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Los Alamos

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memorandum

TO: **Dorothy Hoard, CST-1 ,MS E525** DATE: **May 2, 1994**

FROM: **George L. Morgan, P-15** GLM MAIL STOP/TELEPHONE: **D406/7-1137**

SYMBOL: **P-15-94-U-141**

SUBJECT: **Investigaton of material used in underground chambers at TA-33**

Attached is the report of my investigations of the experiments conducted in the underground chambers in MDA-D and MDA-E at TA-33. The only harazardous material which might be in these chambers are PCB's in some of the electrical components. If the estimated amounts are deemed to be significant, you may want to have someone in the old M or J divisions with a good enginerring knowledge of vacuum tube electronics and implosion firing systems look into this further.

I am returning your photographs with this memo. I have also included a print out of the current data base of photographs in ISD-9 sorted on references to TA-33.

If you have any questions on this report or if I can be of further assistance, please feel free to call on me.

xc: P-15 File

30825

Analysis of Material in Underground Chambers in MDA-D and MDA-E at TA-33

General

This report covers an investigation conducted to determine what, if any, hazardous materials may have been used in experiments conducted in three underground chambers located at TA-33 in areas designated as MDA-D and MDA-E. As part of this investigation I studied a total of seven tests, all of which were closely related. Although three of these tests were not conducted in the chambers in question, they were a source of valuable information about this series of tests. These tests will be labeled 1 to 7. All except the last test were experiments on initiators for fission weapons. The first four tests involved Urchin devices. The fifth and sixth involved Tom and Wally devices, while the seventh test had no initiator, but was a test of the ability of the underground chambers to withstand larger amounts of high explosives than the original design strength.

Of the seven tests, the 3rd, 4th, 5th, and 7th were conducted in the underground chambers at TA-33. The 1st and 2nd tests were conducted in underground chambers at the Trinity site, while the 6th was conducted at TA-33, MDA-E in a shallow pit near the site of the underground chamber used for the 5th test.

Documentation on the tests is extensive and detailed. I was easily able to locate a number of LA reports in the report library as well as progress reports for the Group M-3/W-3 covering the period from 1946 to 1952 in the Archives.

These references were found in the Report Library card catalogue under the following categories:

Numerical (in this case file P - W6)
Authors (in this case Donald P. MacMillan)
Subject (in this case Initiators)

The progress reports are located in the Archives under the collection number A-86-016. The relevant LA reports and progress reports are listed in the section on References.

In addition, I was able to locate a several series of photographs listed in the ISD-9 records in books BW-1, BW-2, and BW-3. These are listed in Appendix A.

The first six tests involving initiators were all very similar. The changes were made from test to test in an incremental fashion. For this reason, the tests conducted at the Trinity site were of interest, even though those particular chambers were not included in the scope of this investigation.

Initially, I will give a general description which applies to all of the tests except the last. This will be followed by a section on each particular test. This overall picture was obtained by studying all of the reports since each individual report usually included some information which applied to all or several of the tests but which was not included in the other reports.

Initiator Tests

The purpose of the six tests in this series was to determine the intensity and the timing of the neutron output of the initiator. The HE system with the initiator was placed in a metal container called the charge box. This box was surrounded by a number of fast neutron detectors which consisted of gas proportional counters. These counters were filled with butane gas to a pressure equal to about one atmosphere. Two different types of counter were used, depending on the time of the test. This will be discussed in more

detail in the following sections. Because the neutron intensities were rather low and the counters were inefficient, large numbers of counters (28 - 504) were employed. The operation of these counters required high voltage supplies, preamplifiers, and their associated power supplies. Also included in the chamber were the high voltage firing units for the HE and trigger units which detected the detonation of the HE and supplied trigger signals for the recording systems located uphole.

As is the case in any experimental program, the exact configuration changed in an incremental fashion from test to test as lessons learned were used to improve the equipment and procedures. With respect to the downhole configuration, the main changes were in the details of the counters, the type of HE system used , the phototriggers, and the size, shape, and material used for the charge box.

