	4/26/46	B-17 E	CP 12/21	4500 CP/RA	20,000	219	352°	1115	99	207	PERFORATED 3 METER ROOF	OK	NEW ALUMINUM WAX 64/20/16	OK	—	9'-0"	9'-0"	FELL IN WATER
19		V	4/26/46	B-17 E	CAR 8l	4500 CP/RA	20,000	210	360°	1116					NEW ALUMINUM WAX 64/20/16					
20	8	V	4/26/46	B-17 E	J-96	4500 CP/RA	20,000	219	355°	1120					NEW ALUMINUM WAX 64/20/16					
21		V	4/26/46	B-17 E	-E-[illegible] E	4500 CP/RA	20,000	210	006°	1142					NEW ALUMINUM WAX 64/20/16					
22	5	V	4/26/46	B-17 F	-E[illegible]96	4500 CP/RA	20,000	225	350°	1135	173-1/2	139	PERFORATED 3 METER ROOF	OK	NEW ALUMINUM WAX 64/20/16	OK	—	9'-0"	9'-0"	ALSO PERFORATED 9" UPPER FLOOR & 15" GROUND FLOOR LODGING IN BASEMENT FLOOR AT 30° ANGLE
23		XXXI	4/27/46	B-17 E	CP 12/26L	4500 CP/RA	20,000	215	085°	0947					NEW ALUMINUM WAX 64/12/20					

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PLAN NO. PROPERTY	NO. HIT	TYPICAL NO.	DATE	AIRCRAFT NUMBER	BOMB NUMBER	BOMB TYPE	TRUE ALTITUDE	TRUE AIRSPEED	MAG. HEADING	TIME OF RELEASE	SCORE: DISTANCE IN FEET FROM WEST EDGE	SCORE: DISTANCE IN FEET FROM SOUTH EDGE	TYPE OF IMPACT	CASE STRENGTH	TYPE OF FILLERS	INSENSITIVITY OF FILLERS	CRATER DATA: DEPTH OF SPALLING	CRATER DATA: DIAMETERS ALONG FLIGHT PATH	CRATER DATA: DIAMETERS TO FLIGHT PATH	REMARKS
24	[illegible]	XIII	4/27/46	B-17 E	[illegible]- 276	4500 CP/RA	20,000	219	015°	0959					RDX ALUMINUM WAX 68/12/20					
25	10	XIII	4/27/46	B-17 F	[illegible]- 261	4500 CP/RA	20,000	220	070°	1000	157	354	PERFORATED 3 METER ROOF	OK	RDX ALUMINUM WAX 68/12/20	OK	—	—	—	BOMB LODGED IN GROUND FLOOR
26	[illegible]	XIII	4/27/46	B-17 D	[illegible]- 267	4500 CP/RA	20,000	220	015°	1005					RDX ALUMINUM WAX 68/12/20					
27		XIII	4/27/46	B-17 G	[illegible]- 279	4500 CP/RA	20,000	222	022°	1007					RDX ALUMINUM WAX 68/12/20					
28		XIII	4/27/46	B-17 G	[illegible]- 308	4500 CP/RA	20,300	222	[illegible]5°	1014					RDX ALUMINUM WAX 68/12/20					
29		XIII	4/27/46	B-17 F	[illegible]- 262	4500 CP/RA	20,000	220	[illegible]	1015					RDX ALUMINUM WAX 68/12/20					
30		XIII	4/27/46	B-17 H	[illegible]- 266	4500 CP/RA	20,000	220	[illegible]	1050					RDX ALUMINUM WAX 68/12/20					
31	11	XIII	4/27/46	B-17 D	[illegible]- 310	4500 CP/RA	20,000	220	3[illegible]°	1045	57	51	PERFORATED 3 METER ROOF	OK	RDX ALUMINUM WAX 68/12/20	OK	—	—	—	FELL IN WATER
32		XIII	4/27/46	B-17 H	[illegible]- 309	4500 CP/RA	20,000	220	070°	1105					RDX ALUMINUM WAX 68/12/20					
33		XVI	5/10/46	B-17 E	[illegible]- 277	4500 CP/RA	20,000	220	[illegible]	1018	NEAR MISS	NEAR MISS	HIT STEAM TUNNEL	BROKE UP	TNT	LOW ORDER	—	—	—	BOTH LOW & HIGH ORDER FRAGMENTS FOUND IN AROUND STEAM TUNNEL
34	13	XVI	5/10/46	B-17 H	[illegible]265 C330[illegible]	4500 CP/RA	20,000	220	180°	1024	205	285	PERFORATED 3 METER ROOF	OK		OK	—	—	—	PERFORATED QUAY
35	15	XVI	5/10/46	B-17 E	[illegible]- 304	4500 CP/RA	20,000	220	[illegible]5°	1041	185	44	PERFORATED 3 METER ROOF	OK		OK	—	—	—	LODGED IN QUAY
36		XVI	5/10/46	B-17 G	[illegible]- 292	4500 CP/RA	20,000	220	170°	1048										
37		XVI	5/10/46	B-17 G	OF- 124	4500 CP/RA	20,000	220	175°	1104										
38		XVI	5/10/46	B-17H	[illegible] I-467	4500 CP/RA	20,000	220	1[illegible]5°	1107										
39	14	XVI	5/10/46	B-17 E	[illegible]- 299	4500 CP/RA	20,000	220	310°	1125	250	270	PERFORATED 3 METER ROOF	OK		OK	—	—	—	FELL IN WATER
40		XVI	5/10/46	B-17 F	[illegible]- 162	4500 CP/RA	20,000	220	1[illegible]5°	1171										
41		XVI	5/10/46	B-17 F	OF- 125	4500 CP/RA	20,000	220	130°	1118										
42	17	XVI	5/10/46	B-17 C	[illegible]- 2023	4500 CP/RA	20,000	220	305°	1150	101	299	PERFORATED 3 METER ROOF	OK		OK	—	—	—	GLANCED OFF QUAY INTO WATER
43		XVI	5/10/46	B-17 J	[illegible]	4500 CP/RA	20,000	204	110°	1252										
44	12	XVI	5/10/46	B-17 J	[illegible]	4500 CP/RA	20,000	204	210°	1300	251	358	PENETRATED 3 METERS	OK	TNT	OK	—	—	—	FELL IN WATER
45		XIV	5/12/46	B-17 J	F 185 78	4500 CP/RA	20,000	220	1[illegible]5°	1024					RDX TNT ALUMINUM WAX CARBON BLACK 20/60/20 /6/2					
46	17	XIV	5/12/46	B-17 E	[illegible] 301 83	4500 CP/RA	20,000	220	[illegible]	1085	278	341	PERFORATED 3 METER ROOF	OK		OK	—	—	—	FELL IN WATER
47		XIV	5/12/46	B-17 H	F 311	4500 CP/RA	20,000	222	276°	1052										
48	19	XIV	5/12/46	B-17 F	[illegible]33 16	4500 CP/RA	20,000	220	[illegible]0°	1052	100	0	PERFORATED OVERHANG	OK		OK	BROKE AWAY OVERHANG NO CRATER			
49		XIV	5/12/46	B-17 D	[illegible]	4500 CP/RA	20,000	220	[illegible]1°	1042										
50		XIV	5/12/46	B-17 H	[illegible]- 272	4500 CP/RA	20,000	222	299°	1044										
51		XIV	5/12/46	B-17 F	OP185 10 83	4500 CP/RA	20,000	220	276°	1051										
52		XIV	5/12/46	B-17 G	OP124 67 14	4500 CP/RA	20,000	220	[illegible]	1054										

PLAN NO. DROP	NO. HIT	TRIAL NO.	DATE	AIRCRAFT NUMBER	BOMB NUMBER	BOMB TYPE	TRUE ALTITUDE	TRUE AIRSPEED	[illegible]	[illegible]	SCORE DISTANCE IN FEET FROM WEST EDGE	SCORE DISTANCE IN FEET FROM NORTH EDGE	TYPE OF IMPACT	CASE STRENGTH	TYPE OF FILLERS	INSENSITIVITY OF FILLERS	CRATER DATA DEPTH OF SPALLING	CRATER DATA DIAMETER ALONG FLIGHT PATH	CRATER DATA DIAMETER TO FLIGHT PATH	REMARKS
53		XIV	5/13/46	B-17 D	[illegible]	1500 CP/BA	20,000	[illegible]	[illegible]	[illegible]										
54	[illegible]	XIV	5/13/46	B-17 [illegible]	[illegible]	1500 CP/BA	20,000	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	PERFORATED 3 METER ROOF	OK	"	OK	—	—	—	FELL IN WATER
55	21	XV	5/13/46	B-17 E	[illegible] 365	1500 CP/BA	20,000	220	[illegible]	[illegible]	[illegible]	[illegible]	PERFORATED 3 METER ROOF	OK	NEW TNT WAX CARBON BLACK 20/20/10/P	OK	—	—	—	PERFORATED GROUND FLOOR AND LODGED IN BASEMENT
56		XV	5/13/46	B-17 F	[illegible] 297	1500 CP/BA	20,000	[illegible]	[illegible]	1460					"					
57		XV	5/13/46	B-17 J	[illegible] 336	1500 CP/BA	20,000	[illegible]	[illegible]	[illegible]					"					
58	20	XV	5/13/46	B-17 G	[illegible] 326	1500 CP/BA	20,000	[illegible]	[illegible]	[illegible]	[illegible]	139	PERFORATED 3 METER ROOF	OK	"	OK	—	—	—	PERFORATED GROUND FLOOR AND LODGED IN BASEMENT
59		XV	5/13/46	B-17 J	F 37[illegible]	1500 CP/BA	20,000	[illegible]	[illegible]	[illegible]					"					
60	[illegible]	XV	5/13/46	B-17 E	[illegible] 295	1500 CP/BA	20,000	[illegible]	[illegible]	[illegible]					"					
61	22	XV	5/13/46	B-17 D	[illegible] 291	1500 CP/BA	20,000	[illegible]	[illegible]	[illegible]	[illegible]	126	PERFORATED 3 METER ROOF	OK	"	OK	—	—	—	GLANCED OFF QUAY INTO WATER
62		XV	5/13/46	B-17 F	[illegible] 72	1500 CP/BA	20,000	[illegible]	[illegible]	[illegible]					"					
63	[illegible]	XV	5/13/46	B-17 G	[illegible]	1500 CP/BA	20,000	[illegible]	[illegible]	1114					"					
64	23	XV	5/13/46	B-17 D	[illegible] 302	1500 CP/BA	20,000	220	[illegible]	1135	[illegible]	[illegible]	PERFORATED CHECKERED [illegible]	OK	"	OK	—	—	—	PERFORATED 1" STEEL PLATE ON GROUND
65	27	XVII	5/[illegible]/46	B-17 E	[illegible] 73	2000 S.A.P.	20,000	[illegible]	[illegible]	[illegible]	[illegible]	365	HIT ON 3 METER ROOF	BROKE UP	PICRATOL	DETONATED LOW ORDER	2'-3"	12'-0"	13'-0"	PICRATOL IN AND AROUND CRATER NO BOMB FRAGMENTS RECOVERED
66		XVII	5/[illegible]/46	B-17 J	[illegible] AOS 72	2000 S.A.P.	20,000	217	[illegible]	[illegible]										
67		XVII	5/[illegible]/46	B-17 G	23-[illegible] AOS 72	2000 S.A.P.	20,000	[illegible]	359°	[illegible]										
68		XVII	5/[illegible]/46	B-17 F	19 AOS 72	2000 S.A.P.	20,000	[illegible]	139°	[illegible]										
69		XVII	5/[illegible]/46	B-17 E	21-2 AOS 72	2000 S.A.P.	20,000	[illegible]	[illegible]	[illegible]	14[illegible]	145								
70		XVII	5/[illegible]/46	B-17 F	[illegible] AOS 72	2000 S.A.P.	20,000	[illegible]	[illegible]	[illegible]										
71		XVII	5/[illegible]/46	B-17 J	[illegible] AOS 72	2000 S.A.P.	20,000	217	[illegible]	[illegible]										
72	26	XVII	5/[illegible]/46	B-17 D	[illegible] AOS 72	2000 S.A.P.	20,000	[illegible]	[illegible]	[illegible]	170	[illegible]	HIT ON 3 METER ROOF	OK		OK	3'-6"	9'-0"	9'-0"	BOMB IN CRATER AT 81° ANGLE TO VERTICAL
73	[illegible]	XVII	5/[illegible]/46	B-17 E	[illegible] AOS 72	2000 S.A.P.	20,000	[illegible]	[illegible]	[illegible]	[illegible]	165	HIT ON 3 METER ROOF	BOMB CASE DENTED 1/8"		OK	3'-0"	8'-0"	8'-0"	BOUNCED OUT OF CRATER
74		XVII	5/[illegible]/46	B-17 G	[illegible] AOS 72	2000 S.A.P.	20,000	[illegible]	[illegible]	[illegible]										
75		XVII	5/[illegible]/46	B-17 E	23-5 AOS 72	2000 S.A.P.	19,[illegible]	[illegible]	[illegible]	[illegible]										
76	25	XVII	5/[illegible]/46	B-17 E	[illegible] AOS 72	2000 S.A.P.	20,000	[illegible]	[illegible]	1395	[illegible]	200	HIT ON 3 METER ROOF	SLIGHTLY DENTED		OK	3'-6"	10'-0"	[illegible]	BOMB LODGED IN CRATER
77		XVII	5/[illegible]/46	B-17 D	[illegible] AOS 73	2000 S.A.P.	20,000	[illegible]	[illegible]	[illegible]										
78		XVII	5/[illegible]/46	B-[illegible] G	[illegible] AOS 72	2000 S.A.P.	20,000	[illegible]	[illegible]	1390										
79		XVII	5/[illegible]/46	B-17 G	[illegible] AOS 72	2000 S.A.P.	DROPPED IN TRAIN			1390										
80		XVII	5/[illegible]/46	B-17 E	23-2 AOS 72	2000 S.A.P.	19,990	[illegible]	390°	[illegible]										
81	[illegible]	XVII	5/[illegible]/46	B-17 U	23-3 AOS 72	2000 S.A.P.	20,000	[illegible]	[illegible]	1396	[illegible]	143	HIT ON 3 METER ROOF	BROKE UP	↓	DETONATED LOW ORDER	2'-9"	10'-0"	9'-0"	FRAGMENTS RECOVERED SHOW NO INDICATION OF DETONATION

