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LAMS-252

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PROGRESS REPORT NUMBER TEN OF THE GADGET PHYSICS DIVISION OF THE LOS ALAMOS PROJECT

MAY 15, 1945

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PROGRESS REPORT NUMBER TEN OF THE GADGET PHYSICS
DIVISION OF THE LOS ALAMOS PROJECT
MAY 15, 1945

This design will be used whether or not the preassembly of the high explosive is incorporated immediately.

Further critical assemblies of 25 have been carried out by Group G-1. It has been found that the critical mass of a pseudosphere made of 0.5" cubes of 78 percent 25 in a WC tamper 10.8 cm thick is 26.6 Kg of enriched U metal. In a similar assembly with a Tu tamper, 16.5 cms thick, the critical mass was found to be 27.3 Kg. Neutron distributions using a variety of detectors have been made in the critical assemblies operating at a power in order to obtain information for the understanding of the measurements of alpha and dα/dm (variation of multiplication consistent with mass of the active material). Experiments to determine these latter quantities have been carried out by Group R-1 for a WC tamper and have led to a value of dα/dm 1.8 times smaller than that expected. This deviation has been tentatively attributed to the lower energy of the neutrons returning from the tamper. If Tu does not show this same effect, it may actually be a better tamper than WC in spite of the slightly small critical mass of the latter which may well be due to its slowing effect.

[redacted]

Nearly all of the efforts of Group G-2 have been devoted to various tests of initiators. Several different tests have been made on the jet mechanism. [redacted] Results have also been obtained for various angles of incidence of the shock wave, for sheet jets actuated by shock in Be. These have been photographed with x-rays using Au [redacted] plating.

[redacted]

These tests make the mechanism of the urchin, the selected initiator, seem reasonably well confirmed.

Further x-ray studies have also been carried out to test the melonseed and nicodemus initiators. For the former studies of the ejection of loaded paraffin, plugs have been observed and studied in some detail. Some evidence of jet or spall formation in the region outside the plugs has been observed, and this is not at present

understood. The examination of the plugs of various shapes in these wax models allows much more detailed investigation under conditions representing high shock than is possible with the use of actual materials. Considerable aid has also been given in the preparations for experiments carried out in cooperation with Group G-10 for the observation of the alpha particles from the Po carried by a jet a few μsecs. after ejection. These experiments have been found to give considerable contamination, but preliminary results are, nevertheless, encouraging.

DOE b(2

Experiments with the pulse loop circuits by Group G-3 have led to results which are not as encouraging as the first experiments.

[redacted]

In all of these shots, a washer .125" thick of Mycalex is inserted in the Al as a non-conductor, and in the shots with U, a plastic bonded UO_2 washer was used. The origin of the difficulties encountered in the shots with U is not understood.

Preparations are well under way for the proposed shots using full scale assemblies at the Medium Site in Pajarito Canyon, and test shots at the site have already been fired. Some further experiments have been carried out on the study of marble as a possible non-conductor substitute for Al in implosions for magnetic study. Comparison of compound shell, Al-marble assemblies with Al spheres, indicates that there is only a small evidence of reflected shock wave from an Al-marble surface, and this is probably due to the gap.

[redacted]

With Cd, however, good records were obtained.

DOE b(2)

These records show some differences from the shots fired in Pajarito Canyon, but in general give an accurate time of the actual start of tamper motion and check very well with the over-all time scale computed from the transit times with correction for holdup at the boundary of the slow component.

A large part of the work of Group G-4 in the design and construction of electronic equipment has been devoted to the instruments needed in the field work away from Site Y. This has included a large amount of timing equipment and various circuits used in the blast measurements at Trinity, as well as the development of informer circuits which are expected to be used to obtain information about the simultaneity of detonators in drop tests. Neutron monitoring equipment suitable for testing initiators in the field has been designed and is under construction. A simple and rugged instrument for measuring alpha-particle contamination in the field has also been developed. Several of the members of this group gave considerable aid in some of the emergencies arising immediately prior to the 100 ton shot at Trinity.

The observed ratios of diameter to original diameter show a considerable spread, and the experiments are being carefully considered and checks made to find the origin.

DOE (3)

Considerable variation in the diameter of the setup shots has also been observed, and attempts are now being made to find a more accurate means than the densitometer method now used to determine the diameter. To illustrate the sort of asymmetry which can be observed in a setup shot, Tu cores with flat machined sides of depth 1/16", 1/8" or 1/4" have been observed. The 1/8" flat is clearly discernible on the cloud chamber record while the 1/16" flat is barely visible.

One shot with a Cd core gave a record still more difficult to interpret, and the experimental work has therefore been confined largely to the investigation of Tu which is both more directly applicable and easier to study.

This result needs confirmation.

DOE (b)

Due to the absence of Ra La, few additional results have been obtained for Group G-6.

The transmissions from different banks of chambers did not agree very well, probably due to the fact that the source was only 150 g Ra equivalent. On the Al experiment, no time variation in the high explosive absorption could be found.

The outer surface showed some evidence of blast

DOE (b)

between the explosive blocks of the inner charge, but this only produced gashes in the surface.

The study of the time resolution correction has been completed, and it has been found that it is adequate to assume that a square pulse is changed into an exponential pulse with a small delay. The time constant in this analysis is considerably smaller than that used in the analysis of the data previously made, and it is now believed that the time corrections made to previous results should be reduced by a factor of 2. Since these corrections in some cases with the smaller assemblies have been quite large, this change is quite appreciable.

Work on the research and development phase of wire detonators by group G-7 was brought to a climax on May 12. Specifications for the assembly and loading of the 1773 units with the exception of a possible change in the preparation of the PETN have been set, and the responsibility for loading, together with some trained personnel, has been turned over to Greisen's group of Division X. [redacted] DOE (3)

Work on a more stable form of PETN had not reached a point where recommendations could be made, but it appears likely that a more stable form can be prepared which has even lower threshold. Considerable difficulty was encountered in the tests of 1773 units loaded at South Mesa. This was traced to electrical breakdown in the leads to the detonators. Although difficulties have been encountered in overcoming this defect, it now appears likely that it can be corrected.

[redacted] DOE

Work of the detonator group is now turned toward the development of a spark detonator, probably with lead azide. Drop tests have verified that the lead azide

pressed to 20,000 psi is less sensitive than the PETN preparation pressed to 500 psi. Since the timing spreads observed with spark detonators are smaller than with wires, and particularly since this spread is not dependent upon the voltage above threshold, the development of a spark lead azide detonator seems desirable. These detonators fire with very small capacity, and it has been found recently that one of their serious disadvantages is their small capacity threshold (approximately 100 $\mu\mu$f). This small capacity threshold makes them dangerous to handle where static charges are possible. The lead azide also shows a sensitivity to high humidity, but it is believed that this can be overcome with adequate sealing of the unit.

DOE (b)(3)

[redacted] It may be, however, as pointed out by Peierls, that this velocity is actually not the Al material velocity, but the shock wave in air, in which case the material velocity might be 10 percent smaller. Experiments have been carried out to try to settle this point, and shots have been made filling the cavity with hydrogen or using insulator-covered pins.

Further

DOE (b)(3)

experiments are contemplated in an effort to settle this point.