The following sections will describe each test, with the emphasis on those details which were different from other tests or which were common to all tests but only described in that particular report.

Test 1, Trinity

Ref. 1 covers the first Urchin test. The shot was fired on 8 Sept., 1946, but a problem with the firing switch resulted in a misfire. However, the report was a useful source of information about the chamber and the experimental configuration. The illustrations in Ref. 1 provide useful information, but are black and white prints of photographs not having any identification numbers on them.

Figure 1 in this report is a drawing of the firing chamber and is a copy of Drawing No. Y-5570, dated 6/21/46 and titled "Concrete Test Structure". Apparent in this drawing and explicitly stated in the text of the report is the fact that the chamber was not sealed, but had 14 nine inch diameter pipes five feet in length, two in each of seven walls of the octagonal chamber, protruding three feet outside the wall. The eighth wall had the door to the elevator shaft. These pipes ended in a volume of loose rocks. The purpose of these pipes was to vent the over pressure created in the chamber by the detonation of the HE. This is the only report which explicitly describes these vent pipes and their purpose. Subsequent chambers constructed at Trinity and at TA-33 had this same feature. This leads to the conclusion that, in fact, the chambers are not sealed and it was never intended that they would be.

This chamber was constructed with its roof 14 feet underground and was covered by a mound of earth to a total depth of 30 feet So although the chamber was nearly identical to those constructed later at TA-33, it was buried in a different manner.

Figures 3, 4, 5, and 6 in this report show the experimental configuration in the chamber. The charge box consisted of two concentric copper boxes where "the lid of each of these boxes dips into a mercury well around the rim". The purpose of the mercury was to insure good electrical contact between the lid and sides of the boxes as the main purpose of the charge box was to shield the counters located outside from electrical impulses generated by the detonation of the HE. From the pictures included in the report, I would estimate the total amount of mercury at less than 1 kilogram. Examination of subsequent reports, indicates that mercury was not used in any of the tests conducted at TA-33. The text states that the charge box was surrounded by six tanks of counters, four on the sides with one on top and one on the bottom. The boxes had dimensions 25" x 25" x 35". Each tank contained 84 counters consisting of tubes with concentric central wires. Each tank had 21 preamplifiers, one for each four counters. The text states that this system contained 225 vacuum tubes. No other details of the preamplifier circuits are given.

Figure 3 also shows the HE assembly. The photos and text indicate that a quantity of silver was in the assembly. Reference is made to these silver parts in Ref. 2. This information would allow one to estimate that the amount of silver was on the order of 70 grams.

Figure 4 details the top of the counter tanks. This experiment had six counter tanks which were probably made of steel. Figure 5 shows the details of the HE assembly. This assembly is different from that used on tests 2, 3, and 4 (see below). Figure 6 shows the high voltage box for the firing circuit. It appears to

contain a large number of batteries of the "dry cell" type in use at that time. According to the text, a voltage of 6500 V was used. Judging from the voltage and the photo in Figure 6 there were probably 66 100 V batteries connected in series. A capacitor was used to store energy for firing the detonators, but no details are discernible. The text states that the firing box contained the implosion switch, firing condensers, 6500 volt battery, firing transformers, condenser charging switch, and blasting caps. The chamber also included a 30 gallon copper tank for cooling water.

The text mentions that the phototriggers for this experiment consisted of photo cells viewing small explosive charges fired by the firing circuit. No specific details of the photo cell electronics are given.

The photos and text contain no indication that any shielding materials were used. In typical neutron experiments these materials could be lead (used for gamma-ray shielding), cadmium (used to shield against thermal neutrons), or paraffin, with or without such additives as lithium or boron, (used to shield against unwanted neutron backgrounds).

As stated earlier, this shot misfired and it was judged to be too dangerous to re-enter the chamber. It was destroyed at some later date.