Enclosure A1, page 3

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DROP NO.	NO. HIT	TRIAL	DATE	AIRCRAFT NUMBER	BOMB NUMBER	BOMB TYPE	TRUE ALTITUDE	TRUE AIRSPEED	MAG. HEADING	TIME OF RELEASE	SCORE: DISTANCE IN FEET FROM WEST EDGE	SCORE: DISTANCE IN FEET FROM SOUTH EDGE	TYPE OF IMPACT	CASE STRENGTH	TYPE OF FILLING	INSENSITIVITY OF FILLERS	CRATER DATA: DEPTH OF SPALLING	CRATER DATA: DIAMETERS ALONG FLIGHT PATH	CRATER DATA: DIAMETERS TO FLIGHT PATH	REMARKS
82		XVII	5/23/46	B-17	22-2 A0872	2000 S.A.P.	20,000	207	053°	1602					PICRATOL					
83		XVII	5/23/46	B-17 H	22-2 A0872	2000 S.A.P.	20,000	[illegible]	060°	1610					"					
84	29	XVII	6/6/46	B-17 P	82 A0872	2000 S.A.P.	20,000	[illegible]	065°	1556	108	390	HIT ON 3 METER ROOF	OK	"	OK	3'-6"	9'-0"	7'-6"	BOMB LODGED IN CRATER
85	[illegible]	XVII	6/6/46	B-17 F	84 A0872	2000 S.A.P.	DROPPED IN TRAIN				87	320	HIT ON 3 METER ROOF	OK	"	OK	3'-0"	8'-6"	8'-0"	BOMB UPSIDE DOWN IN CRATER
86		XVII	6/6/46	B-17 E	85 A0872	2000 S.A.P.	20,000	[illegible]	[illegible]	[illegible]					"					
87		XVII	6/6/46	B-17 S	[illegible] A0872	2000 S.A.P.	DROPPED IN TRAIN								"					
88		XVII	6/6/46	B-17 J	22 A0872	2000 S.A.P.	20,000	[illegible]	360°	1112					"					
89		XVII	6/6/46	B-17 S	22 A0872	2000 S.A.P.	20,000	[illegible]	253°	1115					"					
90		XVII	6/6/46	B-17 S	31 A0872	2000 S.A.P.	DROPPED IN TRAIN								"					
91		XVII	6/6/46	B-17 J	33 A0872	2000 S.A.P.	20,300	[illegible]	[illegible]	1125					"					
92	31	XVII	6/6/46	B-17 Q	22 A0872	2000 S.A.P.	DROPPED IN TRAIN				[illegible]	271	HIT ON 3 METER ROOF	DENTED	"	OK	3'-6"	10'-6"	10'-0"	BOMB LODGED IN CRATER
93		XVII	6/6/46	B-17 D	21 A0872	2000 S.A.P.	20,000	[illegible]	[illegible]	1130					"					
94		XVII	6/6/46	B-17 D	A0872	2000 S.A.P.	DROPPED IN TRAIN								"					
95		XVII	6/6/46	B-17 Q	21 A0872	2000 S.A.P.	20,000	[illegible]	[illegible]	1134					"					
96	[illegible]	XVII	6/6/46	B-17 Q	12 A0872	2000 S.A.P.	DROPPED IN TRAIN								"					
97	32	XVII	6/6/46	B-17 P	A0872	2000 S.A.P.	20,000	[illegible]	[illegible]	1140	125	[illegible]	HIT ON 3 METER ROOF	BROKE UP	"	DETONATED LOW ORDER	2'-6"	11'-0"	9'-6"	PICRATOL AROUND AND IN CRATER NOSE WITH 3' FRAGMENT FOUND 25' FROM CRATER
98		XVII	6/6/46	B-17 P	[illegible] A0872	2000 S.A.P.	DROPPED IN TRAIN								"					
99		XVII	6/6/46	B-17 J	[illegible] A0872	2000 S.A.P.	20,000	[illegible]	[illegible]	1140					"					
100		XVII	6/6/46	B-17 D	A0872	2000 S.A.P.	20,000	[illegible]	[illegible]	1150					"					
101		XVII	6/6/46	B-17 D	A0872	2000 S.A.P.	DROPPED IN TRAIN								"					
102		XX	7/11/46	B-17 R	[illegible]	1,500 CP/BA	20,000	215	[illegible]	1530					PICRATOL					ROCKET FUNCTIONED
103		XX	7/11/46	B-17 R	[illegible]	1,500 CP/BA	20,000	[illegible]	356°	1143					PICRATOL					ROCKET FUNCTIONED
104		XX	7/11/46	B-17 R	[illegible]	1,500 CP/BA	20,000	215	055°	1150					PICRATOL					ROCKET FUNCTIONED
105		XX	7/11/46	B-17 S	[illegible]	1,500 CP/BA	20,000	[illegible]	357°	1157					PICRATOL					ROCKET FUNCTIONED
106		XX	7/11/46	B-17 P	[illegible]	1,500 CP/BA	20,000	[illegible]	275°	1500					PICRATOL					ROCKET FUNCTIONED
107	95	XX	7/11/46	B-17 Q	90 276	1,500 CP/BA	20,000	[illegible]	010°	1505	134	[illegible]	PERFORATED 3 METER ROOF	OK	PICRATOL	OK	—	8'-0"	7'-6"	ROCKET FUNCTIONED
108	[illegible]	XX	7/12/46	B-17 Q	[illegible] 272	1,500 CP/BA	DROPPED IN TRAIN			—	85	205	PERFORATED 3 METER ROOF	OK	PICRATOL	OK	—	8'-0"	9'-0"	LANDED IN WATER ROCKET DID NOT FUNCTION
109	97	XX	7/11/46	B-17 P	[illegible]	1,500 CP/BA	20,000	[illegible]	310°	1511	274	325	PERFORATED 3 METER ROOF	OK	PICRATOL	OK	—	9'-0"	10'-0"	LANDED IN WATER ROCKET FUNCTIONED
110		XX	7/11/46	B-17 P	[illegible] 275	1,500 CP/BA	20,000	[illegible]	055°	1520					PICRATOL					ROCKET FUNCTIONED
111	[illegible]	XX	7/11/46	B-17 I	[illegible]	1,500 CP/BA	20,000	[illegible]	305°	1527					PICRATOL					PARTIALLY FUNCTIONED
112	[illegible]	XX	7/27/46	B-17 J	23 2[illegible]	[illegible] CP/BA	20,000	212	308°	1535	[illegible]	250	PERFORATED 3 METER ROOF	OK	PICRATOL	OK	—	10'-0"	9'-0"	ROCKET DID NOT FUNCTION

PLOT NO.	DROP NO.	TRIAL NO.	DATE	AIRCRAFT NUMBER	BOMB NUMBER	BOMB TYPE	TRUE ALTITUDE	TRUE AIRSPEED	MAG. HEADING	TIME OF RELEASE	SCORE: DISTANCE IN FEET FROM WEST EDGE	SCORE: DISTANCE IN FEET FROM SOUTH EDGE	TYPE OF IMPACT	CASE STRENGTH	TYPE OF FILLERS	INSENSITIVITY OF FILLERS	CRATER DATA: DEPTH OF SPALLING	CRATER DATA: DIAMETERS ALONG FLIGHT PATH	CRATER DATA: DIAMETERS TO FLIGHT PATH	REMARKS
113	33	IX	7/22/46	B-17 J	WB 237	4500 CP/RA	20,000	218	346°	1116	895	196-1/2	PERFORATED 3 METERS	OK	PICRATOL	OK	—	9'-0"	6'-0"	ROCKET FUNCTIONED
114		XXII	7/17/46	B-17 E	A08 71	2000 S.A.P	20,000	219	210°	0955					PICRATOL					
115		XXII	7/17/46	B-17 J	A08 71	2000 S.A.P	20,000	218	190°	1010					PICRATOL					
116		XXII	7/17/46	B-17 R	A08 71	2000 S.A.P	20,000	220	260°	1320					PICRATOL					
117		XXII	7/17/46	B-17 K	A08 71	2000 S.A.P	DROPPED IN TRAIN								PICRATOL					
118		XXII	7/17/46	B-17 S	A08 71	2000 S.A.P	20,000	219	200°	1021					PICRATOL					
119	39	XXII	7/17/46	B-17 J	A08 72	2000 S.A.P	20,000	218	210°	1025	92	122	HIT ON 3 METER ROOF	FUZED	PICRATOL	HIGH ORDER	3'-9"	16'-0"	12'-8"	CEILING SCABBED OVER LARGE AREA
120	42	XXII	7/17/46	B-17 D	A08 72	2000 S.A.P	20,000	220	276°	1035	19	351	HIT ON 3 METER ROOF	FUZED	PICRATOL	HIGH ORDER	3'-1"	13'-0"	11'-0"	CONSIDERABLE SCABBING OF CEILING HIT 300' FROM CRATER
121		XXII	7/17/46	B-17 D	A08 72	2000 S.A.P	20,000	220	265°	1058					PICRATOL					
122	41	XXII	7/18/46	B-17 O	A08 71	2000 S.A.P	20,000	220	185°	1025	10-1/2	186	HIT ON OVERHANG	FUZED	PICRATOL	OR DUD	3'-0"	16'-3"	8'-3"	SLIGHT SCABBING ON UNDERSIDE OF OVERHANG
123		XXII	7/18/46	B-17 O	A08 71	2000 S.A.P	20,000	220	205°	1040					PICRATOL					
124	38	XXII	7/19/46	B-17 F	A08 71	2000 S.A.P	20,000	220	095°	0920	185	112	HIT ON 3 METER ROOF	FUZED	PICRATOL	HIGH ORDER	3'-1"	11'-6"	13'-6"	NO SCABBING
125		XXII	7/19/46	B-17 F	A08 72	2000 S.A.P	DROPPED IN TRAIN			0920	NEAR MISS		HIT SIDE OF STEAM TUNNEL	BROKE UP	PICRATOL	BURNED	BOMB BROKE UP HITTING WALL OF TUNNEL AND FILLER BURNED			
126	12	XXII	7/19/46	B-17 S	A08 71	2000 S.A.P	20,000	220	218°	0943	67-1/2	286	HIT ON 3 METER ROOF	FUZED	PICRATOL	HIGH ORDER	3'-6"	9'-3"	8'-6"	LARGE AREA SCABBED
127	M	XXII	7/19/46	B-17 E	A08 72	2000 S.A.P	20,000	225	211°	0954					PICRATOL					
128	[illegible]	XXII	7/19/46	B-17 D	A08 72	2000 S.A.P	20,000	220	269°	0959	94	85	HIT ON 3 METER ROOF	FUZED	PICRATOL	LOW ORDER	NO DEFINITE CRATER BOMB APPEARED TO LAND FLAT			PICRATOL SCATTERED OVER LARGE AREA BASE PLATE FOUND INTACT
129		XXII	7/19/46	B-17 E	A08 72	2000 S.A.P	20,000	220	214°	1001					PICRATOL					
130		XXII	7/19/46	B-17 E	A08 72	2000 S.A.P	DROPPED IN TRAIN			1001					PICRATOL					
131	43	XXII	7/19/46	B-17 F	A08 72	2000 S.A.P	20,000	220	210°	1006	165	116	HIT ON 3 METER ROOF	FUZED	PICRATOL	HIGH ORDER	3'-0"	14'-6"	12'-6"	VERY SLIGHT SCABBING
132		XXII	7/19/46	B-17 F	A08 72	2000 S.A.P	DROPPED IN TRAIN			1006					PICRATOL					
133	40	XXII	7/19/46	B-17 D	A08 71	2000 S.A.P	20,000	220	270°	1009	8	[illegible]	HIT OVERHANG	FUZED	PICRATOL	HIGH ORDER	BLEW THROUGH	20'-0"	15'-0"	1' STRIP LEFT ON EDGE OF OVERHANG

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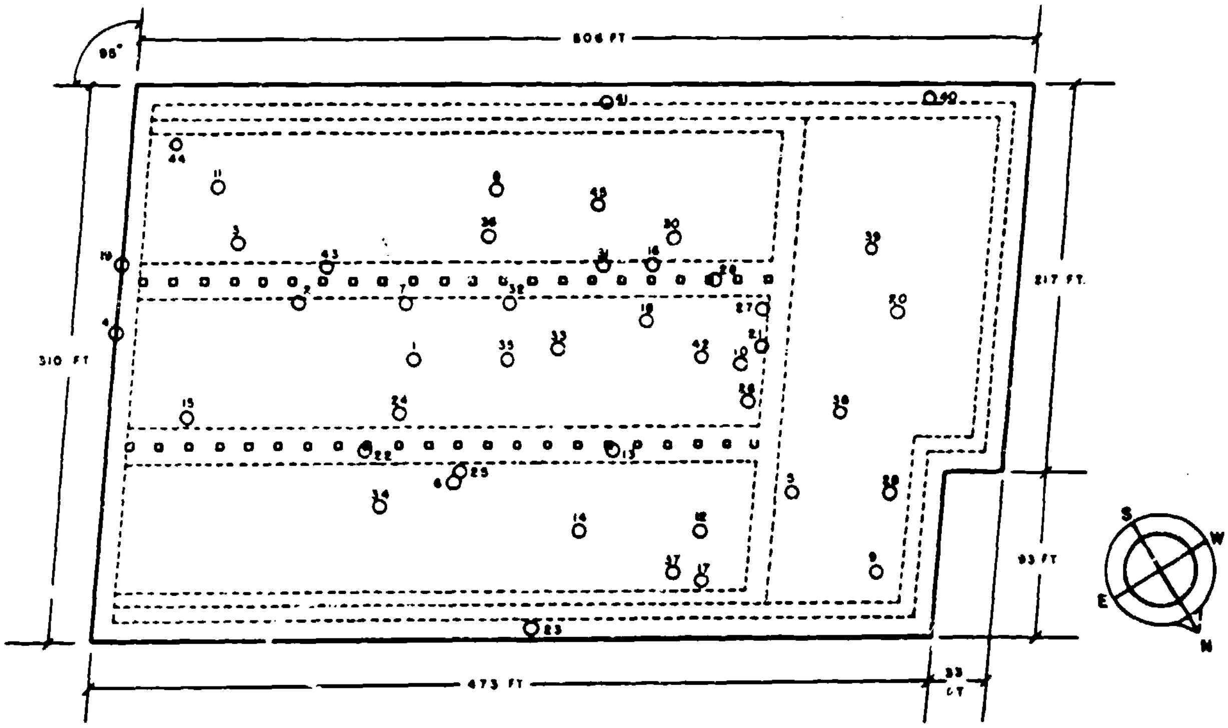
HELIGOLAND BOMB PLOT



TRIAL	BOMB	FILLER	PLOT NUMBERS	BOMBS DROPPED
I	4000 LB CP/NON-RA	SHELLITE 70/30	1 - 4	10
V	4000 LB CP/NON RA	RDX/AL/WAX-64/20/16	5 - 9	12
XIII	4000 LB CP/NON-RA	RDX/AL/WAX-68/20/12	10 - 11	10
XVI	4000 LB CP/NON-RA	TNT	12 - 16	12
XIV	4000 LB CP/NON-RA	RDX/TNT/AL/WAX/CB-[illegible]/20/6/2	17 - 19	10
XV	4000 LB CP/NON-RA	RDX/TNT/WAX/CB-20/60/10/2	20 - 23	10
XVII	2000 LB SAP M 103	PICRATOL	24 - 32	37
XX	4000 LB CP/RA	PICRATOL	33 - 37	12
XXII	2000 LB SAP M 103	PICRATOL (FUZED)	38 - 45	20
		TOTAL	45	133

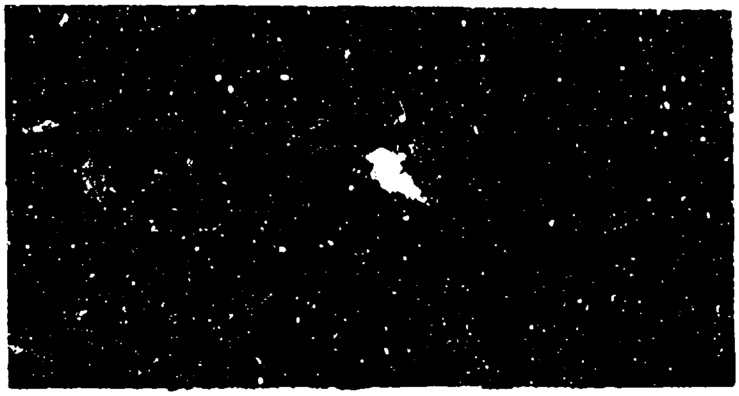
SCALE
0 25' 50'

-NOTES-

ALL APPARENTLY PARALLEL SIDES ARE PARALLEL - THE ANGLES AT THE CORNERS ARE 95° AND 85°

THE ROOF IS 3 METRES THICK, WITH AN OVERHANG ALL AROUND TAPERING DOWN TO 1 METRE AT THE EDGES

RELEASE ALTITUDE - 20,000 FT

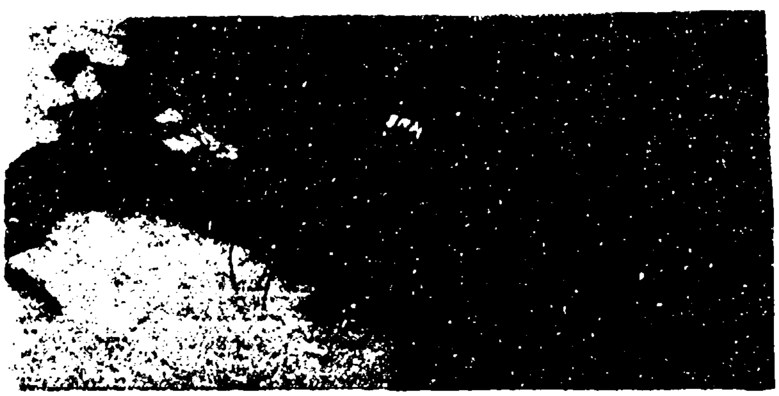


Crater and perforation made by Disney Bomb (Plot No.1)
Trial I.