Further experiments on shock velocities in steel and other metals using plates with conical lens acceleration have given results which do not agree very well with previous measurements. It appears that the results of these experiments are not well understood, and further work is being carried out in an effort to clarify the situation. Experiments are also being started to determine shock velocities of converging shock waves where the shock pressures are much higher.

The work is being extended to cover the sheet jets directly applicable to the urchin initiator.

Most experiments carried out with the electrical timing method are now accompanied by observations to determine the transit time of the detonation wave through the lens assembly and inner component.

The work of Group G-10 has had a sharp change during the past month. On May 1, it was recommended on the basis of experimental and theoretical work, that project plans could be made on the assumption that a modulated initiator could be constructed. This recommendation was not based upon a conclusive proof of the initiator which seems not to be feasible outside of an actual gadget test, but was based on much supporting work and detailed investigation of the mechanisms employed in many different proposed initiators. It was further proposed that efforts be devoted mainly to the design and production at the earliest possible date of a modulated initiator of the urchin type. Work on the melonseed and nicodemus initiators was not dropped entirely, but is not allowed to interfere with the urchin design. A major effort is now being made by the CM Division to prepare satisfactory inhibiting coatings for the urchin and to cover these at high density with Po.

It is hoped, however, that if this background cannot be achieved it can at least be approached. Preparations are being made for rather exhaustive tests of initiators for temperature, vibration, etc. to find out what they will be able to stand.

At the same time, considerable work is being continued further to prove and test the selected design. Extended jet studies are being made by Group G-2 using the x-ray technique.

The experiments to measure shock pressures by the section of Group G-10 under Comdr. Goranson have had some preliminary success in gun tests. It is now proposed to carry these experiments directly to the measurement of pressures in a converging shock wave of an implosion, and considerable hope is now held on the basis of preliminary experiments for success in this undertaking.

The work of Group G-11 has been largely devoted to the preparations for the photographic experiments at Trinity. Ten experiments were set up and in operation for the 100 ton shot on May 7. Of the ten experiments, results were obtained for eight, although not with complete success in all cases. The group is now devoting its main effort to the completion of its equipment, and its installation prior to the real Trinity test.

GROUP G-1 - O. R. Frisch, Group Leader

May 22, 1945

2. Safety Tests at Omega - Osborn, Feld

293-1/2 "25" blocks (1" x 1/2" x 1/2") were found to be critical when "dunked" in water. These were distributed in a lattice of 5 layers, the lines between block centers forming a rectangular parallelepiped of sides 1", 1-1/2" and 1-1/2". Subsequent experiments showed that this was close to the optimum lattice configuration. The smallest thickness of the water tamper was about 5 inches on the side, with about 1-1/2 feet of water on the top and bottom of the configuration.

The mass of material used was 22.6 kg and the total area exposed was 4734 cm^2 (the "25" was of about 80 percent concentration). Rough estimates indicate that, if the effective thickness of the metal is considered to be about 1/4 of a thermal neutron mean free path, the "effective" mass of 25 for criticality is slightly less than the water boiler mass.

8. Rossi and F.M. Experiments - Baker

Group R-1 has made Rossi and F.M. experiments under identical conditions on 25 metal in a WC tamper, as described under no. 12. They were found to give the same periods within the limits of error. Further experiments were made to measure $d\alpha/dm$ by removing small amounts of material from the center. This gives, after proper interpretation, a value of $d\alpha/dm$ smaller than that expected (LA-235) by a factor of about 1.8. The reason may be a lower energy than expected of the neutrons returned by the tamper, and experiments are in progress to study the energy distribution of the neutrons emerging outward from the tamper. Some preliminary results are reported in LAMS-242 and 242A.

12. Critical Sizes of 25 Metal Assemblies - Baker, Hammel

The critical mass of 78 percent material stacked to a density of 17.7 in WC tamper of density 14.7 and 10.8 cm thick was found to be 26.6 kg.

The critical mass of 78.5 percent material stacked to a density of 17.7 in a tuballoy tamper 16.5 cm thick was found to be 27.8 kg.

13. Neutron Distribution in Reacting 25 Metal Assembly - Camac, Bistline, Hughes, Hammel, Feld

A. 25 WC-Fe Assembly

(1) The fission rates of 25, 28 and 37 were measured throughout this assembly by the use of Bright's "spiral" chambers.

(2) 25, 28, Mn, Al, P and Ag foils were irradiated in this assembly and their activities measured in a Geiger-Mueller counter.

B. 25 WC Assembly. 25 Au and W activity distributions were measured by exposing foils in this assembly.

C. 25 Tu Assembly. 25, 28, Au, Al, Ag and In activity distributions were taken in this assembly by the use of foils.

All activations were made by constructing a critical assembly and running it at the power required to sufficiently activate the detectors in the assembly. The foils were 1/2" square and were stacked into the central, horizontal plane of the critical assembly.

A rough calibration of the 28 and 25 foils was obtained by comparing the foil measurements with the fission chamber activities in assembly 1. The other detectors have been compared by activating them with thermal neutrons in the "thermal column" of the water boiler. A direct calibration of the 25 and Au foils for neutrons of about 200 KEV, by use of the W long-tank, is planned for the near future. A comparison of the 25 and 28 foil activities induced by the fission spectrum is also planned.

This will be achieved by irradiating the foils, sandwiched between 25 blocks, in a thermal neutron flux.

15. Gun Model Tests - C.P. Baker, J. Bistline

There were indications that wet sand was a poorer tamper than water.

The geometry necessary in the projectile tests is not one that admits of reliable extrapolation since as more material is added the shape changes. The perturbation of sandbags, etc., also changes the efficiency of the detector. These tests, therefore, should be taken merely as indications and not as reliable results.

16. Critical Mass of 49 in Solution - Slotin

The details of this experiment have been described in LA-272.

17. Instrumentation of Field Testing of Nuclear Components. O. R. Frisch

A Chicago type electroscope was lined with boron and tested, and it is concluded that by lining with B^{10} its sensitivity could be raised enough to make 1000 neutrons per second detectable. The gamma rays of Po can be sufficiently reduced by 1/2" of tuballoy or 1" of lead, with the source about 3" from the edge of the instrument. Paraffin is used to slow down the neutrons, and their intensity is measured by the effect of inserting a thin Cd sheet in front of the electroscope.

McDaniel has taken over the development of an instrument suitable for field use.

GROUP G-2 - L. G. Parratt, Group Leader

May 20, 1945

I. X-Ray Photographs - Tuck (in charge), T/4 Adler and T/5 Mayers

1.2 Jet Studies for Initiators. A hot shot was fired with a true Munroe jet.

The pictures show:

a) that an opening effect is still observed at 45° incidence;

The wax is made opaque to x-rays by the addition of white lead (25 percent). The first pictures have given good jets. It is proposed to extend the experiments to the observation of the jet in course of penetrating a target of similar material.

Preparations are also in hand to detect the jets from a hemispherical lens implosion by terminal observation methods.

In general, the penetration is about equal to, or less than, the maximum linear dimension of the cavity.