Test 2, Trinity

This test is the least well documented of the series. Evidently a report was started (LA-693) but was, according to the records in the Report Library, "killed". This was the second Urchin test. Reference in the report for test number 4 (see below) stated that it "was not published". However, references in the M-3 progress reports (Ref. 3) indicate that the HE systems was the same as that used in tests 3 and 4. This report also states that a mechanical recovery system was added to allow safe removal of the Urchin in case of misfire. Ref. 4 indicates that twice the amount of silver was used in this test and that a refrigerator was added to chill the cooling water. Another change mentioned was that the high voltage batteries in the phototriggers had been replaced with regulated power supplies. One would infer from this that test 1 contained more batteries than just those explicitly shown in the photo of the firing system. I have assumed that in subsequent tests these particular batteries were also replaced by power supplies.

A M-3 progress report (Ref. 5) states that test 2 was fired on 8 July, 1947. Apparently things functioned properly, although subsequent reports indicate that the data left something to be desired. These reports also indicate that this test was not significantly different in configuration than others in the series. Whether or not mercury was used to seal the charge box is not discussed in any of the references.

Test 3, TA-33

The test is described in considerable detail in Ref. 6. In addition, a M-3 progress report (Ref. 7) first mentions the consideration of TA-33 for the continuation of initiator tests. Note that in this and Ref. 8, test 3 is referred to as test 2. The numbering system was changed as noted in Ref. 10 for test 4 and its successors.

This test was fired 14 April, 1948. Pages 4 - 6 of Ref. 6 detail the process of getting the chamber built. This is the chamber referred to as HP-4 in Rogers report (Ref. 11) on MDA-D. Page 7 details the site lay-out and cable/wire installation.

Figure 1 is a drawing of the chamber, labeled "Underground Chamber No. 2 - TA33" and dated July 1948. It has the identification number 45-128. Note that date is after the fire date for this test and I believe that it is actually a drawing of the second chamber built at TA-33 and was used for this report because the two chambers were essentially identical. It shows contours of the mesa edges but gives no coordinates. Comparison to Fig D-1 in Ref. 11 confirms that the chamber shown here has the same position relative to the mesa edge as chamber 2 (HP-6). The drawing appears the same as that of the first chamber at Trinity including the 14 nine inch diameter vent pipes.

Figure 2 is a photo (ID 7228-B) of the shaft house and the text notes the great improvement due to installation of an elevator, not available on earlier tests.

Figure 3 (ID 7649-B) is a good overview of the experimental configuration. The text states that the number of counter tanks was reduced to four, on the sides only. These were "essentially at ground level". These is no evidence in the photo nor mention made in the text of any shielding materials such as lead, cadmium, or paraffin (with or without lithium or boron additives). A mechanical recovery system, shown in the photo, was added to permit recovery of the Urchin in case of a misfire. This system is probably very similar to the one used in test 2.

The Urchin was held in a Dural sphere with copper cooling tubes. A drawing is given in Figure 11. This system replaced the silver cooling plates used earlier. Figure 25 (ID 7637-B) shows the sphere above the charge box. Page 23 gives some additional details of the cooling system. This photo also shows the charge box which was described to be 35" square and made of 1" boiler plate. It was surrounded by four counter tanks containing 84 counters each.

The four counter channels were described as each having; a counter tank with preamplifier housing, a preamplifier filament supply, a high voltage supply, and a phototrigger. The report contains detailed circuit diagrams for much of the electronic equipment used on this test.

Page 8 states that the counters were nearly the same as the first experiments. On page 18 they are described as being 21" long and 2" in diameter. There were 84 of these in each of the four counter tanks. They contained somewhat more than one atmosphere of butane. Lucite was used on the insulation for the battery boxes, high voltage switch and counter tops to reduce noise. Figure 3 shows the counter tanks with the associated preamplifier housing and filament supplies. Details in the text and Figure 12 indicate that the B+ supplies for the preamplifiers were located uphole. A circuit diagram for the preamplifiers is shown in Figure 20. Few of the components are labeled, but the circuit does not appear to have any large or high voltage capacitors which might be oil filled. Circuits similar to this were probably used on tests 1 and 2.