[redacted]

Crater and perforation made by Disney Bomb (Plot No.2)
Trial I.

[redacted]



Crater and perforation made by Disney Bomb (Plot No.3)
Trial I.

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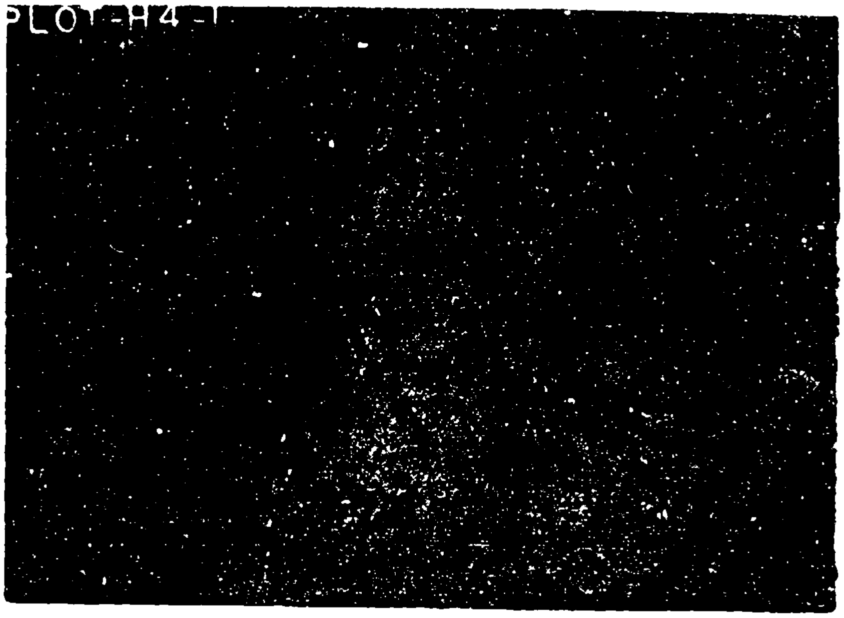
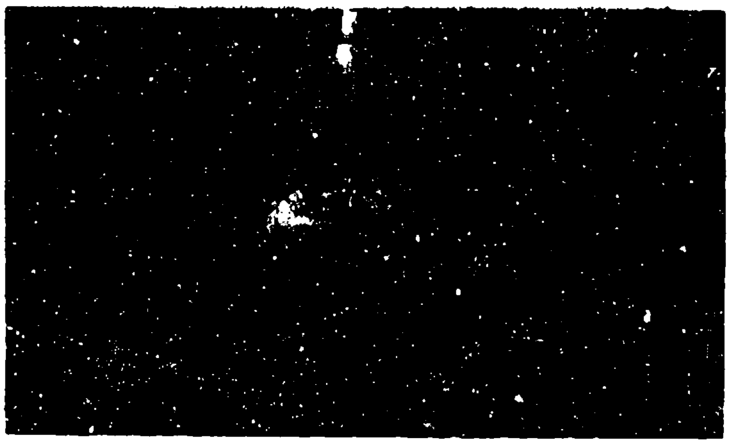


Disney Bomb (Plot No.4) Trial I, struck on edge of roof overhang.

Crater and perforation made by Disney Bomb (Plot No.5) Trial V.

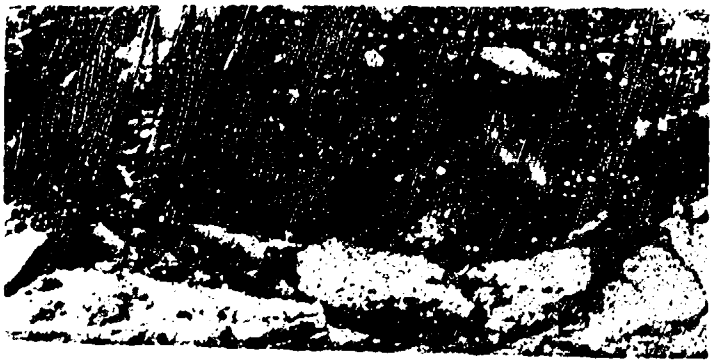
Disney Bomb (Plot No. 5) lodged in basement floor after perforating roof and main floor.



Crater and perforation made by Disney Bomb (Plot No. 6)
Trial V.

Crater and perforation made by Disney Bomb (Plot No. 7).
Trial V.

Crater and perforation made by Disney Bomb (Plot No. 8) Trial V.



Crater and perforation made by Disney Bomb (Plct No. 9)
Trial V

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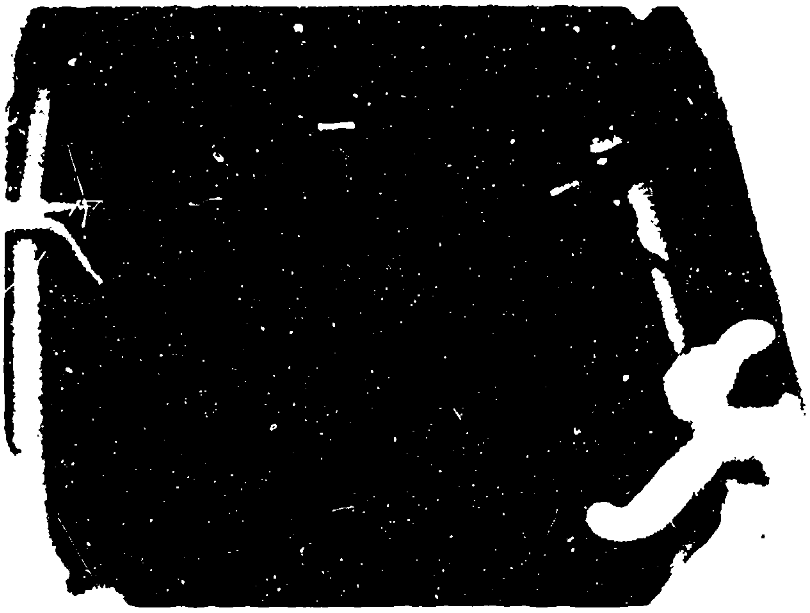
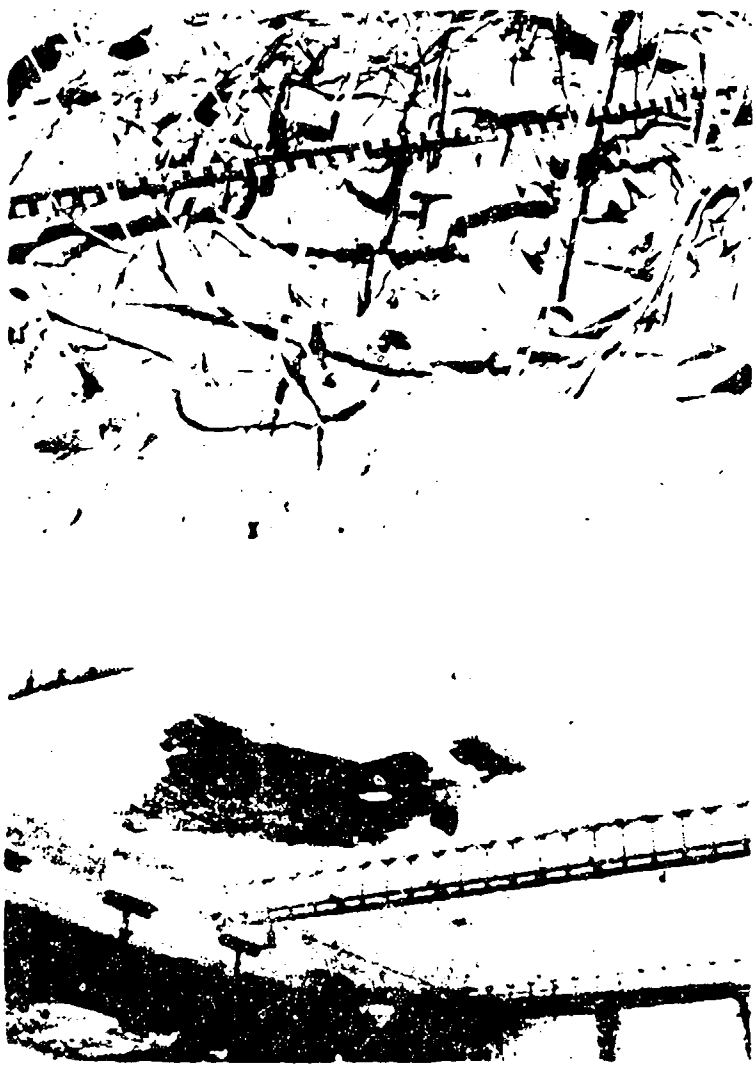


Disney Bomb (Plot No. 9) lodged in basement floor after perforating roof and two floors.

[redacted]

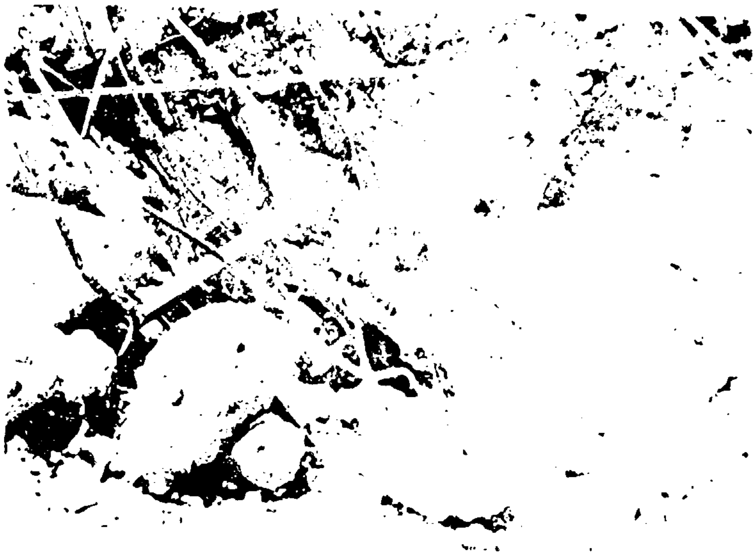
Crater and perforation made by Disney Bomb (Plot No. 10)
Trial XIII.

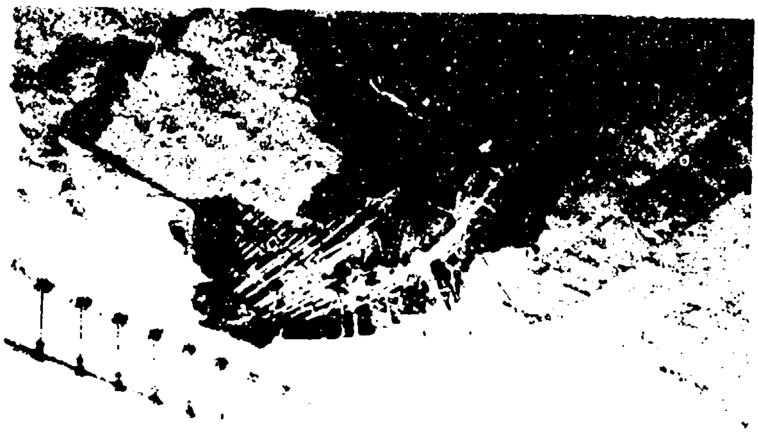
[redacted]



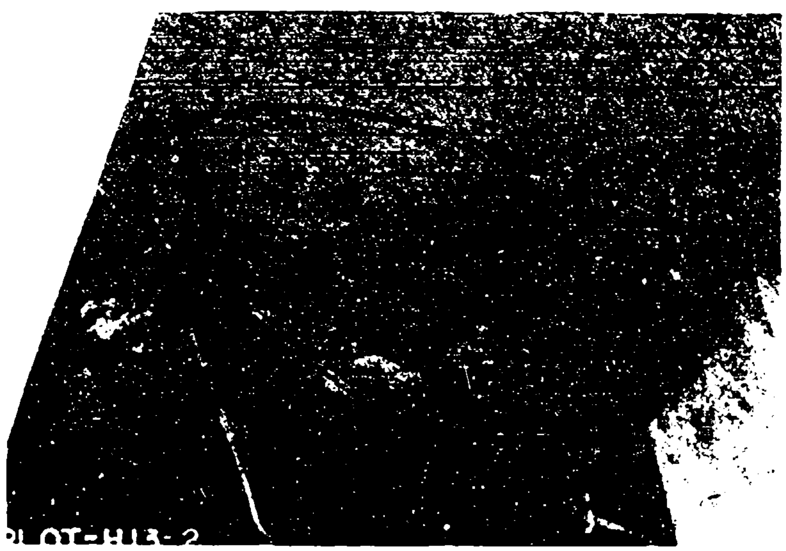
Crater and perforation made by Disney Bomb (Plot No. 11)
Trial XIII

[redacted]



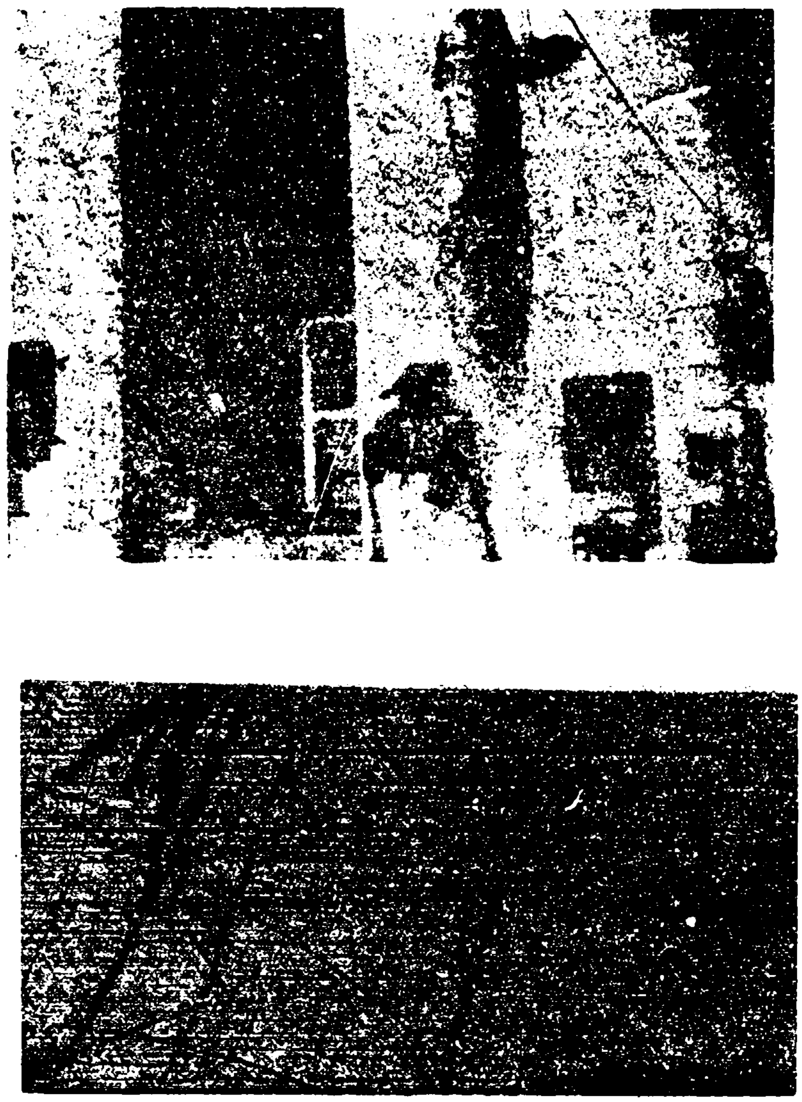


Crater and perforation made by Disney Bomb (Plot No. 12) Trial XVI.