2. X-Ray Photographs - D. P. Macmillan (in charge), H. Wilcox

2.1 Nicodemi or Grape-nuts Initiators.

2.2 Melon Seed Initiators. Because available experimental techniques yield shocks which are very weak by comparison with the shock anticipated in the actual initiator, it was decided to seek substitute materials fulfilling the following conditions:

a) The strength of material should be negligible when the material is subjected to the shocks which are available for experimental use, just as the strength of any material is expected to be negligible under the conditions of use in the actual initiator;

surface velocities were calculated by him for pentolite working against lead.

Lead and wax satisfactorily fulfill conditions a) and b). The x-ray absorption of the wax can be increased to a satisfactory degree by admixture of some material of high atomic number. It would be preferable to dissovle such a material in the wax but since no suitable solute could readily be found, very finely divided basic lead carbonate was suspended in the molten wax. Bethe was consulted regarding the possibility of the heavy particles being left behind when the wax is accelerated by a shock: he concurred in our belief that any such effect would be negligible.

DOE 6(3)

2.3 Earth Absorption Experiments. It was desired to obtain an x-ray profile of the earth flying out of the crater formed by an explosion at scaled height above ground level. It was decided to try to accomplish this by making a radial lami of earth x-ray opaque by admixture of a lead compound, and then, at a suitable time after the explosion, photographing an x-ray beam passing above the earth surface at right angles to the radial lamina of leaded earth. A number of difficulties were encountered but earth was detected in the air at 400 μs and 500 μs but not at 365 μs nor at a number of times as short as 200 μs and as long as 1000 μs. Since there is

apparent reason why material from the crater should take so long to get in motion, experiments were made using as filling for the opaque lamina finely divided lead compounds undiluted with earth. It was then observed that streams of earth move into the air at a reasonably definite angle. Material from near the center of the crater apparently goes up at about 50° and material near the outside of the crater at about 35°. Pictures showing material in the air were taken at 350, 450 and 575 μs after detonation of the charge. As material rises into the air it apparently becomes more dispersed, and it is, therefore, possible that the apparent position of the material front in the late pictures is considerably behind the fastest moving material. In any case the apparent position of the material front is not definitely marked. However, on the basis of the pictures taken at 350, 450 and 575 μs, a material velocity of about 110 meters per second is obtained if the material is assumed to start moving when the shock wave reaches the earth.

It was learned that Segre needs information regarding the maximum angle at which earth flies into the air in order to determine a suitable position for his equipment in his Trinity experiments. Therefore, some terminal observation experiments were carried out using a 1/2" charge fired at scaled height (4.6") above wet mud. Mud from the crater was blown up against a solid wall about 25" from the center of the charge. Observations of the mud adhering to the wall showed that all earth on the wall is confined between an upper and a lower hyperbola. The maximum angle between material adhering to the wall and the crater center was 45° and the minimum angle was about 13°. (Two explosions observed). Observations show what appear to be two separate and distinct deposits of earth. One consists of perfectly dry spots of earth flattened to negligible thickness against the wall and ranging up to a quarter of an inch in diameter. These particles are found between 13° and 45°. In addition wet clods of earth ranging

roughly from 1/2" diameter to 2" diameter are found clinging to the wall between angles of 13° and 29°. While the distribution of earth density on the wall was estimated visually, it is believed fair to say that there is at least 10:1 ratio of wet earth to dry earth. It is suspected that the material giving rise to the dry deposit was projected at a velocity so high that only tiny particles were aerodynamically stable, and were dried immediately by the hot gases, while the main body of the crater was formed much later by ejection of a large amount of material in the form of large clods moving at low velocity, about 10 meters/sec. Such clods are found lying about on the ground to a distance of perhaps 10 feet.

The results of measurements of the size of small craters at Trinity have been considered and extrapolations made to 100 ton and 5000 ton shots. Charges shot at scaled height above ground from which the loose surface material had been removed to a depth of about 8 inches produced craters of the following character:

$$\frac{D}{W^{1/3}} = 1.78$$

$$\frac{H}{W^{1/3}} = 0.108$$

where the diameter D and the depth H are in feet and the weight of explosive, W, is in pounds. Extrapolating from these values, 100 tons of explosive would give $D = 104$ feet and $H = 6.3$ feet. For 5000 tons $D = 383$ feet and $H = 23.2$ feet. A comparison of these extrapolated figures for the 100 ton case with those measured in the recent Trinity shot is being made by Reines.

A LAMS describing these earth experiments in detail is in preparation.

3. X-Ray Equipment and Initiator Assistance - Cuykendall (in charge), Finlayson, Langsness, T/5 Schluter, T/4 Kilburg

3.1 X-Ray Tubes. Eighteen standard AL 389 tubes have been received. The five experimental tubes discussed in the April report were received. The workmanship of these five tubes is of poorer quality than of tubes received previously.

3.3 Magnetic Focussing. Tests of the experimental tubes has proceeded at low priority and but little positive results are yet available. One "pin-point" cathode style has been given a short test; on focussed flashes a single focal spot about 0.4" dia. is always obtained. This tube became gassy after about 30 flashes. After 200 flashes at 150 to 180 KV the tube again became hard and gave satisfactory intensity. Further tests will continue.

3.4 Surge Generators and Timers. Available condensers for the auxiliary surge generator for pulsing the cathode are not suitable. Delivery of units expected May 1 has been postponed until June 15. The program has been stopped pending receipt of the low capacity condensers.

The high frequency (about 30 megacycle) oscillation present in the surge generator current pulse has been eliminated from the oscillograms by the introduction of a low pass filter in the signal lead and a terminating network at the generator. Identical current pulse shapes were obtained in about 60 percent of flashes of a standard x-ray tube.

3.6 Assistance to G-10, Initiator Studies. Assembly, test and modification of electronic equipment has been carried out and installation made in Bldg. 4 at P-site to record the pulse from an ion chamber as a shock excited jet containing polonium is shot past the chamber.

Background noises, thermal as well as those caused by the HE detonation, have been eliminated. Two "cold" shots (no polonium) and one hot shot have been made satisfactorily.

Additional hot shots await completion of overall calibration of the system. For this purpose, with G-10 personnel, a slit in a disk rotating at high speed, which modulates a known source, has been constructed.

4. General Facilities at P-Site - Crocker (in charge), T/3 Ritner, T/4 Whitworth, White, Garn

A new program, hot shots by Barnes and Fulbright of Group G-10, has been added to the P-Site agenda. The first firing site chosen for hot shots, viz: the rim of the canyon 100 feet Northeast of Bldg. no. 4, proved too close, so the resultant contamination was first washed with about 600 gallons of water from a fire hose and finally covered with a layer of earth. A second site, in the bottom of the canyon and about 600 feet further East was then cleared. At this location it has proven possible to clear the area of contamination after each shot by scraping the top layer of earth with a bull-dozer and dumping this contaminated earth in a small gorge and then covering the dump with clear earth. Two of the P-Site crew passed a test on the operation of the bull-dozer for clearing contamination areas.

The magnetic focus tube and holder have been received, installed, and used for a series of Tuck's shots. Only moderate improvement was noted over the ordinary tube when used at the same geometry.