Figures 24 (ID 7636-B) and 25 show the HE assembly with its mounting plate and brass hardware. This hardware was the same as that used on test 4 and is discussed in more detail in the report of that test (see below). There appear to be no noticeable quantities of materials other than iron, brass and aluminum.

Figure 13 is a circuit diagram for the phototrigger. The text describes this as a photomultiplier tube viewing a spark plug driven by the firing circuit. A signal from the photomultiplier fired a thyratron circuit which generated a trigger signal sent uphole to the recording trailer. This circuit diagram does not appear to show any potentially hazardous components.

Test 4, TA-33

Test 4 is described in Ref. 9. This test was fired on Dec. 23, 1948. First, note that in the W-3 progress report of Ref. 10, the statement is made that the numbering system for the tests has been changed and this test is now referred as number 4. This same progress report also mentions for the first time the consideration of scintillation counters for initiator tests, but concludes that no improvement would result from their use. This adds additional evidence that only the gas counters were used for these tests.

Page 6 of Ref. 9 mentions a memo written to the AD's office on June 25, 1948 requesting construction of another firing pit at TA-33. The report describes the pit for this test as being 200' closer to the trailers than that used for test 3. This is the chamber labeled HP-6 in Ref. 11. It was on the road connecting the trailers to the old pit. The general layout above ground was approximately the same as in the preceding experiment.

The biggest change between this test and the preceding ones was the use of a new type of gas counter. For this reason the report (Ref. 9) gives considerable detail about the construction of these counters. Thus we know much more about these particular counters than the ones used in previous tests. They are described in the text and are shown in figures 1 - 4 (ID 's 10117, 001931, 001934, and 001932). Note the discontinuity in ID numbers for the photos. Photos with ID numbers in the 1900's do not correspond to photos in the ISD-9 collection with the same numbers. Figure 3 shows a picture of a preamplifier on a counter top. Figures 8 and 9 (ID 's 9928 and 10113) show close-up pictures of the preamplifier. These show two oil filled capacitors. The photo is clear enough to read the make and model: TOBE OIL-MITE, OM 501, 1.0 microfarad, 600 V D C. I consulted Eugene Vigil of ESH-5 on the possibility that such capacitors could contain PCB's. He stated that PCB's were in use by that time and could not be ruled out. The name of the manufacturer was visible on the capacitor (Tobe Deutschmann Corp.). I looked this company up in the Thomas Register . I talked to a Jack Ahern at this company, Canton, MA (617-828-3366). He said that the capacitor manufacturing operation had been sold in the mid 1950's to Cornell Dubilier Electronics. He also said they received numerous calls each week inquiring about PCB's in capacitors. I described the model to him and he stated that small capacitors of that type were usually not made using PCB's but with mineral or castor oil instead.

I looked up Cornell Dubilier in the Thomas Register. Their oil-filled capacitor operation is located in New Bedford, MA (508-996-8564). I called and was referred to a Curtis Lopes. He had been with Cornell Dubilier since about 1950. According to him, the Tobe Deutschmann company's capacitor operation had been bought out and shut down in the mid-1950's. He said that no records existed on the products produced by Tobe Deutschmann. He said that PCB's were in wide spread use in the time frame of the TA-33 tests. Capacitors with ratings greater than 0.5 mf and 270 V often used PCB's. AC capacitors were almost always filled with PCB's while DC capacitors (the ones shown in Ref. 9) used PCB's somewhat less often. If the explosive charge ruptured the can and the contents burned, the combustion products were likely to contain hazardous products such as dioxin. – from PCBs?