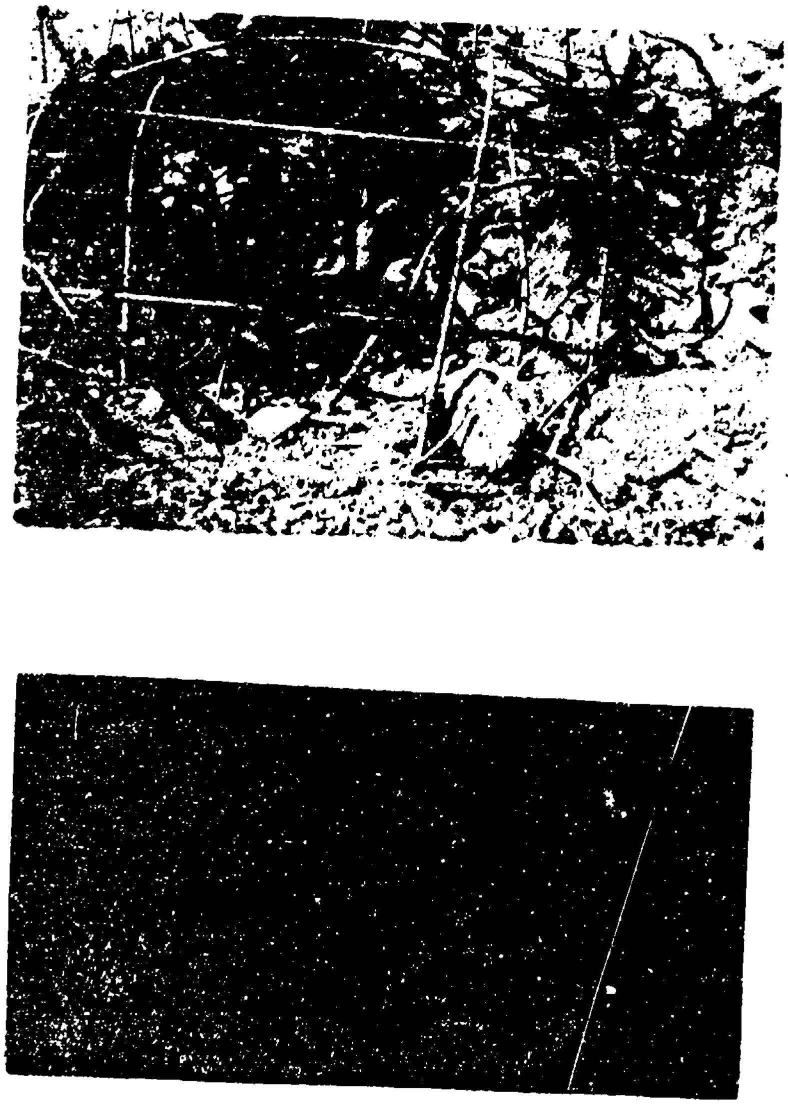
Crater and perforation made by Disney Bomb (Plot NO.13)
Trial XVI.

[redacted]

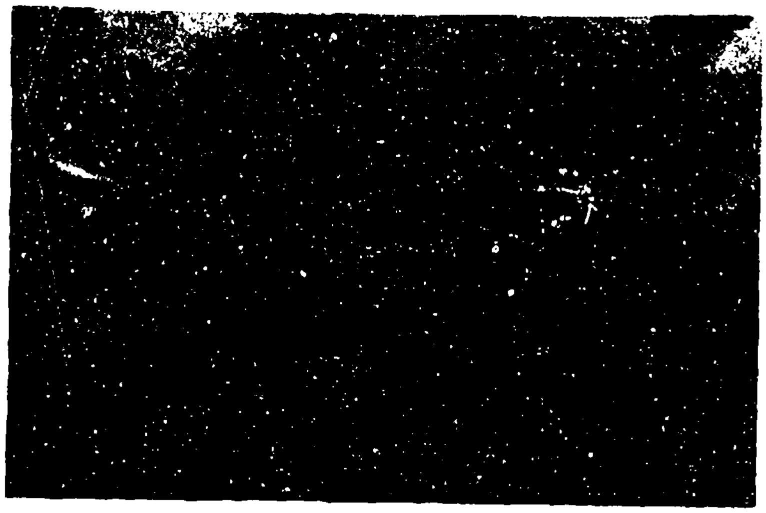


Disney Bomb (Plot No. 13) perforated roof, struck edge of pillar, and buried in floor of catwalk.

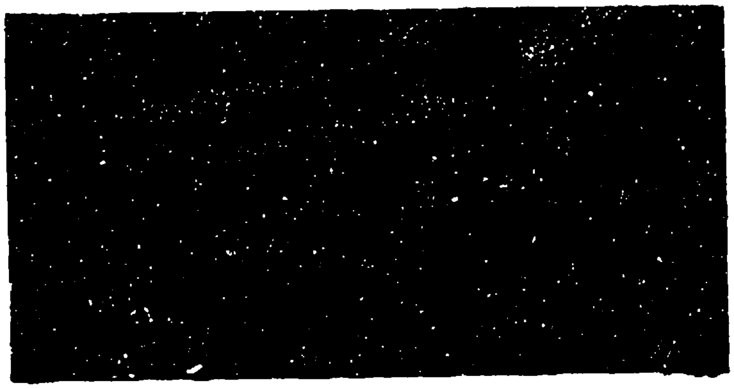
[redacted]



Crater and perforation made by Disney Bomb (Plot No. 14) Trial XVI.



Crater and perforation made by Disney Bomb (Plot No. 15) Trial XVI.

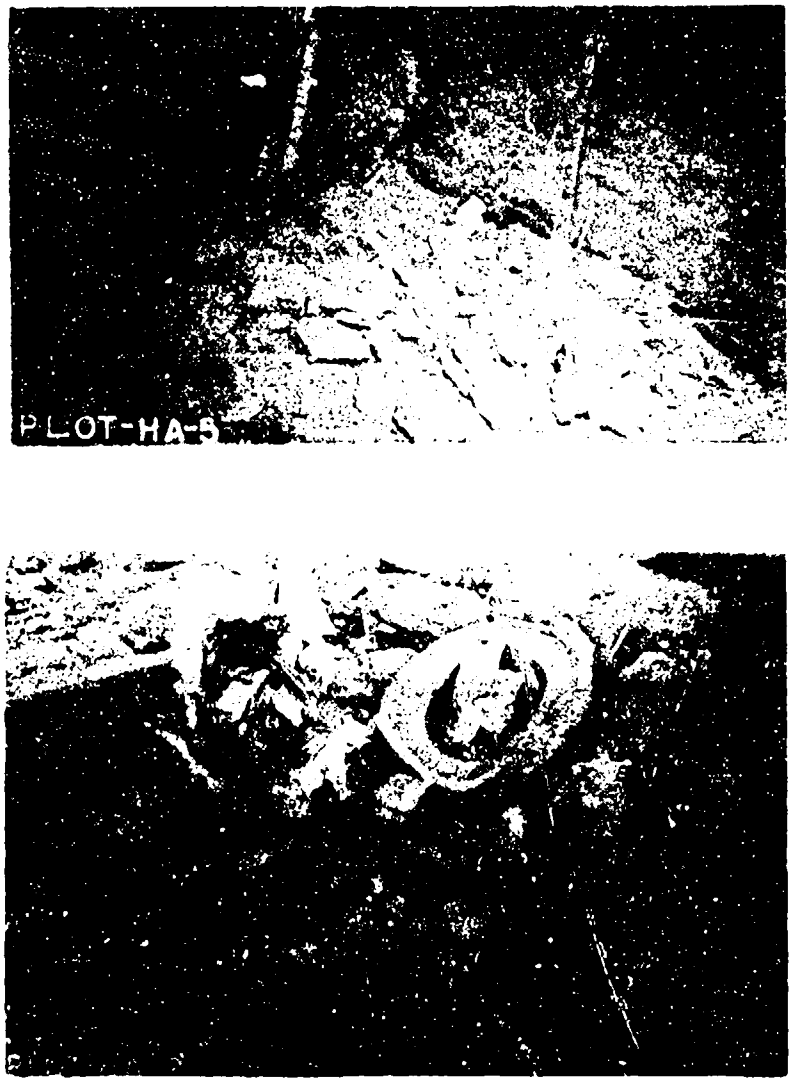


Crater and perforation made by Disney Bomb (Plot No. 16)
Trial XVI

[redacted]

Disney Bomb with TNT filler (Trial XVI) exploded upon striking wall of steam tunnel leading to target. Lower view shows fragments typical of high order detonation.

[redacted]



Views showing rocket motor plate, rocket fuze pot, and base cap of Disney Bomb of Trial XVI, which exploded in steam tunnel. Note pistol to left of ruler in upper view.

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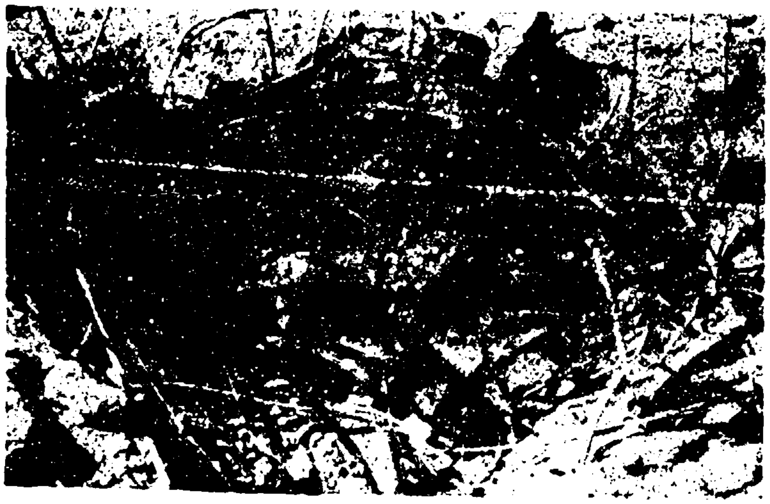
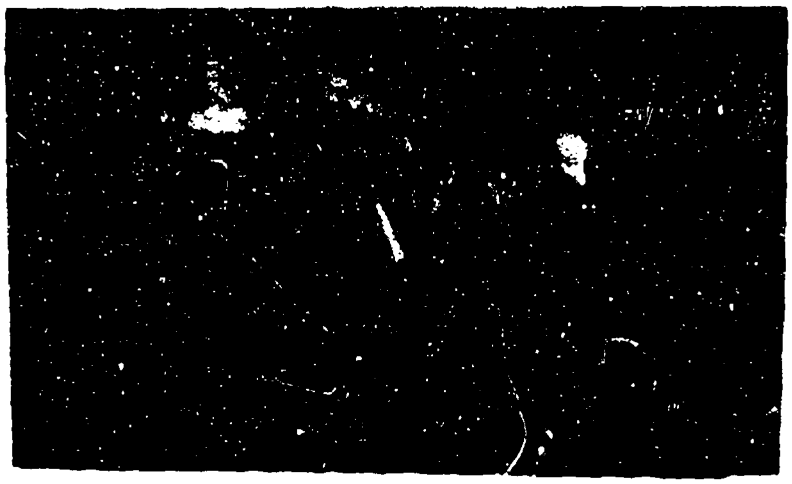


Crater and perforation of DisneyBomb (Plot No. 17) Trial XIV.

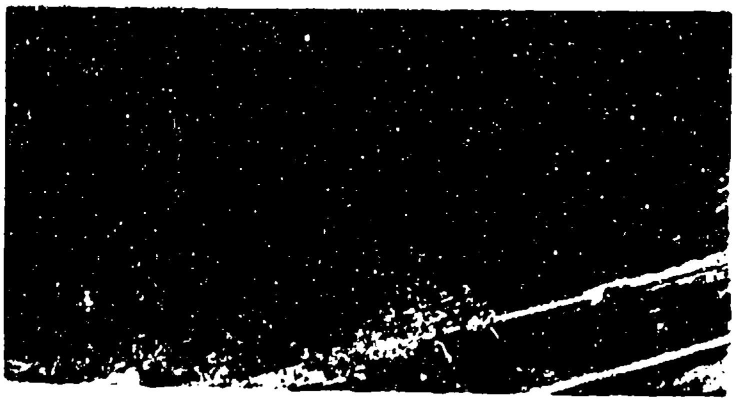


Crater and perforation of Disney Bomb (Plot No. 18) Trial XIV.

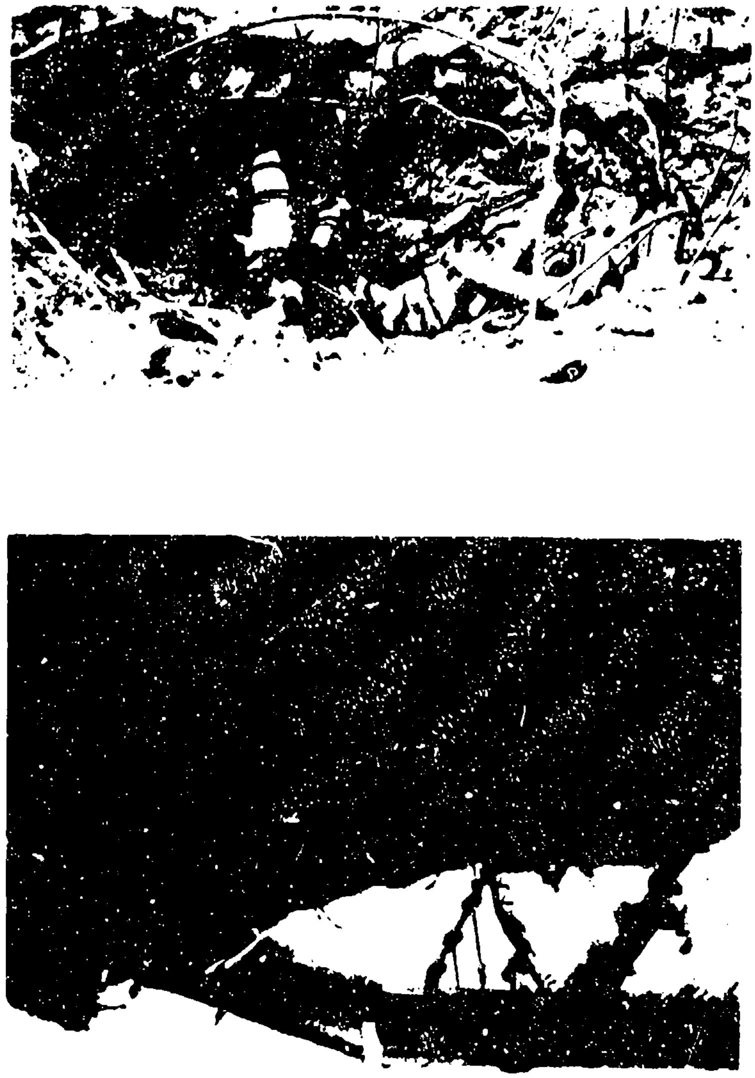
[redacted]

Disney Bomb (Plot No. 19) goes through roof overhang in Trial XIV.

[redacted]

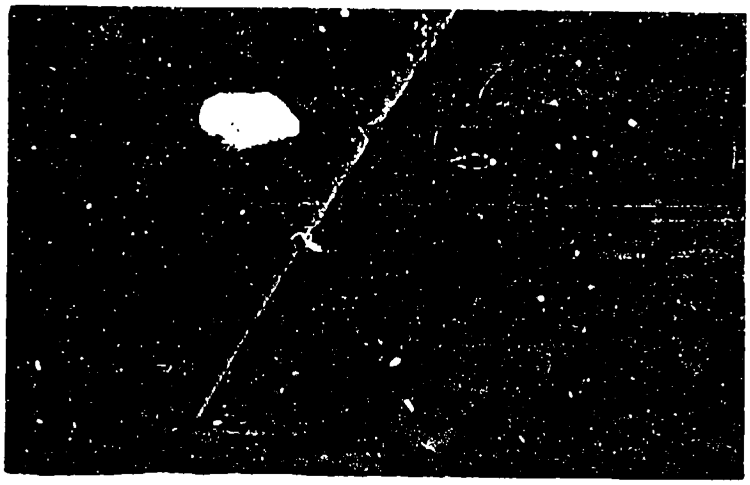


Crater and perforation made by Disney Bomb (Plot No. 20)
Trial XV.