The counter program has bid farewell to P-Site. Jim Allen removed his detector cross. Since then we have closed up the counter-coffin, installed a sheet of boiler plate in front of it to prevent damage from flying fragments and returned all electronic gear to the Tech Area.

5. Radiographing Tu Tampers - Parratt (in charge), T. Finlayson

At the request of the G-Engineers, studies were undertaken on the feasibility of radium radiographing of full scale Tu tampers.

The first phase of the work has been completed. This work, which was done with the facilities at T-Site and largely by M/Sgt. Tenney's staff, involved studies of plane slabs of Tu 1", 2" and 3" thick. Cylindrical holes and V-shaped grooves of sizes 1/64" to 1/2" were placed in the Tu at distances 0", 1" and 2" from the film. A radium source of two 1/2 curies, physical size about 1/2" x 3/4" , was placed 12" to 16" from the film. Eastman Industrial Type A film, as Tenney recommended, was used with an 0.005" Pb intensifying in front and a 0.01" Pb screen in back. (DuFont Film No. 506 and Agfa Superay A films were also tried without improvement). Standard Eastman x-ray developer was used with KI added to eliminate most of the background fog. Conclusions from this work are as follows:

a) Correct exposure times were established: 3-1/2 hr. for 1" Tu, 14 hr. for 2" Tu, and 30 hr. for 3" Tu, all with a sourcefilm distance of 14".

b) A "halation" shield at the edges of the Tu is found to be necessary.

c) 3" Tu thickness: Spherical blowholes 3/8" in diameter could probably be detected in the region of the Tu next to the film and something larger than 1/2" in diameter in the region on the opposite side of the Tu.

d) 2" Tu thickness: Detectable hole sizes are about 1/8" and 3/8" (guess) respectively.

e) 1" Tu thickness: Detectable hole sizes are about 1/16" and 3/16" (guess) respectively.

f) Super-position of 2 films during exposure and also in viewing increases the apparent contrast.

This work was extended to find the optimum filter to be placed between the

Tu and the casette. This filter turned out to be about 0.015" to 0.020" Pb to absorb soft secondary x-rays and about 1/16" Cu to absorb secondary electrons. With such a filter, the contrast is markedly improved and considerably smaller blowholes can be detected.

Reduction in exposure time and also a further improvement in contrast was then achieved by introducing a standard pair of fluorescent intensifying screens, Patterson No. 353, between the film and the Pb screens. With the combination of filter and sandwich arrangement of intensifying screens, the sizes of detectable blowholes as judged with 1" thickness Tu are approximately one-half as large as listed in paragraph 2 (e). Exposures have not been made with 2" and 3" Tu; these exposures are in process. The prognosis so far is rather promising.

To radiograph the entire volume of such geometry by placing the casette in the central hole (greater resolution is required in detecting blowholes and/or cracks in the region of the inner surface, hence the casette can not be placed on the outer surface) would require about 25 separate radial exposures, a task which is not too enticing. It is hoped that a single exposure of the shell, with a large casette adjacent to the equatorial side of the shell, will prove fruitful.

To relieve the pressure which this work has imposed on the T-Site facilities, specifically designed for routine HE lens examination, and to incorporate such prospects as using Ra-La, it has been decided to rig a special set-up in the basement of the ice-house to continue this work.

GROUP G-3 - Edwin M. McMillan, Group Leader

May 19, 1945

PERSONNEL: Section 1 - Arkin, Clancy, Daly, Fowler, Miller, Rosen and Thompson.

Section 2 - Chandler, Chavez, Cohen, Creutz, Davisson, Feder, Foss, Frankel, Fuller, Guttchen, Hershey, Hobday, Klein, Kratz, Lanahan, Major, Nichols, Peterson, Rose, Shank, Stark, Van Beneden, Wenner and Young.

Section 3 - Fishbine, Schelberg, Smith, Wieneke.

Section 1

I. Instrumentation. All.

A. New Apparatus -- Electric detonators installed and put into operation. Apparatus (I.F. Amplifier, etc.) for detection of high-frequency pulse-loop signals put into operation. [redacted] DOE b(3)

VIII. Exploration Shots. Thompson.

Work has begun (on low priority) to utilize piezo-electric charge in the production of pulse-loop signals.

X. Pulse-loop Circuits. Fowler, Rosen, Thompson.

A number of plate shots have been made in a continuing attempt to determine the optimum design for pulse generators. DOE b(3)

XI. Static Tamper Attenuation Measurements of Pulse-loop Signals. [redacted]

XII. Pulse-loop Studies of Implosions. Fowler, Rosen, Thompson DOE b(3)

On the first of these shots a good record of the motion of the outside surface of the Al was obtained. No record was obtained which could be attributed to the pulse-loop generator inside the sphere. This was not entirely unexpected since the contact pins in this case were 17/32" and 25/32" from the inside surface. It is quite possible that a jet reached some vital section of the generator before the Al surface reached the pins. The second shot mentioned above was a complete failure in every sense. The magnetic record indicated very bad timing as did recoveries of the Al after the shot. This is the only case in which the magnetic record taken in conjunction with an inside record has proved unusable. In this connection, it might be well to point out that this experiment differed from others in that solid CO_2 was placed around the charge in an attempt to displace the air with CO_2 gas and thus possibly avert a shift baseline. The charge and primacord were, therefore, quite cold at the time of firing.

DoE b(3

A good record of the motion of the outside surface was obtained. Also obtained was a pulse from the inside of the correct magnitude sign and duration.

b(3)

Good magnetic records were obtained from the motion of the outer surfaces indicating good

implosion (fast rise time of record, etc.). There were no signals on the pulse-loop records, however, which could be attributed to the signals from the inner surface. It is suspected that one or both of the insulating shims broke down.

XIII. Insulating Shims. Fowler, Rosen, Thompson.

The metallurgy division has again undertaken to produce suitable insulators to match Tu as nearly as possible.

Experiments are being started to investigate systematically the behavior of insulating shims used in the pulse loop technique.

Additional samples of mycalex have been submitted to Froman for measurements of shock wave velocity.

One 12S60-180 shot was made for terminal observation.

After the shot, the steel ball, 2/3 of an Al hemisphere and some of the mycalex were recovered. The part of the face of the Al hemisphere recovered had apparently not been marred. Also the mycalex was still an insulator and chemical analysis showed that no important changes had taken place.

Section 2.

I. Summary

Tests made with the plastic shell around a charge show that the background may be reduced somewhat. Shots with compound spheres of Al and marble indicate that the acoustic impedance of the two is well matched. Electric detonator background can be made negligible by careful arranging of the coaxes.

Test shots preliminary to the full-scale experiments have been made.

II. Background Due to High Explosive.

There are no significant changes in the status of the HE background since last month. The timing of the spikes is consistently in agreement with calculated interactions of detonation waves.

A 1/4" lucite shell appears to cut down the background somewhat. No significant differences are observed when a 9" non-lens charge is fired with a booster point, a double or a triple interaction point lined up with the field.

A 9" charge detonated at two points showed the usual dip and then a rather steep negative spike at the time when the interaction waves met at the equator. This was expected since, at the time of interaction, there should be a net outward motion of ions.