The electronic equipment used with the counters is detailed in Table I, on page 21 as follows:

4 phototriggers
5 preamp filament supplies
35 counters
35 preamps
9 High Voltage supplies, 4900 V each.

From the circuit diagram in Figure 7 and the accompanying text I believe that every third preamplifier had two of the oil-filled capacitors while the other two in a three-counter set had only one. This appears to be confirmed by the photograph in Figure 31, which shows all of the counters around the charge box. One preamplifier is uncovered and can seen to have only one oil filled capacitor.

Lopes said that generally about 30% of the capacitor volume was oil. PCB's have a density of 1.5. I estimate the volume of the capacitors shown in Figure 8 to be about 1" x 2" x 3/4" = 1.5 in^3 so the amount of PCB would be about 0.025 lbs. (= 0.3*1.5*16.4*1.5/454). In the case of test 4 there were 35 counters and 23 preamplifiers with one capacitor and 12 preamplifiers with 2 capacitors implying 46 capacitors or a possible total of 1.2 lbs. of PCB's.

It should be noted that Figures 8 and 9 only showed one preamplifier. Other types of capacitors by other manufacturers could have been used in the other preamplifiers, however it seems likely that they would be of the same general type.

Figure 32 (ID 001968) shows the high voltage supply for the counters. It appears to contain a large number of dry cell batteries. From the photo there appears to 16 EVEREADY No. 493 300 Volt batteries and two BURGESS 45 Volt B Batteries (W30) and two EVEREADY Mini-Max "B" Batteries (appears to

be 671/2 volts). This is consistent with the stated operating voltage of 4900 V. For the nine HV supplies listed in Table I, the total would be 180 batteries.

Figure 33 (ID 001933) is a photo of the firing box. It is stated to use 6500 V. Page 58 of the report states that the firing condensers were charged through transformers and high voltage selenium rectifiers. Evidently the batteries shown in the firing box on test 1 were absent. The photo confirms this. The photo does show 8 can capacitors. Only a Los Alamos property label can be seen. An illegible label can be seen on one end of a capacitor. Enhancement , if possible, might make this readable. The capacitors are connected to the voltage supply in parallel so they must have a rating of at least 6500 V. These probably have a somewhat higher voltage rating and are undoubtedly oil filled. There was presumably only one of these firing boxes down hole. The report states that "the firing box employed essentially the same type of firing switch (Fig. 33, No. 1) as used in the previous experiment".

In reading the report on test 3 (Ref. 6) I came across Figure 19 (Hughes Aircraft Co., Drawing RD412H002D, July 12, 1948) which is a circuit diagram for the thyratron circuit used uphole to dry run the recording system. This diagram shows 6 capacitors labeled as "G. E. Pyranol". Two have the model number 26F360 and the designation 1.25 mf, 7500 V. These capacitors are likely to be similar to those used in the firing circuit. I called the G. E. Business Information Center (1-800-626-2004) and was given the name of Jesse Ruiz, El Paso, (915-774-9107) who put me in touch with Bob Patton, G. E., Fort Edwards, NY, (518-746-5586). Pyranol is the brand name of a PCB fluid. Patton stated that, in general, such capacitors were 35% by weight PCB's. Patton's records indicate that the 26F360 capacitor was a "dual unit" listed as (1.25/1.25 mf, 7500 V) and contained 0.9 lbs. of Pyranol. From Figure 33, I estimate the capacitors in the firing circuit to be 2" x 3" x 4" = 24 in^3. Using Curtis Lopes number of 30% by volume for the oil fill and a PCB density of 1.5, I calculate one of these capacitors would contain 0.3*24*16.4*1.5/454 = 0.4 lbs. of PCB's , or about half of one of the "dual units" described above. This seems reasonably consistent. The total in the firing circuit would then be 3.2 lbs.

Figure 31 (ID 001930) shows a good view of the experiment in the chamber. The Urchin was located 2' above the floor and contained in a aluminum sphere. The charge box in this test consisted of 1/16" steel and was 30" in diameter. A cooling system similar to the previous test was employed. The Urchin recovery system was the same as the previous test.