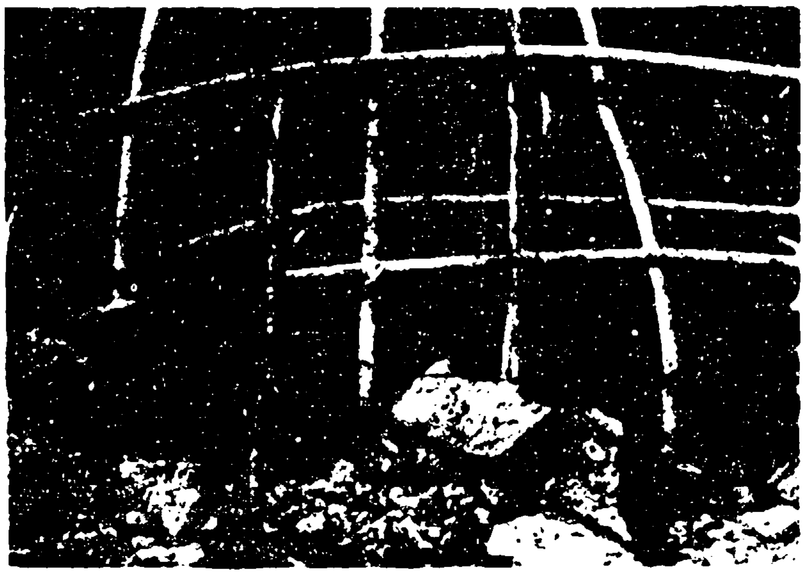


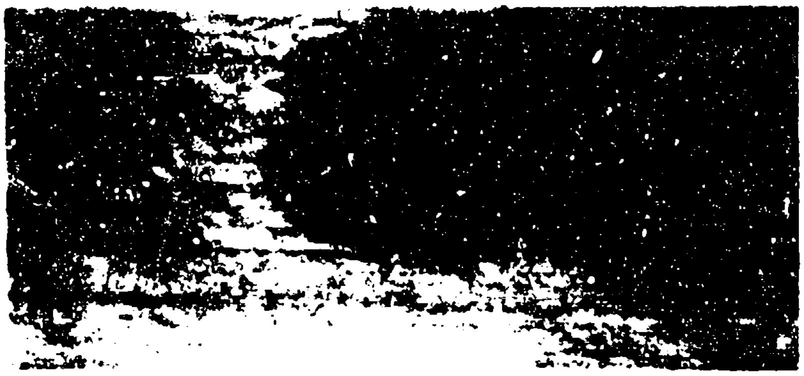
Crater and perforation made by Disney Bomb (Plot No. 21)
Trial XV.

Crater and perforation made by Disney Bomb (Plot No. [illegible])
Trial XV.

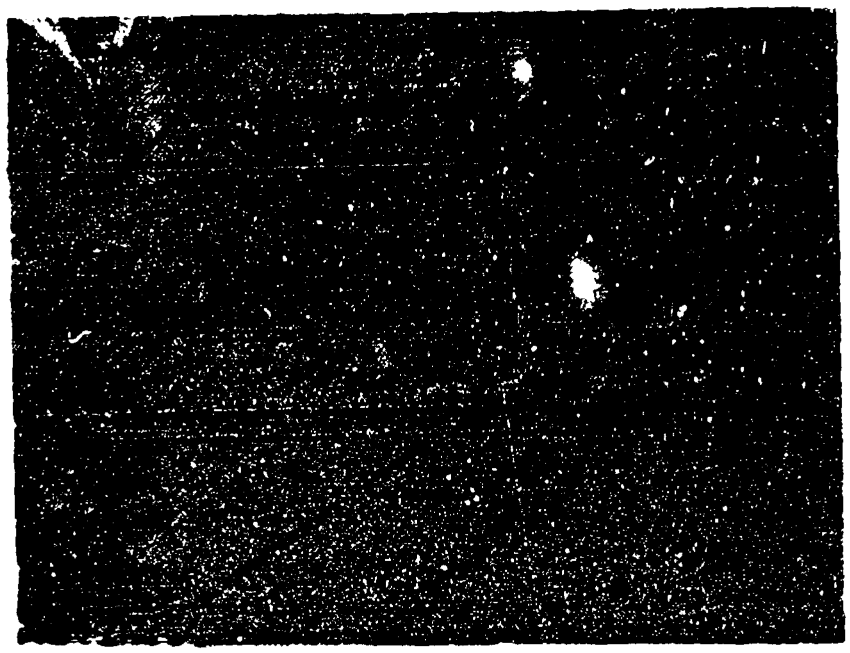


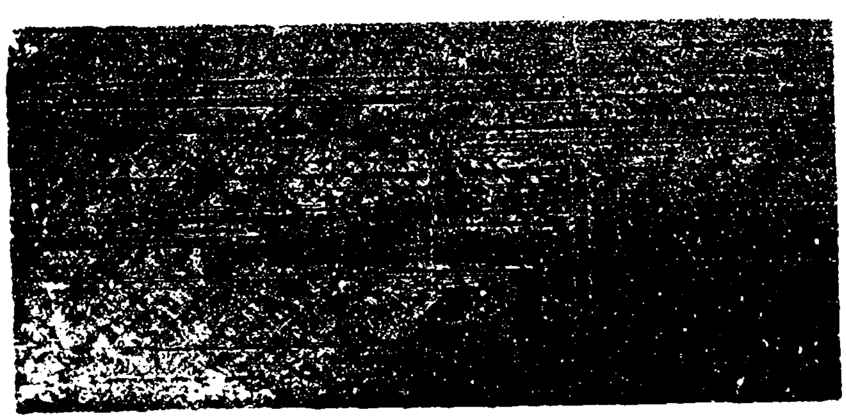
Disney Bomb (Plot No. 23) perforates roof overhang in Trial XV, and perforates 1" steel plate on ground.





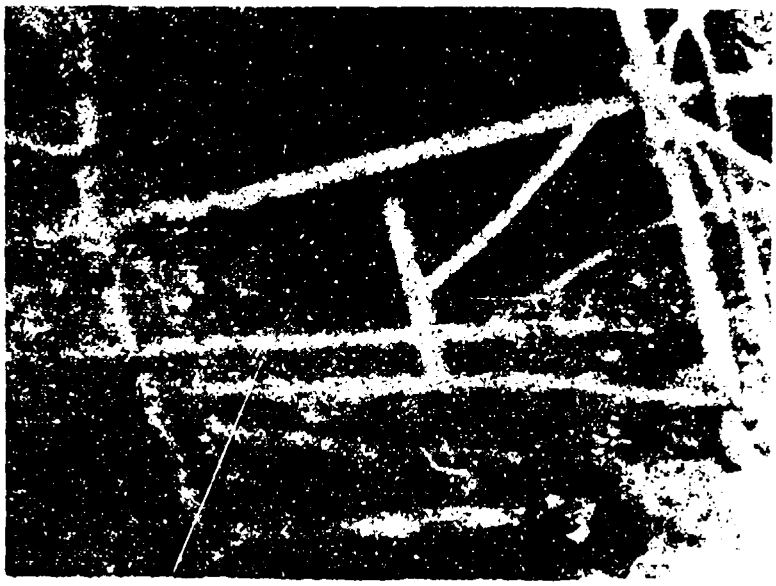
Crater and perforation made by Disney Bomb (Plot No.33), Trial XI.





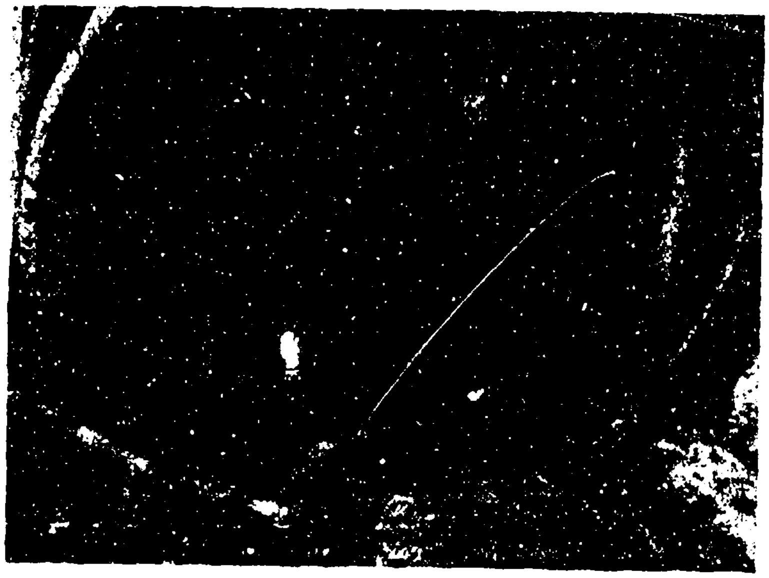
Crater and perforation made by rocket assisted Disney Bomb (Plot No. 34) Trial XI.

[redacted]

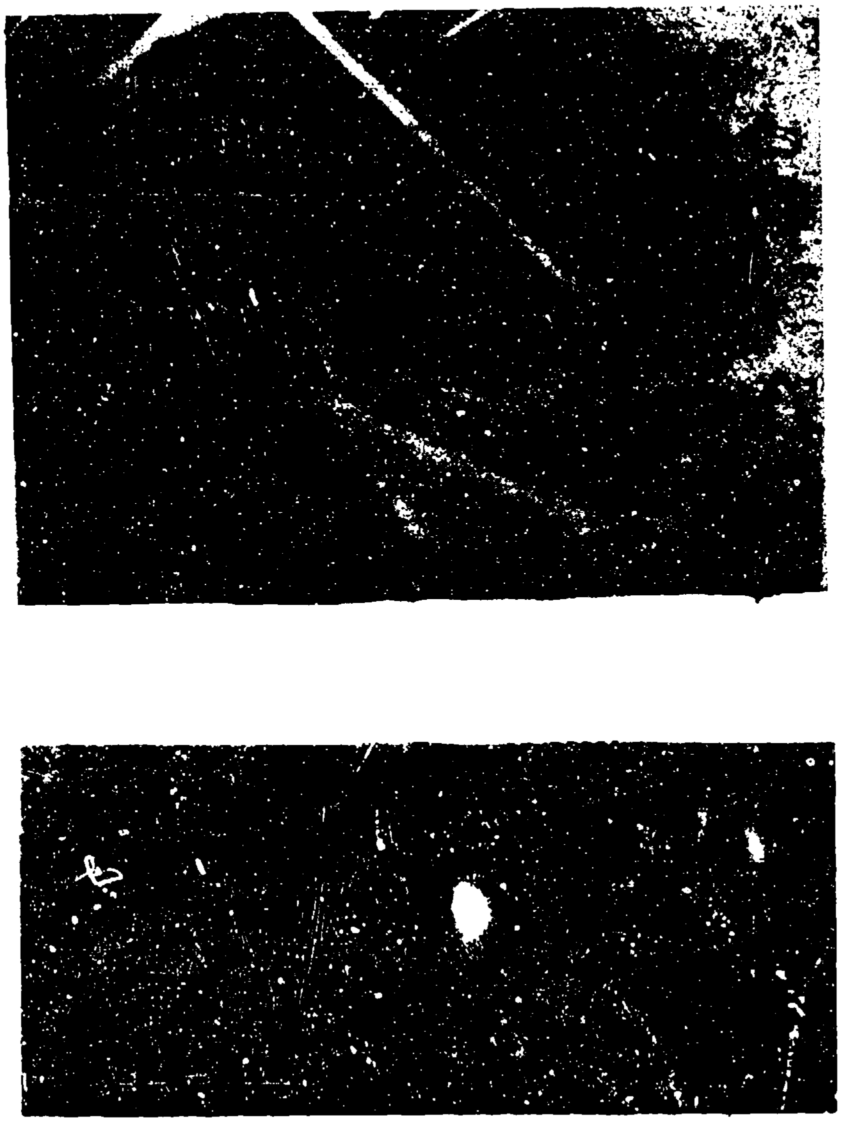


Crater and perforation made by rocket assisted Disney Bomb (Plot No. 35) Trial XX.

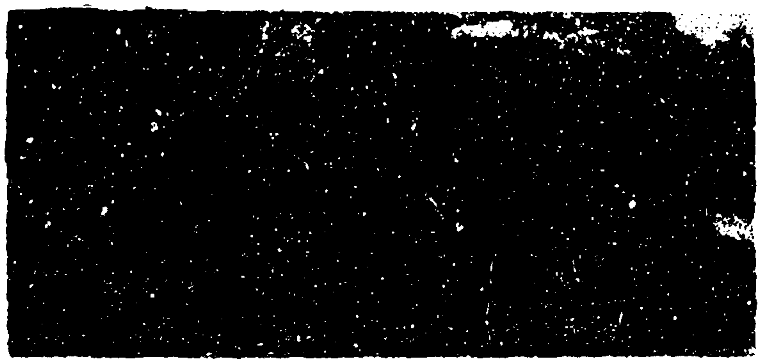
[redacted]

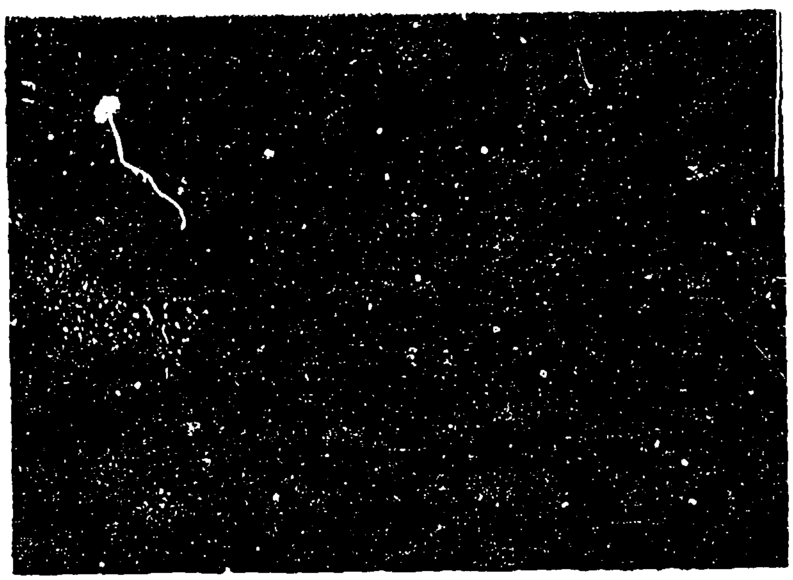


Crater and perforation made by Disney Bomb (Plot No. 36)
Trial XI

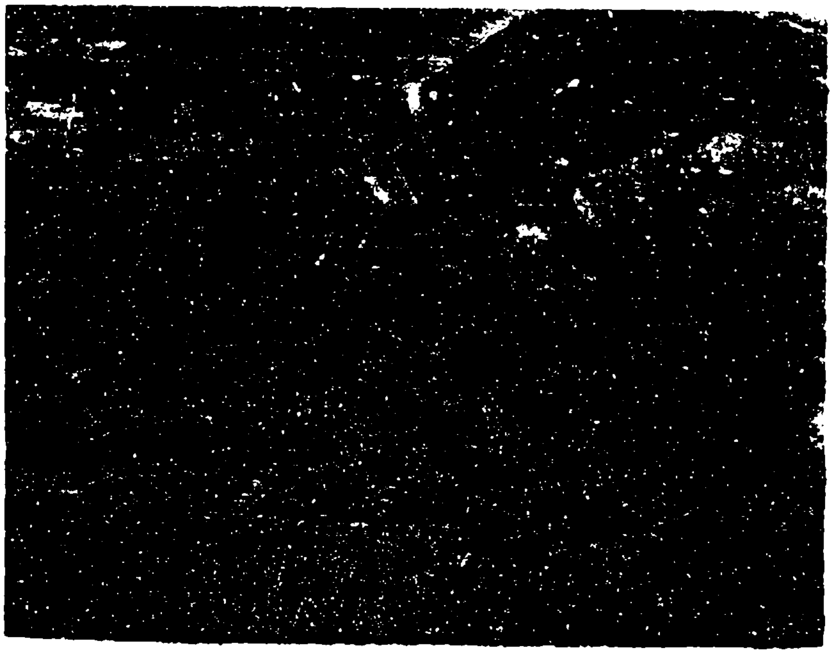


Crater and perforation made by rocket assisted Disney Bomb (Plot No. 37) Trial XX.