IV. Electric Detonator Background.

[redacted]

DOE b(3)

V. Compression Studies.

VII. Full-scale Plans.

DOE b(3)

Preliminary small test shots have been made at the Pajarito medium site to test the equipment which will be used for full-scale shots. Construction of the foundation for the first full-scale shot has begun. A coil winder has been constructed and coil forms are available.

[redacted]

DOE b(3)

shop. Makeshift lucite double detonator assemblies are ready to be tried out. They will be used with two special pellets and two [redacted] pellets.

[redacted]

DOE b(3)

Section 3. (X Site)

I. Schedules.

A. Schedule to date.

[redacted]

DOE b(3)

B. Expected future schedule.

[redacted]

II. Set ups.

A. [redacted]

The charge, pickup coil and field coil are in a coplanar coaxial orientation. The coils are mounted in a vertical plane. The magnetic field in parallel to the X-ray beam.

The field coil is 60" OD and is wound on a permanent steel ring. This gives a steady field of approximately 150 gauss.

The pickup coil is 36" diameter and is made from RG 11U coax cable with the shield broken at one point.

B.

Field coils are 92" OD and are wound on expendable wooden forms. Two size coils are now in use, one containing 250 pounds of Cu and one 110 pounds. Field strengths range from 100 to 150 gauss. In the lighter coil, the rate of change of field strength is approximately 1.5 percent/sec. due to heating of Cu. In the heavier coil, this rate of change is approximately 0.4 percent/sec. Greater accuracy can be achieved with the heavier coil but the lighter coils are satisfactory for studying timing. A permanent iron ring for these large size coils has recently been ordered from Berkeley.

III. **Data.**

A.

1) Conducting vs. non-conducting charge supports.

The Al tripods used to support the charge in the cradle give rise to a very pronounced dip in the base line of the magnetic record. The dip starts several microseconds before the start of the magnetic trace and ends about the time that the blast

wave reflected from the center of the gadget reaches the Al surface. It reaches a maximum about equal to the maximum implosion signal and occurs shortly after the Al surface first starts moving in. No such dip is observed when non-conducting supports are used. The first four shots had Al tripods: all subsequent ones have been non-conductors.

2) Shorting switch vs. no shorting switch.

Records of shots not having shorting switches seem to have more high-frequency hash lasting throughout the trace. The data are not cleancut and the conclusion is tentative.

DDC

3) Timing correlation between magnetic trace and betatron-cloud chamber record.

a) In order to correlate magnetic record times with the betatron-cloud chamber record, it was necessary to have a common time mark or base on both records. Three methods were discussed:

1. To introduce a pip caused by the X-ray burst into the magnetic trace.

2. To produce an artificial pip which would be introduced into both the X-ray timing trace and into the magnetic trace at any desired place.

3. To use common 5 microsecond time markers generated by one "clock" on the two traces.

The third system was adopted and was installed by Titterton. It has proved reasonably simple to use and interpret and has given excellent results.

b) Of seven shots measured to date, the time of motion of Al (i.e. the time interval between start of motion of Al and the X-ray burst) as measured by magnetic method has agreed within 1/4 microsecond with the time as calculated from the H.E. train if 1.0 microsecond is allowed in the calculation for a baratol-Comp. B delay. The shift in timing is consistently in the same direction, indicating that one to two tenths of a microsecond should be added to the hypothetical delay.

4) Quality and consistency of magnetic records.

a) H.E. signal preceding metal signal. The shape of the H.E. spikes is inconsistent from shot to shot. The amplitude is similarly inconsistent and only rarely have the very large spikes characteristic of the Pajarito records been observed. The time between the 1st H.E. spike and the start of the Al motion averages 8.3 microseconds with a maximum deviation of ± 0.3 microseconds.

b) Metal signal. The shape of the curve is reasonably consistent and characteristic. Time intervals are as follows:

	Avg.	Max. Deviation
Initial rise time	.95 μsec.	± .35 μsec.
Reflection time from Tu surface	4.57	± .30
Reflection time from center	11.34	± .14

5) Absolute calibration of magnetic record.

[redacted] Effort has been concentrated upon elimination of background which render calibrations inaccurate.

B. [redacted] DOE 4/2)

1) Effect of conducting charge supports.

Al supports do not cause noticeable dip in base line which is characteristic of 3" scale. They may, however, give rise to some hash.

2) Shorting switches.

Up to a few days ago no shorting switches have been used on this scale. The latest records are not yet analysed. It is planned to use switches for the next several shots in order to have comparison data.

3) Timing correlation.

Of 5 records measured to date, the magnetic method measured time of motion of Al has disagreed with the predicted time from H.E. calculations by 0.1 to 0.8 microseconds. The H.E. figures include a 1.0 microsecond allowance for Baratol-Comp. B delay.

4) Quality and consistency of magnetic records.

The shape and amplitude of both the H.E. and metal signals are inconsistent. [redacted] Satisfactory explanation of the source of these poor results has not been made. It is possible that poor implosions might be the cause. Time interval data are not available at present.

GROUP G-4 - W. A. Higinbotham, Group Leader

May 25, 1945

In this period most of the first Trinity equipment was completed. At the same time a great many other jobs were done. 238 pieces of equipment were completed of which 75 were major jobs involving a certain amount of development work and 163 were standard pieces or routine shop jobs.

1. Trinity Blast Equipment - Sands

Amplifiers, controls, and associated test equipment were designed for the measurements at Trinity of the air and ground waves. Units were constructed for the operation of twelve of piezo gauges, and for twelve of the geophones.

2. Trinity Photographic, Blast Equipment - Elmore

A six channel direct coupled photocell amplifier to drive six 308 Dumont scopes (for Julian Mack) was completed.

Two five-channel sound ranging circuits (for Barschall). (These circuits worked very well on small charges, but cross-talk, probably originating in the six miles of multiconductor cable, caused great confusion in the record from the 100T charge. The trouble can be cured by limiting the signal at the pick-up end, and by presenting the signals on separate scopes, instead of mixing the signals for presentation on a single scope.)

3. Trinity Blast Equipment - Hane, Huffhines

Sixteen Cal. Tech. capacity - blast informers were modified by the addition of power output stages. Sixteen receivers and power supplies were also modified. A trailer was equipped for location of most of the receiving equipment. This work was done in conjunction with Waldman and Bright who had charge of these measurements.

4. Trinity Fast Timing - McDaniel and Titterton

Electronic equipment to provide timing signals in the range (t_o - 100 m.sec.) to (t_o) with accuracy of $\pm$ 1 ms or better was designed and used with success. The set-up comprises:- (a) Sawtooth generators with associated discriminators set to fire at appropriate times. Two sawtooths, one 100 ms long and the other 20 ms long to cover the latter part of the interval. Three discriminators were provided in each channel. (b) Coding Unit and Line Driver - The signals from the discriminators could be converted to have either positive or negative sign, mixed together and generated at low impedance for transmission over a twisted pair line. Decoding is effected at the receiving end. Two channels were used to drive lines from station B to A and station B to P. A t_o signal was supplied locally to all recording apparatus in shelter B. For the 100T shot, only two signals were required to be sent over the lines to A and P so that the decoding problem was very simple. (c) A counter chronograph with a time resolution of 1/16 ms was provided for measuring the time intervals. Calibration of the oscillator driving this unit was effected by comparison with a 1000 cycle fork. (d) A 4035 Driver Unit which generates a positive pulse for transmission over coaxial cable to the Raytheon Detonator Firing Unit. (e) Sundry circuits for operating Bausch Lomb and Hilger Spectroscope Shutters at P and A. (f) Circuits which take the t_o signal and convert it into a step wave for galvanometer recorders. The system will have to be revised for the next shot since more signals are required.