Figures 34 and 35 (ID 's 9887 and 9888) show the HE assembly, described to be the same as used in test 3 and made of "hard soldered brass construction". This would seem to indicate the presence of small amounts of silver solder (<100 grams). The base plate for the assembly appears to be aluminum.

Test 5, TA-33

This test is described in Ref. 12 and was conducted in MDA-E. It was fired on 6 April, 1950 and was a test of a Tom device. The report states "Tom shot was conducted at TA-33 about one mile west of Hot Point where Urchin tests 3 and 4 were made." It is said to be 700' airline from the control room in Building 7 (This building is shown in Figure E-3 of Ref. 11 and is now identified as 33-24). This chamber is the one labeled HP-29 in Ref. 11. The report states that locations for the pits were proposed by W-3 in a letter to John Bolton dated Sept. 7, 1949. Page 29 states "Construction of the pit for the Tom shot was requested by the lab in a letter from ENG-4 to the AEC Office and Eng. and Const. dated Sept. 14, 1949".

The report mentions the recent Urchin Test 4 and refers to the discussion of the gas counters in LA-954. It discusses some details in the electronics which made this test different from Urchin test 4. Changes made to counters included the use of Dural for the counter housing instead of the steel used previously. Figure 4 is a diagram showing some details of the counter construction. The photo on page 32 (no ID) shows 2 rings of counters (28 total) surrounding a charge box 20" in diameter and made of 1/16" steel.

Two important changes were made for this test. New preamplifiers were designed and built for this test. They are detailed in circuit diagrams in Figure 6 (Drawings 2Y-26157-B-2 and 4Y-26161-C-2). The first section preamplifiers were used one per counter, the second section preamplifiers could accommodate up to 10 inputs from first section preamplifiers. On page 13 it is stated that 28 first section and 10 second section preamplifiers were used. The photo on page 32 shows these preamplifiers. From the circuit diagrams and the photo I conclude that these preamplifiers probably did not contain the oil filled capacitors used in test 4.

The second change was the elimination of the phototriggers for this test. Instead triggers were generated by pulse forming networks coupled to the firing circuit and also by electrical pins in the high explosive.

A photo on page 32 shows the HE system. The Tom was in a shell of aluminum and the HE assembly was suspended from the lid of the charge box which appears to be about 1" thick. The HE assembly had a different designation from tests 2, 3, and 4 .

This test is referred to in several of the W-3 progress reports. Ref. 13 describes the switch to Building 7. It mentions minor alterations in the pit plans to incorporate the results of previous experiments. Ref. 14 mentions the possibility of using tuballoy in this test, but Ref. 17 indicates that tuballoy was not used. Ref. 14 may be the source of the statement in Ref. 11 on page D-1 that there was perhaps a trace amount of uranium in the chambers. It appears that this is not the case as no mention of uranium is made in any of the reports sited here.

Ref. 15 indicates that beneficial occupancy of the pit for the Tom test (5) occurred in this period. Refs. 16 and 17 discuss small changes in the counters to be used on the Tom test. Ref. 17 also states that no recovery equipment or cooling system would be used.

For reference, note that Figures 1 and 2 of Ref. 12 show details of both the Urchin and Tom devices along with the quantities of materials. Likewise the photo on page 32 shows details of the recording station, i.e. the interior of Building 7.

Test 6, TA-33

This test is documented in Ref. 18. It was not conducted in one of the underground chambers but is included here for completeness and because it is buried in Pit No. 2 inside the fenced area around HP-29. This was a test of the Wally device and was fired August 8, 1950. According to page 16 of Ref. 18, the Wally was fired inside a partially evacuated steel tank in a 10 foot deep pit dug out by a bulldozer. Figure 6 on page 22 gives a drawing of the counter arrangement. Page 17 contains a photo of the set-up in the pit, including the steel tank and the counters. The report references the Tom test for details of the site and control room.