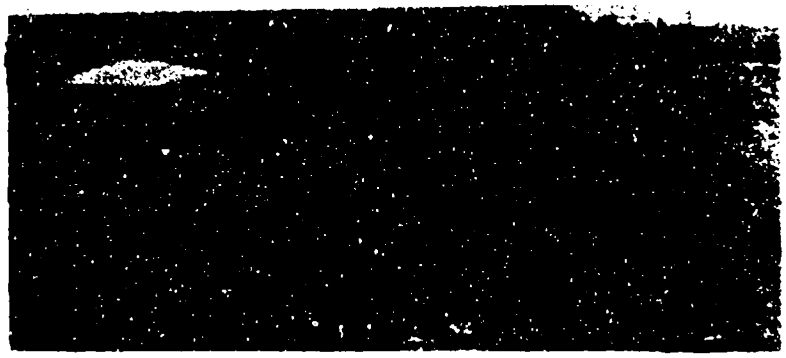


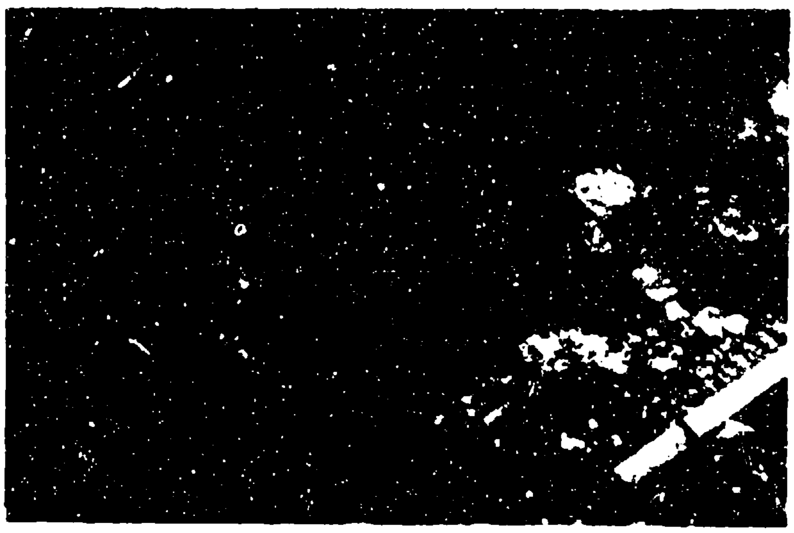
Upper view shows the crater of 2000-lb SAP Bomb (Plot No.24) Trial XVII. Lower view shows dent on bomb body.



Crater of 2000-lb SAP bomb (Plot No. 25) Trial XVII. Bomb remained in crater.

Crater of 2000-lb. SAP bomb (Plot No. 26), Trial XVII.
Bomb remained in crater.





Crater and fragments of 2000-lb SAP Bomb (Plot No.27)
Trial XVII. Bomb broke up and filler ignited low order.

Crater of 2000-lb. SAP bomb (Plot No.28) Trial XVII. Bomb not found, but picratol scattered finely over wide area indicates low order detonation.

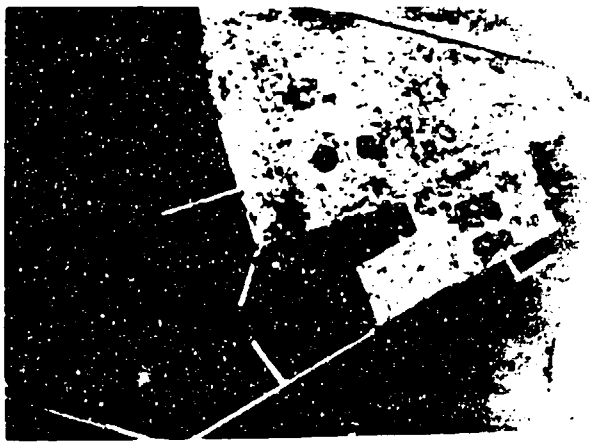
Crater of 2000-lb. SAP bomb (Plot No. 29) Trial XVII.
Bomb remained in crater.

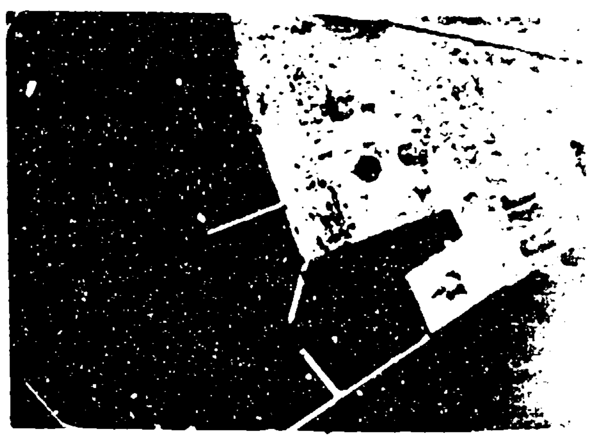
[redacted]

Crater of 2000-lb SAP bomb (Plot No. 30), Trial XVII.
Bomb is resting upside down in crater.

Crater of 2000-lb. SAP bomb (Plot No. 31), Trial XVII.
Bomb remained in crater.

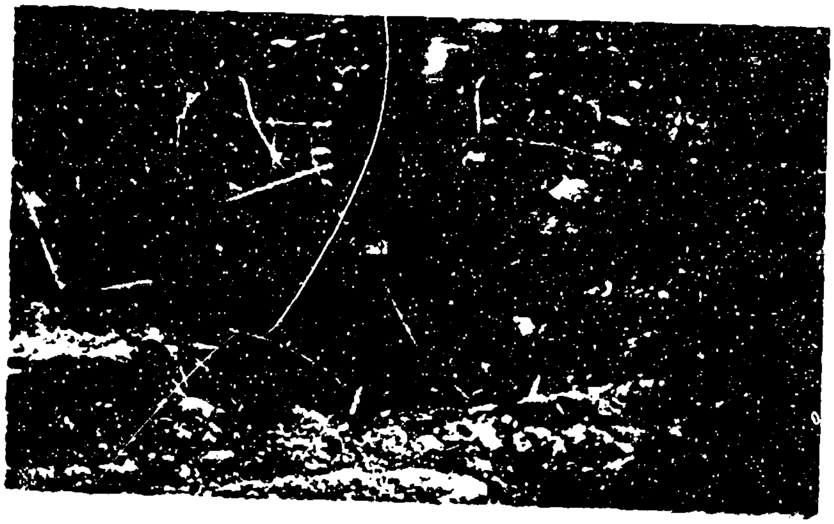
Crater and nose fragment of 2000-lb. SAP bomb (Plot No. 32) Trial XVII. This bomb broke up and the filler functioned low order.

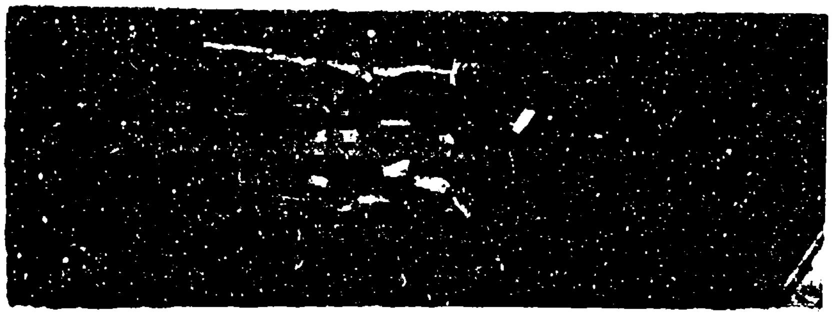




Aerial photographs showing low order detonation
of 2000-lb SAP bomb (Plot No. 32.)

Crater produced by live 2000-lb. SAP bomb (Plot No.38)
Trial XXII.

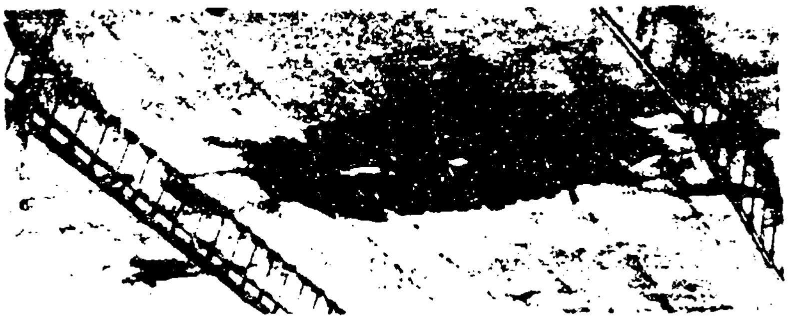




Crater and scabbing produced by live 2000-lb. SAP bomb (Plot No. 39) Trial XXII.

Live 2000-lb. SAP bomb (Plot No. 40), Trial XXII. Struck overhang and blew through.

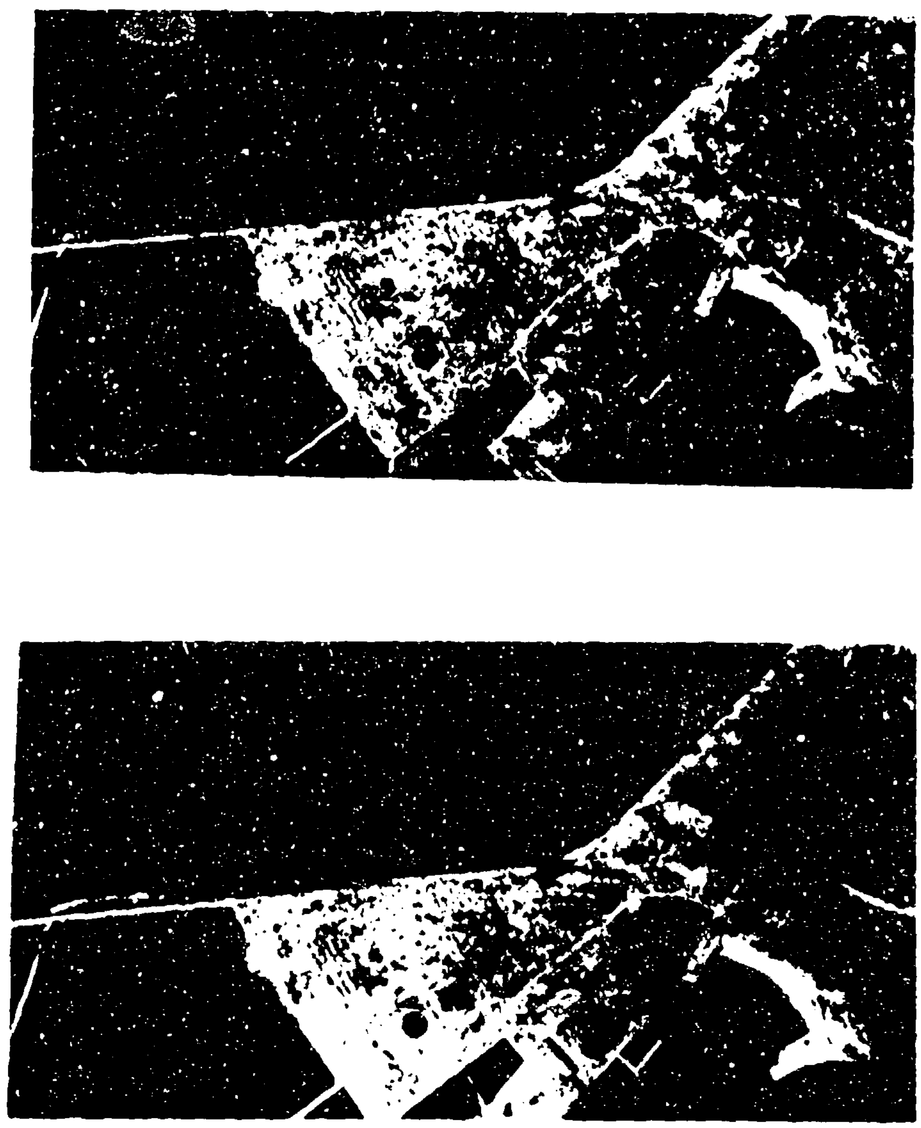
Live 2000-lb. bomb (Plot No.41), Trial XXII which did not explode. Fuze was armed.



Crater and scabbing produced by live 2000-lb. SAP bomb. (Plot No. 42), Trial XXII.

Crater produced by live 2000-lb. SAP bomb (Plot No. 43)
Trial XXII.

Crater of live 2000-lb. SAP bomb (Plot No. 44) Trial XXII which functioned low order. Picratol was scattered over wide area.



Aerial views of impact of 2000-lb SAP bomb (Plot No. 44) Trial XXII. This bomb broke up and left a trail as it ricocheted from the roof.

Crater of live 2000-lb. SAP bomb (Plot No. 45), Trial XXII.

[redacted]

PENETRATION FORMULAS

1. The problem of concrete penetration has been the subject of much investigation both in the United States and Great Britain. The American work since 1940 was carried out at Princeton University by the Committee on Passive Protection Against Bombing of the National Academy of Sciences, and by its successor, the Committee on Fortification Design of the National Research Council, and has been closely integrated with the program in terminal ballistics of Division 2, NDRC. British work on this subject was done at the Roads Research Laboratory.(1)

2. The Appendix of the OSRD Weapon Data Handbook(2) gives the most widely used American formula in literal and in alignment chart form:

$$s = \left(1/2 + 282\, S^{-0.5}\, \frac{W}{d^3}\, d^{0.215}\, V_s^{1.5}\right) . f(\theta),$$

where

- s = penetration of projectile in calibers,
- W = weight of projectile in pounds,
- d = caliber of projectile in inches,
- V_s = striking velocity of projectile in thousands of feet per second,
- S = compressive strength of concrete of target in pounds per square inch, A.S.T.M. test on 6" diameter, 12" long cylinders,
- θ = Angle of impact measured from the normal to the target,

and f(θ) is a function of the obliquity of the impact. This formula was based on an analysis of approximately 600 rounds of AP projectiles of calibers ranging from 37 mm. to 16", and 70 rounds of inert bombs, fired in tests up to February 1943.

3. A British formula of approximately the same date is:

$$s = 6.3\left(1 - \frac{S'-2500}{20000}\right) \frac{W}{d^3} \left(\frac{d}{c}\right)^{0.2} V_s^{1.5},$$

where all symbols have the same meaning as before, and

- c = maximum diameter of the aggregate used in the concrete,

[redacted]

and S' = compressive strength of concrete of target in pounds per square inch, standard British test on 6" cubes.

This formula is not considered to be valid for large bombs. The new British formula will replace the linear function of S' by $S'^{-0.5}$, and will have a different exponent for the velocity. For comparison, the American test for concrete strength gives a figure equal to 3/4ths of the figure obtained from the British test.

4. Later American work indicated that the concrete properties entered into the formula in much more complicated a fashion, and that the effect of the nose shape of the projectile has to be taken into account. This lead to the formula(3):

$$G(z) = Knd^{0.2} \frac{W}{d^3} V_o^{1.8} ,$$

where

$$G(z) = \frac{z^2}{4} \text{ if } 0 \leq z \leq 2,$$

$$= z - 1 \text{ if } 2 < z,$$

n = nose shape factor, numerically equal to $0.72 + 0.25\sqrt{N - 0.25}$, where N is the radius of the ogive of the nose - in calibers,

and K = the penetrability of the target concrete.

5. The dependence of K on the concrete properties has not been completely analyzed. For the purposes of this report an analysis was made of the caliber .50 firing data for the Strength and Aggregate series of the CPD Interim report No. 28, (slabs 22A2, 22B1, 22C1, 22D1, 22E1, 22F1, 22G1, 22H1, and 22J1)(4). The following formula for K was obtained:

$$K = 226\, c^{-0.2}\, s^{-0.5} .$$

The accuracy of this formula is questionable, since the aggregate used in these figures ranged in size from 1/4 to 2 times the caliber of the projectile used; whereas, on the Farge target the aggregate ranged from 1/6 to 1/23 times the diameters of the projectiles used.