6. Model 5 Sweep - Titterton

This unit has been designed for test measurements on electric detonators at Alberta. A sweep delay of up to 10 microsecs. after the initiating trigger signal can be obtained and sweep speeds range from 1 microsec. per inch to 20 microsec. per inch. The sweep chassis incorporates its own timing unit which yields 0.1 microsec. pips at 2 microsec. intervals. A standard unregulated 6KV 5CP5 scope is employed for presentation.

6. Neutron Monitor - Sands

The Model 220 Amplifier and Scaler has been designed and several units are under construction. These instruments are intended for use with BF_3 proportional counters in the measurement of the neutron background of initiators. The circuit consists of an amplifier with a gain of 20,000 and a scale of 8 built into one case with a type of construction and choice of components which make it satisfactory for overseas use.

7. Densitometer - Elmore, Hough

A densitometer potentiometer circuit for use with photocells (to measure the density of cloud chamber photographs from the betatron experiment) has been designed and constructed for driving a Brown Instrument recorder. Light from a high intensity mercury arc, pulsating at 120 cycles, is received by a photomultiplier tub after passing through part of the photograph; light also passes directly to a secon photo-tube to serve as a comparison intensity. The system automatically records the difference on the Brown Recorder. The system is sensitive to intensities in the 10- lumen range. The use of 120 cycles makes the instrument insensitive to small amount of stray light not of this frequency.

8. Trigger Delay - Elmore

A trigger delay circuit 0.3 microsec. to 100 microsec., has been designed built. The unit contains an input discriminator which starts the variable delay, a which triggers a blocking oscillator to supply an immediate output trigger for con trolling other circuits. A second blocking oscillator is triggered at the end of t delay when a linear sawtooth trips a second discriminator. The circuit has a singl trigger feature, preventing a second delayed trigger. It contains an internal rela oscillator to aid in setting the delayed trigger (by use of an external calibrated pulsed oscillator). (For Froman).

9. "Super-Suds" - Watts

A simplified and rugged instrument, similar to the "Plutos" has been developed for field applications when ruggedness and long life are essential.

GROUP G-5 - S. H. Neddermeyer, Group Leader

May 17, 1945

I. K-SITE OPERATIONS

[redacted]

Magnetic record. are now being taken on nearly every shot, the main limitation on this being the rate at which the electric shop can wind coils. Three new steel boxes have been installed in the ground on a radius of 10 feet from the firing point; one for housing the primacord pulse generator for the main timing sequence, the second for a primacord pulse generator to trigger the magnetic sweep, and the third for a pin mixer circuit which is used with a second oscilloscope for monitoring the lenses. Two methods for lens monitoring have been tried, one in which the pins are spaced in the primacord at distances from the detonator increasing by 1/16" intervals from one detonator to the next, and another in which they are buried in the surface of the explosive, likewise at successively increasing distances from the booster. Results are inconclusive but indicate that the second method, which is applicable when the detonators are in contact with the boosters, will be satisfactory. A spark detonator unit is ready for installation and trial within the next week; this will replace the explosion switch method which has been used up to the present. The ion-chamber apparatus to be used for transmission measurements has been moved out to the site for preliminary testing.

II. EXPERIMENTAL RESULTS

[redacted]

The results of the magnetic time records are indicated on the graph by vertical lines, and the spread between the magnetic time and time determined using the known transit time

in the high explosive is shown by the horizontal connecting lines.

An indication of the quality of the diameter measurements is given by the points at the tops of the graphs, which show the measured diameters of the set-up photographs compared to the known absolute initial diameters. A great deal of work remains to be done in studying and correlating the data, but the situation as it now exists can be summarized as follows:

2) In those cases where magnetic records exist the times determined from them are in good agreement with the times determined by using the computed H.E. transit time. (Both determinations depend on the measured time to the x-ray pulse, from the same zero). The presumption is then that most of the time measurements are good and that the non-existence of a regular curve is not likely to be attributable to faulty time measurements.

3) Poor magnetic records can be correlated to some extent both with second quality explosive assemblies and with feeble compressions, but much more work has to be done, both new and on existing records before a more definite statement can be made.

4) The set-up diameter measurements have rather large variations which reflect a corresponding uncertainty in the compression measurements. Although the reasons for the variations in the measurements are not fully known, some bad implosions are also strongly indicated.

5) No positive evidence exists for observable dissymmetries in the implosion. There are apparent irregularities in the shadows which exist as frequently on the setups as on the shots themselves.

The photographs have not been densitometered, but the 1/16" flat was barely visible, while the 1/4" flat was very clearly defined.

III. DATA ANALYSIS

The main reliance has so far been placed in microdensitometer traces and work is being pushed in various directions to try to improve the diameter measurements. The following points may be mentioned: (a) improved criteria for interpreting the densitometer traces; (b) more rigid control of the illuminated region in the chamber and attempts to determine the effective depth of the illuminated region by stereoscopic methods; (c) use of an annular cone of light and a photo-cell for diameter measurements; the purpose of this is to avoid the necessity for averaging a large number of traces when one is concerned mainly with the average diameter without regard to minor deviations from perfect symmetry; (d) a modification of the above in which a solid cone of light is used instead of an annulus; this is an integral method which might have some advantages over (c); (e) use of stereoscopic methods by which it may be possible to make a more objective visual estimate of diameters than can be done when the tracks are not seen in three dimensions; (f) a flicker comparison method with an adjustable magnification to match images of setup and shot.

IV. PERSONNEL

The present personnel of G-5, listed so far as possible according to sub-projects, are as follows:

Betatron:	Kerst, Ogle, Conklin
Cloud Chamber:	Neddermeyer, Streib, Allison, Althaus
Data Analysis:	Sayer, Bloch, Christian, Price, Sherman Streib, Wangsness
Electronic Equipment:	Wiora, Conklin
H.E.:	Mueller, Brown, Friedlander, Feldman Keller, Nines
Ion Chamber:	Seren, Lanzl
Photography:	Sopp
Shop:	Tamarelli

The magnetic work is being carried out by Wieneke, Fishbine, Schelberg and Smith.

DOE 543

SECRET

[redacted]

DOE 5(3)

SECRET

DOE
b(3)

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0137

GROUP G-6 - B. Rossi, Group Leader

May 22, 1945

The new firing site in Bayo Canyon was completed and tested. Shot no. 20 was fired successfully on this site.

(1) Results of Ra La Tests

Shot no. 19, April 20, 1945 (Ra La shipments no. 4 and no. 5 combined)

Metal sphere: O Al 900

Source: Approximately 230 g Ra equivalent

Magnetic detection: magnetic field: 123 gauss; pickup coil 72 cm below center of charge

Experimental results:

Average

Correction for time resolution has not yet been made but it will not be very large. This shot was fired to investigate the variation in the absorption of the H.E. lenses during the time of detonation. There is no evidence which indicates any measurable effect.