A schematic diagram of the Wally device is shown in Figure 1 (Drawing No. 2Y27310) and is shown in a photo on page 11. Details of the tank can be found in memos GMX-444 (June 21, 1950, D. P. MacDougall to M. G. Holloway) and W-3-51 (July 11, 1950, R. J. Lanter to D. P. MacMillan).

The reports states that immediately after the test, the tank was checked by HP and no contamination was found. The counters and preamplifiers were removed and the tank was covered to a depth of eight feet by a bulldozer. Subsequent checks showed no contamination.

Other details of this test are included in Refs. 19 and 20.

Test 7, TA-33, Reuse of Chamber 2, MDA-D

There was no LA report that I could find on this test. However, the W-3 progress reports give a rather good picture of what transpired. In Ref. 21, page 4 the rational for this test is given. Apparently some

consideration was being given to the use of larger HE systems in a future test and the question was what the upper limit might be for the unused chambers in MDA-E. Pages 26 and 27 detail the operation. Based on previous experiences, described in this report, it was concluded that the underground chambers might be able to withstand the explosion of up to 600 lbs. of TNT. Chamber 2, (MDA-D) was dug out and 600 lbs. of granulated TNT was placed on a five foot high stand in the center of the chamber. "A vial containing 0.61 mCi of ^{210}Po was placed in the center of the TNT to use as a tracer in case gas trickled up through the ground". The door was sealed and the shaft refilled. Though not explicitly stated, since the TNT was in bulk, I believe that it is safe to assume that ordinary detonators were used not requiring any sophisticated firing system. The test was fired on April 15, 1952 at 11:15 am.

The chamber failed to contain the explosion. A large number of photos and descriptive text are contained in Ref. 22, pages 43 to 52.. The damage to the chamber resulting from the first test is documented as well as the damage at the surface of the ground due to the second test. The former information may be useful in assessing the condition of the other two chambers (HP-4 and HP-29) after their tests. Photos with ID 's 22091, 22089, 22103, 22108 22163, 22165, 22198, and 22201 (see Appendix A) are included in this progress report.

There is no indication that any materials other than those described above were placed in the chamber. No mention is made in the progress reports of any material being removed from the chamber in preparation for the 600 lb. test.

Summary

This section will attempt to summarize the information presented in the previous sections in order to outline the information available on each test as determined by consideration of all the documentation. The picture presented is my best guess based on my study of the reports available. I will organize the summary along the lines of equipment used in the different tests. No. 7 (the 600 lb. test) will not be included since it apparently involved no equipment other than the TNT.

1. HE system: Test 1 had a different system than any of the other tests. Test 2, 3, and 4 all used the same HE system. Test 5 had a different system from the previous tests and test 6 used only a very small system such that it did not require an underground chamber.

2. Cooling system: Tests 1 and 2 used a cooling system consisting of thin silver plates with cooling coils at the edges. Test 2 used a refrigeration system to chill the cooling water whereas test 1 did not. Tests 3 and 4 had the device in an aluminum sphere with copper cooling tubes to circulate the water. Test 5 had the aluminum sphere, but no cooling system. Test 6 had neither aluminum sphere or cooling system.

3. Counters and preamplifiers: Test 1, 2 and 3 used the same counter systems although tests 1 and 2 apparently used six tanks of counters on all sides of the charge box while test 3 had only four tanks on the horizontal sides. The preamplifiers used on these three test were probably the same, but details are not available. Tests 4, 5, and 6 used counters of different configuration but of the same basic type. Test 4 used preamplifiers which were well documented in the report. Tests 5, and 6 had a different design of preamplifier with some details of their construction.

4. Phototriggers: Tests 1 and 2 probably used the same type of phototrigger consisting of photo cells viewing small blocks of explosive. Test 3 and 4 used photomultiplier tubes coupled to thyratron pulsers. Tests 5 and 6 did not use phototriggers, but obtained triggers from other means.