6. The dependence of penetration normal to the surface of the target on velocity and angle of impact is given on page 6 . This is

taken from OFD Interim Report No. 26, Fig. 20 (5), for the caliber .50 steel projectile with 1.5 caliber radius head. It is known that this factor depends on nose shape as well as velocity and angle of impact, and it is probable that the length of the projectile is involved, particularly near the ricochet range.

7. The penetrability of the Farge concrete is tabulated on pages 7 to 11 for each strike on the Farge target which made a crater. The penetration formula used is the latest one given in para. 4. Corrections were made to the penetrations using the curves of the figure on page 6. Values of the predicted penetration from the American and British formulas of paras. 2 and 3 are also given. These have been computed for non-normal incidence using the curves of the figure on page 6. For these computations the strength of the concrete has been taken to be 5270 psi British test, 3950 psi American test, and the maximum diameter of the aggregate as 2 inches. These figures are taken from German construction data obtained from the principal construction firm. The concrete specifications called for aggregate of maximum diameter 40-42 mm, and a compressive strength of 400 kg/cm^2 by the German standard test on 20 cm cubes. The aggregate size turned out to be 40-50 mm, and because of seasonal variations in the water content of the aggregate, the average compressive strength turned out to be 370 kg/cm^2. Since the strength of a short column depends on the slenderness ratio (length/diameter) rather than the size, the German figure is used. Examination of broken concrete surfaces on the target confirms the figure for aggregate size, while a test by the Roads Research Laboratory on samples cut from rubble gave an average value of 4900 psi for the compressive strength. This latter figure may be too low, since the rubble had already been subjected to a breaking stress. The following is a glossary of the symbols used in the tables:

x = normal penetration measured in inches,

x_1 = predicted normal penetration calculated from the American formula of para. 2 and the correction factors of the figure on page 6.

x_2 = predicted normal penetration calculated from the British formula of para. 3 and the correction factors of the figure on page 6.

x_3 = predicted normal penetration calculated from the American formula of paras. 4 and 5 and the correction factors of the figure on page 6.

s = measured penetration corrected for non-normal incidence, in calibers.

$$G(z) = \frac{z^2}{4} \text{ if } 0 \leq z \leq 2,$$

$$= z - 1 \text{ if } 2 < z,$$

V_e = impact velocity in thousands of feet per second.

θ = angle of impact in degrees (accuracy 10%).

W = weight of bomb in pounds.

d = caliber of bomb in inches.

N = radius of best-fitting tangent ogive in calibers.

n = nose shape factor = $0.72 + 0.25\sqrt{N - 0.25}$.

$K = G(z')/(nd^{0.2}\, V_e^{1.8}\, \frac{W}{d^3})$, the penetrability of the concrete calculated from the formula of para. 4, for the plot in question.

8. The average value of the penetrability of Farge, using all drops that made recognizable craters, is 2.8; if all drops with penetrabilities below 1.0 and above 4.0 are excluded (AP # 2, Tall Boys # 93, 104, Grand Slams # 96, 97, and Disney # 85), this drops to 2.6. In contrast to this, the formula of para. 5 predicts a penetrability of 3.13, if the concrete strength of 370 kg/cm^2 is used, and 3.00 if the figure of 400 kg/cm^2 is used. Clearly it is necessary to find a more trustworthy formula for penetrability than the one given here. A possible source of error in penetration data of this report is that most of the hits used were bombs that broke up. This includes the Disneys, because the tail unit, which is about one-fourth the weight of the bomb, drops off at some time during the impact and is of no further aid. However, this effect is not calculable; all that can be said is that the penetrability should be smaller.

9. The unassisted Disneys just reached the scabbing limit at Farge. According to the Weapons Handbook(5), the maximum thickness that can be scabbed is given by

$$s = 2.28\, d + 1.13\, x.$$

For a penetration of 10'-6", the scab limit is 14'-9", the thickness of the Farge roof.

10. In the same reference, the relation for the maximum thickness

perforable in terms of penetration is

$$e = 1.23\, d + 1.07\, x.$$

For the unassisted Disneys, this gives a perforation limit of 12'-10" for an average penetration of 10'-6". This is in accord with the Heligoland Disneys, which perforated the 10 foot roof every time, and also in accord with the Farge Disneys which never perforated. The assisted Disneys of Farge which stopped in the roof have an average penetration of 13'-10", and for this the perforation limit is 16'-4". In the case of the Amazons, the average penetration, while not as accurately known, is 11'-2"; the corresponding perforation limit is 15'-10". These figures agree with the perforations by Disneys and Amazons at Farge.

11. An immediately obvious phenomenon is the J-ing of the trajectory in concrete; the nose of the bomb turns up in penetration, and the bomb tends to line up with the back side of the crater. This can be seen particularly in the Disney crater profiles (Inclosure 9), and in the denting of the other bombs. This turning arises because the resistance to penetration is not along the axis of the bomb, but above it. The consequent turning moment slaps the bomb against the back side of the crater, causing denting, bending and breakup. This does not happen in normal incidence, hence a design theory of bombs should consider them not as axially loaded columns, but as columns with a non-axial load and a further force perpendicular to the axis applied at a point towards the rear of the bomb. The same holds true of a bomb emerging from a concrete slab, except that the directions of the turning moments are reversed.

FOOTNOTES

(1) A complete bibliography of American work on this subject is given in Final Report on Concrete Penetration, by R.A. Beth, NDRC Report No. A-388, (OSRD-6459), March 1946. Confidential.

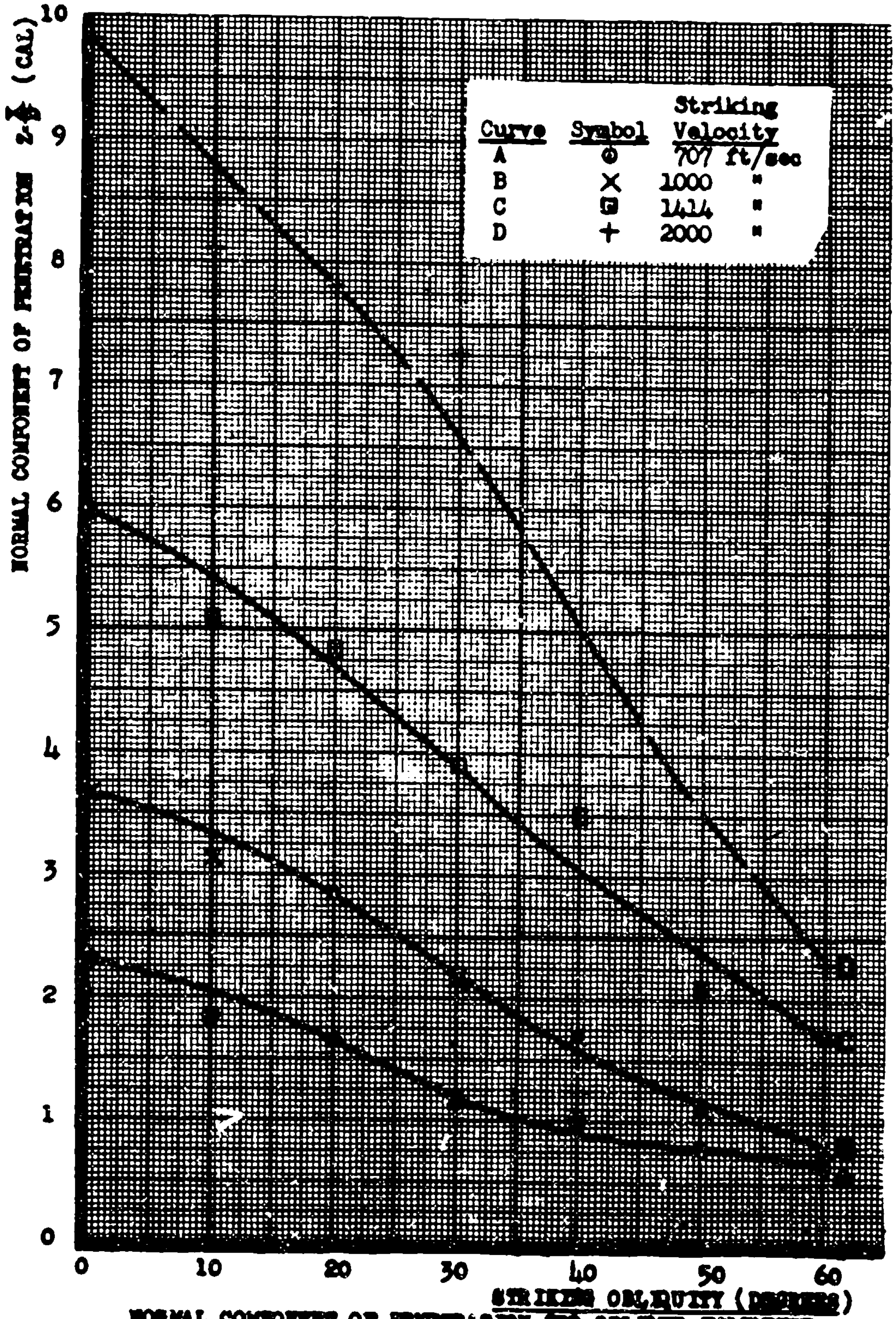
(2) Weapon Data: Fire, Impact and Explosion, OSRD no. 6053, Final Edition, September 1945. Confidential.

(3) See (1).

(4) Ballistic Tests on Concrete Slabs, Tables of Data, CFD Interim Report No. 28, Appendix A, by J.G. Stipe, Jr., M.E. DeReus, J.T. Pittenger and R. J. Hansen. June 1944. Unclassified.

(5) Ballistic Tests on Concrete Slabs, CFD Interim Report No. 28, by J.G. Stipe, Jr., M.E. DeReus, J.T. Pittenger and R. J. Hansen. June 1944. Unclassified.

(6) See (2).



NORMAL COMPONENT OF PENETRATION FOR OBLIQUE INCIDENCE

Taken from Interim Report No. 26, Ballistic Tests on Concrete Slabs

DISNEY (wo/RA) $W = 4500$, $d = 15$, $N = 2.5$, $n = 1.095$

Plot No.	x	x_1	x_2	x_3	V_e	θ	z'	$G(z')$	K	Remarks:
2	132"	168"	164"	136"	1.120	15°	10.333	9.333	3.033	Slight scab.
3	133"	168"	164"	136"	1.120	15°	10.400	9.400	3.055	
9	127"	168"	164"	136"	1.120	15°	9.933	8.933	2.903	Broke up.
10	113"	168"	164"	136"	1.120	15°	8.867	7.867	2.557	
26	103"	168"	164"	136"	1.120	15°	8.067	7.067	2.297	Bounced out and broke up.
28.	126"	168"	164"	136"	1.120	15°	9.867	8.867	2.882	Slight scab.
29	111"	168"	164"	136"	1.120	15°	8.667	7.667	2.492	Bounced out, bent.
39	129"	168"	164"	136"	1.120	15°	10.133	9.133	2.968	
59	80"	168"	164"	136"	1.120	15°	6.267	5.267	1.712	Bent badly.
61	60"	168"	164"	136"	1.120	15°	4.740	3.740	1.215	Nose broke off.
85	205"	168"	164"	136"	1.120	15°	16.067	15.067	4.896	

DISNEY (w/RA) W = 4250 d = 15, N = 2.5, n = 1.095

Plot No.	x	x_1	x_2	x_3	V_e	θ	z'	G(z')	K	Remarks:
37	109"	232"	253"	200"	1.450	16°	8.467	7.467	[illegible]	Broke up.
60	183"	232"	253"	200"	1.450	16°	14.200	13.20[illegible]	[illegible]	Roof 16' 7" thick, large scab raised.
84	158"	232"	253"	200"	1.450	16°	12.267	11.267	2.435	In 7 m roof.
88	158"	232"	253"	200"	1.450	16°	12.267	11.267	2.435	Roof 16' 9" thick near West wall.

2000-lb. SAP (M103) W = 2000, d = 18.625, N = 1.5, n = 1.000

Plot No.	x	x_1	x_2	x_3	V_e	θ	z'	G(z')	K	Remarks:
43	31"	52"	56"	51"	1.100	12.5°	1.879	0.8828	1.338	Ricocheted, dented.
55	34"	52"	56"	51"	1.100	13.3°	2.051	1.051	1.593	Broke up.
61	48" app.	52"	56"	51"	1.100	13.6°	2.894	1.894	2.871	Cracked, on foundation footing.
71	36" app.	41"	46"	41"	1.030	19°	2.448	1.448	2.471	At foot of wall, bulged, bounced out.
72	46"	41"	46"	41"	1.030	19°	3.125	2.125	3.627	
73	42"	41"	46"	41"	1.030	19°	2.856	1.856	3.168	At edge of old crater, [illegible]
78	32"	41"	46"	41"	1.030	19°	2.174	1.174	[illegible]	[illegible] broke up.

TALL BOY $W = 12000$, $d = 38$, $N = 2.0$, $n = 1.051$

Plot No.	x	x_1	x_2	x_3	V_o	θ	s'	$G(s')$	K	Remarks:
14*	68"	86"	96"	90"	1.150	16.5°	2.132	1.132	1.929	Broke Up.
16*	65"	86"	96"	90"	1.150	16.5°	2.037	1.037	1.767	Broke up.
17*	68"	86"	96"	90"	1.150	16.5°	2.132	1.132	1.923	Broke up.
90	42"	48"	60"	61"	0.850	20°	1.474	0.5429	1.530	Broke up, ricocheted.
92	48"	48"	60"	61"	0.850	20°	1.684	0.7091	1.998	Broke up, ricocheted.
93	40"	22"	30"	32"	0.620	26.5°	1.947	0.9481	4.713	Broke up, ricocheted.
94	31"	22"	30"	32"	0.620	26.5°	1.511	0.5704	2.835	Broke up, ricocheted.
102	37"	24"	34"	36"	0.610	24°	1.571	0.6170	3.157	Broke up, ricocheted.
104	45"	24"	34"	36"	0.610	24°	1.911	0.9125	4.669	Dented, ricocheted, intact.
114	62"	49"	60"	61"	0.840	19°	2.118	1.118	3.217	At edge of old crater, intact.

*Dropped in 1945 at Farge.

GRAND SLAM $W = 22000,\ d = 46,\ N = 2.0,\ n = 1.051$

Plot No.	x	x_1	x_2	x_3	V_o	θ	z'	$G(z')$	K	Remarks:
4	78"	105"	117"	112"	1.180	19°	2.202	1.202	1.747	Broke up.
30	90"	105"	117"	112"	1.180	19°	2.541	1.541	2.239	Broke up.
31	102"	105"	117"	112"	1.180	19°	2.880	1.880	2.731	Broke up.
96	62" app.	28"	39"	40"	0.610	26.5°	2.496	1.496	7.129	Intact in crater.
97	48"	28"	39"	40"	0.610	26.5°	1.933	0.9339	4.453	Broke up, ricocheted.
113	62"	63"	76"	76"	0.850	20°	1.796	0.8080	2.121	Broke up, ricocheted.

1650-lb. MODEL $W = 1650,\ d = 13.232,\ N = 2,\ n = 1.051$

Plot No.	x	x_1	x_2	x_3	V_o	θ	z'	$G(z')$	K	Remarks:
111	39"	43"	45"	39"	0.800	19°	3.684	2.684	3.196	Bent.
112	38"	43"	45"	39"	0.800	19°	3.590	2.590	3.086	Bent.
124	52"	57"	58"	39"	1.000	16°	5.169	4.169	3.323	Bent.

AMAZON $W = 22000$, $d = 38$, $N = 2.0$, $n = 1.051$

Plot No.	x	x_1	x_2	x_3	V_o	θ	z'	G(z')	K	Remarks:
106	149"	140"	146"	127"	1.144	21°	5.158	4.158	3.834	Broke up, scabbed roof.
107	120" app.	140"	146"	127"	1.136	20.5°	4.100	3.100	2.897	Intact, in 7 m roof near edge of 2.5 m slab.
118	138"	140"	146"	127"	1.136	20.5°	4.716	3.716	3.473	Intact, hit 7 m roof of W. Periscope tower near edge.
119	144" app.	140"	146"	127"	1.144	21°	4.987	3.987	3.676	Intact, in 7 m roof near edge of 2.5 m slab.
	134"	140"	146"	127"						Average for 107,118,119.