Shot no. 20, April 26, 1945 (Ra La shipments no. 4 and no. 5 combined)

Metal sphere: O Cd 224 Al 472

[redacted] DOE 613

Source: Approximately 150 g Ra equivalent

Magnetic detection: Magnetic field: 148 gauss; pickup coil 64 cm below center of charge.

Experimental Results.

[redacted] DOE 613

The magnetic record indicates an acceleration time of 1.0 microsec. and an initial velocity of 1800 m/sec. for the outer Al surface.

(2) Improvements of the Experimental Method for Ra La Tests.

A. Work on timing circuit continued.

B. More static absorption measurements were taken with composite shells and with collimated beams. Also absorption measurements with Aluminum powder were started in order to investigate the effect of a change in density on the transmission.

C. One bank of the newly developed long chambers was used in shot no. 19 and found satisfactory.

D. The study of the time resolution was completed. It was found that one obtains a sufficiently accurate correction by assuming that a square pulse is changed into an exponential pulse starting with a certain time delay. The time constant of the exponential is approximately one half of that used previously. This means that all time

corrections given in the previous reports should be reduced by approximately a factor 2.

(3) Geiger-Muller Counters

Production continued according to request.

(4) Personnel

A. Ra La Detection Equipment in Bayo Firing Site No. 1

Staub, Chromey, Levine

B. Ra La Detection Equipment in Bayo Firing Site No. 2

Allen, Mereson, Everhard, Burditt

C. Magnetic Detection Equipment

Fairbank, Kiszenick, Mallinckrodt, Stone

D. Preparation of Shots (including H.E., Source Transfer Devices, Etc.)

Diven, Menz, Friedrick, Kissee, Jordan, McCaughey

E. Construction of Expendable Electronic Equipment

Harper, Hartig, Venghaus

F. Construction of Auxiliary Electronic Equipment

Staub, Miller, Levine, LaBarge

G. Experiments on the Time Resolution

Staub, Dellenbaugh

H. Development, Construction and Testing of Ion Chambers

Nicodemus, Dellenbaugh, Powers, Volpe, Lustgarten, Haley, Hudson

Henderson, McLaughlin, Newberry

I. Evaluation of Data

Koontz, E. Staub

J. Static Absorption Measurements

Koontz, Hall

K. Timing Circuit

Jurney, Chromey

L. Shop

Moloznik

M. Tests for Radiation Hazards

Miller, E. Staub

N. Secretary

H. Nyer

GROUP G-7 - E. J. Lofgren, Group Leader

May 22, 1945

Following a number of conferences in the first few days of May between Bacher, Kistiakowsky, C. C. Lauritsen, Lofgren and Oppenheimer, the following decisions were made:

1. PETN- Bridge Wire investigations should be brought to a conclusion on May 12 so that the 1773 design could be essentially frozen.

2. Production and testing of the 1773 should be centralized in X division under Greisen, G-7 providing some people and advice.

3. G-7 should make an all out effort to get a lead azide detonator into the July program. This should be a joint effort with Cal Tech.

1773 Detonators

DDE 6[illegible]

From April 15 to May 12 we loaded about 800 1773's, the limiting factor being the non-availability of mechanical parts. [redacted]

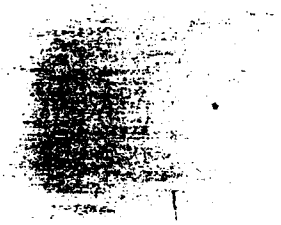
[redacted] While these figures are satisfactory for the early stages of production, the failures increased to a disastrous 1 in 4 for single detonation. This was traced to electrical break down in the coax cores. Production was halted while the bad cores (40 percent) were rejected by an electrical test.

[redacted] DDE 6[illegible]

When the work was turned over to Greisen on May 12, we were able to recommend [redacted] decreased size of PETN tube. The work on more stable PETN types had not reached the point where recommendations could be made; however, the investigations are continuing on some very promising leads found by Hansen.

Lead Azide Detonators

[redacted]



GROUP G-8 - D. K. Froman, Group Leader

May 15, 1945

5. RESISTANCE WIRE: (J. H. Roberts)

The method of measuring the velocity imparted to plates by driving them into a nichrome spiral has been further developed. It is found that no interaction results when two such spirals are placed under the same plate and the records obtained from each fed into separate amplifiers and oscilloscopes. The method has been used on both steel and copper plates 1/8" thick, and results in good agreement with the pin contact method were obtained.

Several small shots were fired to determine whether a straight nichrome wire could be substituted for the spiral. Inconsistent records were obtained, probably because of disturbing effects from the shock wave moving down the wire ahead of the plate.

[redacted]

resistance wires. Considerable hash appeared on the records. Research is in progress to develop a preamplifier to eliminate this hash.

10. IMPLODING HEMISPHERES

[redacted] DOE 5/2

In both cases the inward velocities at the pole of the hemisphere and at a point 61° from the axis were measured. The velocity at the pole was measured over a distance of 28 mm, but blast limited the measurement near the equator to the first 8 mm of motion. The velocities found are:

At such velocities the air temperature in front of the imploding surface has been calculated by Peierls to be 11000°K. At such temperatures it may well be that the shock front is an excellent conductor and that our velocities refer to the shock wave instead of the metal surface. The difference in velocity is only about 10 percent and can be calculated, but it would be of interest to determine experimentally which we are measuring. A number of suggestions were made which might resolve this point. Bethe suggested that if the air in the hemisphere were replaced with hydrogen the temperature would be reduced to perhaps 2000°K. Accordingly, two shots were made under these conditions.

These results are in disagreement, and it is planned to repeat this experiment. Until further shots are made no conclusions should be drawn from the data given.

In this shot air was left in the hemisphere but four of the five pins were covered with glyptal to insulate them from the ionized air in the shock wave.

13. SHOCK AND MATERIAL VELOCITIES IN METALS: (J. H. Roberts and V.A. Medzel)

Recent measurements on 1/8" steel plates give results which do not agree with earlier measurements. Three shots have been fired using Tuck lenses and 5" high pentolite cylinders (3-1/2" diameter). The lens for one shot was filled with spherical grained tetryl; for the other two shots they were filled with spherical grained TNT. All three shots give an initial velocity of about 2000 m/sec. and a shock velocity of 4400 m/sec. Since these results vary appreciably from those previously reported it is evident that effects are occurring in these measurements which are not understood.

A good record was obtained on 1/8" copper using the lens filled with spherical grained TNT. It gives a shock velocity of 4700 m/sec. and an initial velocity of 1700 m/sec.

Further work is being done on determining more accurately the shock and initial velocities of aluminum, cadmium and lead using Tuck lenses filled with spherical grained TNT.

14. VELOCITY OF PLATES: (D.K. Froman)

Eight shots were made for X-Division each using two blocks of composition B, 8" x 4" x 12". The two blocks were placed on top of each other to make a total depth of 8", and detonated at a single central point on top. The total time of the detonation and the velocity imparted to a 1/4" steel plate by the charge was measured in each case. The results are given in the table below. For each shot listed the top charge appears first in the table.