5. Firing systems: Tests 1, 2 and 3 probably used the same type of firing system containing batteries as the voltage source. On subsequent tests the batteries were replaced by transformers and rectifiers.

6. Counter High Voltage: At least tests 1 - 4 used batteries for the counter high voltage. Tests 5 and 6 probably used the same type of system. All of the systems used voltages between 4000 and 5000 volts.

Conclusions

All of the chambers contained multiple kilogram quantities of steel, copper, and aluminum.

All of the chambers contained sizable quantities of vacuum tube electronics with soldered components (implying gram quantities of lead solder).

Chambers 1 and 2 and 3 (HP-4, HP-6, and HP-29) in MDA-D and MDA-E contained some oil filled capacitors. There is a high probability that some of these contained PCB's. I was unable to ascertain whether others did or did not contain PCB's, but the possibility cannot be ruled out. Chamber 3 (HP-29) probably at most only contained the 8 capacitors in the firing system and thus less potential PCB's than either chamber 1 or 2. In any case there is no compelling evidence for more than a few pounds in any chamber.

Chamber 2 has the best documentation on electronics and the limits given for PCB's in the section on this test are probably the largest (<5 lbs.). Depending on the assumptions made about the preamplifiers used in chamber 1, it has either as much or less PCB's than chamber 2. Chamber 3 has the least of the three (<4 lbs.).

No commonly used shielding materials such as lead, cadmium, or paraffin (with or without lithium or boron additives) were used in any of the tests.

The chambers at Trinity contain mercury (<1 kg) and silver (<200 grams).

All of the test chambers contained several hundred batteries, some of which are known and are listed in the various sections. All are probably simple carbon-zinc dry cells.

There are small amounts (<1 kg) of soft and hard solders in all chambers.

The exact designs of the test devices are known and are given in the appropriate references. I have these data and can supply them if needed.

No scintillation counters of any type were used on the tests covered in this report.

No evidence was found that uranium in any amount was used on any of the tests covered here.

Appendix A. Relevant Photos in the ISD-9 Collection

Test 3, HP-4:	Book BW-1	p. 257	#'s 7635 - 7676
Test 4, HP-6	Book BW-1	p. 277	#'s 9887 - 9905
	Book BW-2	p. 9	#'s 10113 - 10117
Test 7, HP-6	Book BW-3	p. 227/230	#'s 22086 - 22108
		p. 229	#'s 22155 - 22166
		p. 231	#'s 22167 - 22170
		p. 232	#'s 22196 - 22206

References

1. R. J. Lanter and D. P. MacMillan, LAMS-479, Dec. 4, 1946.

2. M-3 Progress Report for May, 1946 (Archives collection A-86-016).

3. M-3 Progress Report, Feb. 28, 1947 (Archives collection A-86-016).

4. M-3 Progress Report, April 28, 1947 (Archives collection A-86-016).

5. M-3 Progress Report, July 24, 1947 (Archives collection A-86-016).

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7. M-3 Progress Report for Dec., 1947 (Archives collection A-86-016).

8. M-3 Progress Report for Dec., 1947 to June 1948, LAB-M3-4 (Archives collection A-86-016).

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12. W. W. Nicholas, LA-1195, Jan.. 18, 1951.

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14. W-3 Progress Report, LAB-W-3-30, Oct. 25, 1950 (Archives collection A-86-016).

15. W-3 Progress Report, LAB-W-3-36, Jan. 26, 1950 (Archives collection A-86-016).

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19. W-3 Progress Report, LAB-W-3-47, June 1, 1950 (Archives collection A-86-016).

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21. W-3 Progress Report, LAB-W-3-186, April, 1952 (Archives collection A-86-016).

22. W-3 Progress Report, LAB-W-3-190, May 24, 1952 (Archives collection A-86-016).