2000-lb. AP* $W = 2000$, $d = 13.5$, $N = 2.3$, $n = 1.078$

Plot No.	x	x_1	x_2	x_3	V_o	θ	z'	G(z')	K	Remarks:
2	28.5"	91"	92"	75"	1.140	15°	2.481	1.481	0.8187	Hit vertical face of 2.5 m slab.
3	66"	91"	92"	75"	1.140	15°	5.748	4.748	2.634	
6	69"	91"	92"	75"	1.140	15°	6.015	5.015	2.772	
7	77"	91"	92"	75"	1.140	15°	6.711	5.711	3.157	
11	44"	91"	92"	75"	1.140	15°	3.837	2.837	1.568	
12	76"	91"	92"	75"	1.140	15°	6.222	5.222	2.887	

*Dropped on Farge in 1945.

[redacted]

THE D-9 SHACKLE

1. Previous Tests:

The D-9 shackle was tested in Project Nos. 1-45-43 and 1-45-63, and was found to be unsatisfactory. The shackle was modified by Air Material Command, by installing a "Kicker" link connecting the shackle release arm to the locking hook arm. Only two bombs were released from each of two modified shackles on the above tests. One shackle released satisfactorily two 12,000-lb bombs, and the second shackle satisfactorily released one 12,000-lb and one 22,000-lb bomb.

2. Present Tests:

The modified shackle was used for all 26 large bombs released from Project Ruby B-29 airplanes. Of these 26 releases there were only three shackle malfunctions. One 12,000-lb (T10) Tall Boy was dropped with one malfunction. Nine 22,000-lb (T14) Grand Slams were dropped with no malfunctions. Sixteen 22,000-lb (T28) Amazons were dropped with two malfunctions.

a. Tall Boy Drops:

The malfunction of the Tall Boy release was due to the improper position of the A-4 release in relation to the shackle. When changing the bomb load from a Grand Slam to a Tall Boy, the angle of the shackle changes due to the difference in bomb diameter and the position of the A-4 release must be changed to accommodate the change in the shackle position. In loading the Tall Boy the A-4 release was not repositioned. Therefore, when trying to release the bomb it would not drop because the shackle release and arming levers had slipped out of the A-4 release. This malfunction is chargeable strictly to personnel error.

b. Amazon Drops:

The two malfunctions occurring while carrying the 22,000-lb Amazons were the result of the A-4 release failing to trip the release lever of the shackle. This failure was evidently caused by the inability of the A-4 release to provide enough force to overcome the additional load caused by the 22,000-lb Amazon. The Grand Slam is 46 inches in diameter while the Amazon is only 38 inches in diameter, although they both weigh 22,000 pounds. Because of this difference in diameters the shackle makes a greater angle with the vertical when supporting the Amazon, resulting in a larger load factor for the shackle. This increase in load is apparently enough to overload the shackle and cause a hang up due to frictional resistance. The second hang up was on a shackle that had previously dropped two Amazons. This is very similar to what happened on the original D-9 shackle when dropping Grand Slams on Project No. 1-45-43.

The D-9 shackle was not used for arming the bombs at any time. A separate A-2 arming control was used.

3. Conclusions:

a. It is concluded that:

(1) The modified D-9 shackle is satisfactory for carrying and releasing the 12,000-lb (T10) Tall Boy or the 22,000-lb (T14) Grand Slam bomb.

(2) The modified D-9 shackle is not satisfactory for releasing the 22,000-lb (T28) Amazon bomb.

T723 FUZE REPORT.

1. Ten of the 14 Amazon bombs dropped at Farge were fitted with T723 tail fuzes. Each bomb contained one fuze from Lot PAE-T46-365 (empty fuze with metal parts only), one fuze from Lot PAE-T46-366 (loaded detonator and booster leads), and one fuze from Lot PAE-T46-367 (loaded delay elements only). Each bomb was fitted with three adapter boosters from Lot PAE-T46-368, containing inert pellets. The fuzes were dropped unarmed to determine whether they would stand up against concrete when dropped from 17,500 feet altitude. Three fuzes were recovered from Plot No. 100, three from Plot No. 107, and two from Plot No. 109, and these were sent to Picatinny Arsenal for examination. The following paragraphs from 2nd Indorsement Picatinny Arsenal to Chief of Ordnance, 23 September 1946, O.O. 471.82/301(C), ORDB 471.82/2299, contain a report of examination of the above fuzes.

a. "Eight Bomb Tail Fuzes, T723, were received from the Ruby Project, Farge, Germany. Two fuzes are of Lot PAE-T46-365, three fuzes are of Lot PAE-T46-366 and three fuzes are of Lot PAE-T46-367. Fuzes as they were received are shown on Photographs Nos. M-32355 and M-32356, copies of which are inclosed (pages 3 and 4). Results of examination of the recovered fuzes are as follows:

(1) Fuze No. 1. This fuze is of Lot PAE-T46-367. It apparently withstood impact, since the primer-detonator had not fired and the rotor was in the safe position. The primer-detonator was tested but failed because of inability of the M39 Special Primer to ignite the delay composition. A new M39 Special Primer was assembled and the primer-detonator was retested. A delay time of 12.72 seconds was obtained.

(2) Fuze No. 2. This fuze is of Lot PAE-T46-365. It withstood impact, as examination revealed that the inert primer-detonator was undamaged and that the inert rotor was in the safe position.

(3) Fuze No. 3. This fuze is of Lot PAE-T46-367. It did not withstand impact, probably because of weakness of the bomb. The examination revealed that the fuze body was crushed by side impact. The M39 Special Primer was squeezed into an oval shape and apparently fired by the squeezing action. The rotor cavity was wiped off. No rotor was received with fuze. Photograph No. M-32356/1, page 5, shows the fuze body after mechanical sectioning. The remains of the T32 Adapter indicate that the 22,000-lb. bomb, in which the fuze was assembled, did not withstand impact.

[redacted]

(4) Fuze No. 4. This fuze is of Lot PAE-T46-367. The fuze apparently withstood impact. Primer-detonator was removed and fired at a delay of 12.8 seconds. The rotor was in the safe position.

(5) Fuze No. 5. This fuze is of Lot PAE-T46-366. The fuze apparently withstood impact. The inert primer-detonator was not damaged. The rotor was in the safe position. The detonator and tetryl lead were not fired.

(6) Fuze No. 6. This fuze was of Lot PAE-T46-366. That portion of the Adapter Booster containing the tetryl charge (booster cup) was not received with the fuze. Examination indicates that set-forward caused a tension break at the booster cup threads. The inert primer-detonator was not damaged. The rotor had not armed. Neither the Detonator nor tetryl lead had fired.

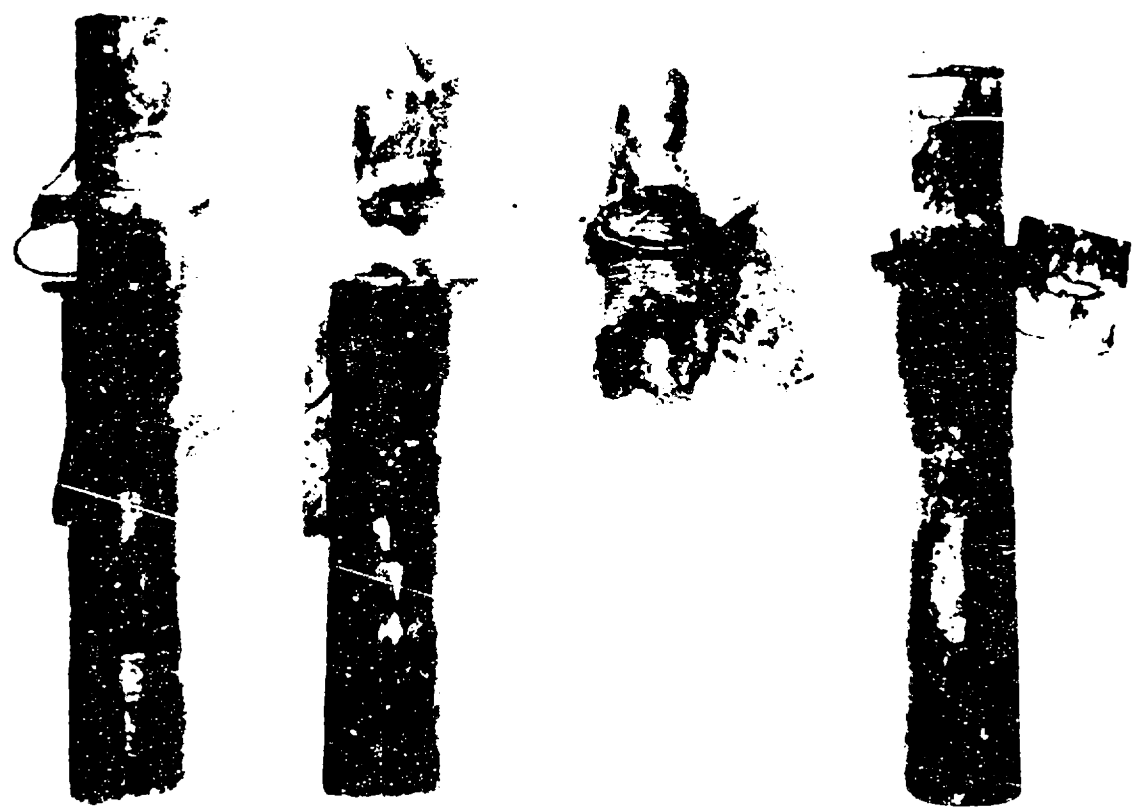
(7) Fuze No. 7. This fuze is of Lot PAE-T46-365. This fuze withstood impact. The inert primer-detonator was not damaged. The rotor was in the safe position.

(8) Fuze No. 8. This fuze was of Lot PAE-T46-366. The fuze withstood impact. The inert primer-detonator was not damaged. The rotor was in the safe position. Neither the detonator nor the tetryl lead was fired.

b. Nine primer-detonators for the T723 Fuze which were loaded at the same time as those which were received from the Ruby Project were tested for comparison. During tests, two primer failures were obtained. The primer-detonators both fired on retests when fresh primers were used. The delay times obtained in seconds are: 13.25, 12.73, 13.11, 13.22, 13.18, 13.15, 13.10, 12.96, and 13.53. Because of the failures of the M39 Special Primer to ignite the delay powder, an investigation is being conducted.

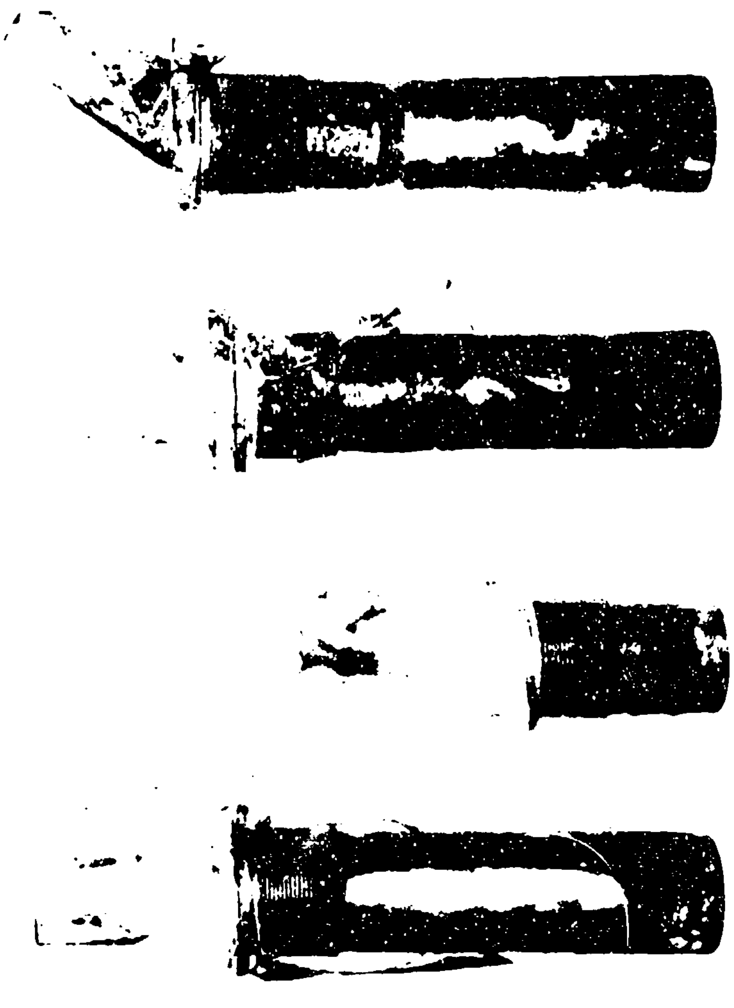
c. Preliminary results of the investigation indicate that M42 Primers which also use the No. 793 semi-gasless mixture are erratic. Measurements of the duration of the flash show that in fresh primers it varies from .004 second to over .100 second with an average duration of .023 second. After one month's storage at 65°C, the average duration is .006 second. Comparison tests with the New No. 4 Primers for duration of flash indicates an average of .002 second with fresh primers. After storage for thirteen days at 65°C, the average duration of flash rises to .007 second. Primer failures are obtained with the New No. 4 Primer after storage at 65°C for one month."

[redacted]



1 2 3 4

M-32355	August 1946	PICATINNY ARSENAL	ORDNANCE DEPARTMENT
		T-723 Tail Bomb Fuzes	(Tech. 5)
		As recovered at Ruby Project, Farge, Germany	(L)



M-32356 August 1946 PICATINNY ARSENAL ORDNANCE DEPARTMENT
T-723 Tail Bomb Fuzes (Tech. 5)
As recovered at Ruby Project, Parge, Germany (L)

M-32356/1 August 1946 PICATINNY ARSENAL ORDNANCE DEPARTMENT (Tech. 5)

T-723 Tail Bomb Fuse, Bomb No. 3
As Recovered at Ruby Project, Farge, Germany.

(L)

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PROJECT NO. 1-46-7

COMPARATIVE TEST OF THE EFFECTIVENESS OF LARGE BOMBS AGAINST REINFORCED CONCRETE STRUCTURES (ANGLO-AMERICAN BOMB TESTS-PROJECT RUBY)

	Quantity
Hq. AAF Wash. 25, D.C. AC/AS-3	12
Proof Division Files	1
Naval Liaison Office, AAFPG	1
AAFPG Liason Officer, AMC	1
CG, AMC ATTN: TSEDL, Mr. R. A. Teters	10
Hq. AAF Library	2
Aero Pub Officer, NAS, Patuxent	2
CO, AAF, Watson Laboratory	1
Command & General Staff School	1
Army Ground Forces - ATTN: Gen. Doyle	1
Air Defense Command	3
Tactical Air Command	3
Hq, Marine Corps	1
Chief, Bureau Aeronautics, USN	2
Dep. Chief, Naval Oper. (Air) Op-517	1
Air University Library	5
CG, Strategic Air Command	3
CG, AAF Training Command, AC/AS-2 Intell	1
Air Tactical School, Tyndall Fld.	1
CO, 620th AAF Base Unit, Muroc, Cal	1
Hqs, Mather Fld, Sacremento, ATTN: Dept of Research and Development	1
Asst Chf of Naval Op, Navy Dept, Wash, ATTN: Marine Aviation (Op-52)	1
Chf of the Bureau of Aero.,Navy Dept.,Wash, ATTN: Asst Chf of Research, Development and Engineering	1
Dep Chf of Naval Op, (Air), Navy Dept., Wash, ATTN: Op-05	1
Chf of Bureau of Ordnance, Navy Dept., Wash, ATTN: Re8	1
CO, 613th AAF BU, Aberdeen PG.	1
CMA, London, ATTN: Colonel F. F. Reed	16
Air Ordnance, ATTN: Colonel Cyr	2
Aberdeen Bombing Mission, Muroc, Cal.	1
Operations Analysis Div, Wash.	2
Hq. USAFE, APO 633, New York, ATTN: A-3	2
Chf, Bureau of Ordnance, US Navy, Wash.	3
Chf, of Ordnance, Wash, ATTN: Research & Development Service	3
A-3 Ordnance Officer, APGC	1

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