Shot	Charge No.	Density gm/cc	Det. time* μsec.	Initial Velocity/ m/sec.	mean.	Final Velocity m/sec.	mean.
1 Low-low	x 5022 x 5023	1.681 1.677	33.25	1650	1550	2350	2320
2 Low-low	x 5041 x 5024	1.686 1.676	33.25	1450		2290	
3 Low-high	x 5040 x 5090	1.685 1.714	32.8	1570	1550	2110	2165
4 Low-high	x 5107 x 5093	1.682 1.705	32.65	1530		2220	
5 High-low	x 5092 x 5042	1.714 1.687	32.7	1600	1540	2190	2200
6 High-low	x 5105 x 5021	1.712 1.676	32.7	1480		2210	
7 High-high	x 5089 x 5091	1.705 1.706	32.45	1700	1640	2180	2195
8 High-high	x 5104 x 5106	1.703 1.715	32.45	1580		2210	

* Time includes 1" primacord going through a ring tetryl pellet onto a solid tetryl booster on top of the 8" of comp. B. Also included is the shock time through the 1/4" steel plate. (The latter by direct measurement in four of the cases above was 1.25, 1.35, 1.27 and 1.29 μsec.) The second shot of each combination was made with electric detonators and the time was corrected to that of the first by assuming (1) 4.3 μsec. loss in an additional 1" of primacord and (2) 1.7 μsec. loss in detonating the primacord from the time the current flowed through the detonators.

/ Initial velocity (before second shock returns through the steel) cannot be determined very accurately. Its probable error is of the order of 200 m/sec. The probable error in "final velocity" (after 7 or 8 μsec) is of the order of 100 m/sec. It is quite questionable whether or not there is a significant variation in the velocities of the steel from the various combinations of high and low density charges.

16. SHOCK AND INITIAL VELOCITIES IN NON-METALS: (V.A. Nedzel)

Four samples of Ca F_2 plates were used in determining the shock and initial velocity of that material for Group J-3. The shock velocity averaged 4700 m/sec. while the initial velocity for the 3/4" plates was 2800 m/sec. and 1500 m/sec. for the 1.5" plates. These runs were made using Tuck lenses filled with spherical grained TNT above 5" x 5-1/2" dia. pentolite charges.

17. VELOCITIES USEFUL TO THE INITIATOR PROGRAM: (H.M. Newson)

Range and Velocity of Jets: A technique for measuring jet range and velocities is being developed.

Five measurements give jet velocities from 15,000 to 19,000 m/sec; however, the clearer records favor the lower value. The velocity appears to be independent of the depth of the hole which varied between 3.5 and 12.5 mm.

The jets are absorbed in a pile of 1/16" Mycalex plates. The course of the jet is followed by electrical contacts made to copper foils between the layers of Mycalex. The range of the jet from a hole 9 mm deep is about three layers of Mycalex and that from a 12.5 mm hole, six. The average velocity in Mycalex during the first two microseconds is 5,000 m/sec. Evidence is insufficient to tell whether this is dependent on the depth of the hole. Probably (see sections No. 21) the velocity of the material in the jet is not decreased greatly in penetrating the Mycalex, but the front of the jet is merely used up in making the hole for the following portion. Thus, the apparent velocity given by arrival times is low. This rapid deceleration makes it possible that the ranges observed are less than the true range. The record is terminated by the progress of the implosion about 3 microseconds after the start of

the jet so that if the jet continues at a lower velocity its later stages would not be observed.

THE PORCUPINE: (H. W. Newson and J. S. Blair) DOE b(3)

pins were copper and found to penetrate the steel to a depth of at least 1/16".

?8. PROPAGATION OF THE CONVERGING SHOCK WAVE IN THE SOLID GADGET: (D.G. Marshall)

It was not possible to interpret the record of the only multi-detonation shot attempted.

20. SYMMETRY OF IMPLOSION: (J. H. Roberts)

Nine pins were placed at various positions 0.32 mm from the inner surface of the steel liner. Five of these pins were placed under detonation points, one under a double interaction point, two under triple interaction points, and one at a selected "random" point.

In this case twenty-four pins were placed at a distance 0.179" (4.55mm) from the inner surface of the steel liner. The pins were placed so that a good representation of the symmetry of the implosion would be obtained, i.e., under detonation points, double and triple interaction points, selected "random" points, etc.

These two shots are not entirely comparable because of the differences mentioned. In the latter shot it is also true that the time spread could have been exaggerated because of possible disturbances from the rarefaction wave from the edge of the charge. Experiments are being initiated to determine how close to the edge of the hemisphere one can make measurements without getting appreciable disturbances.

21. SHAPED-CHARGE EFFECTS: (G. Felt)

Several shots were fired to investigate depth of penetration and velocities of brass jets. The jets were formed from brass cones of 75° included angle and 1/16" wall placed in the base of 2-1/2" diameter x 3" pentolite charges. Three jets were fired into stacks of three 2" steel blocks; one through 8" of oak penetrated 5"; one through 8" of comp. B detonated simultaneously with the pentolite, penetrated 5";

one through 12" of comp. B detonated similarly, penetrated 4-1/2". In the two shots fired through H.E., only the middle and bottom steel blocks were recovered. One jet was fired through 8" of comp. B into a stack of three 4" dural blocks. The middle and bottom blocks were recovered but no brass was found on either.

Two velocity shots were fired through two 2" steel blocks and two through two 4" dural blocks. The initial jet velocities varied with each shot but averaged 6300 m/sec. The jets were decelerated in each case but in three cases out of four were accelerated after leaving the first block. Though recovery of the blocks indicated that in each case the jet had penetrated both blocks, no record was obtained beyond the entry of the jet into the second block.

22. OVERALL TIMING MEASUREMENTS: (V.A. Kedzel)

Apparatus was set up to measure the time interval between the moment of the surge of current through the detonators and any other pulse such as pin pulses. The circuit consists of the input of a 4.5 microsec. delay line connected in parallel with the trigger input of the scopes which is connected through appropriate voltage dividers to a detonator condenser. The output of the delay line goes to a fast-flip-slow-flop circuit. The flip pulse is differentiated in a very short time constant input to a cathode follower which shares the same cathode resistor as the cathode follower of the pin pre-amp. This is permissible since only one of the two cathode followers is passing pulses at any one time. The circuit flops back long after the last pulse on the scope sweep.

This circuit was used in measuring overall times through blocks of comp. B (see section 14 of this report) and through Tuck conical lenses plus 5" x 3-1/2" dia. pentolite cylinders.

GROUP G-10 - C. L. Critchfield, Group Leader

May 22, 1945

Fabrication

On May 1, the emphasis of implosion-initiator work was transferred from methods of proof to fabrication of a service unit. Because of the limited time in which the difficulties of fabrication must be overcome, it has been decided, both by the Initiator Advisory Committee and by G-10 in conference with Bacher and representatives of G-2, G-8 and CM-15 who had been directly engaged in investigation of initiators, that the future efforts of those concerned will be concentrated on making a service unit of the urchin design. Two other designs, the melon seed and the nicodemus, will be carried along as things to fall back on in case the difficulties peculiar to the urchin prove insurmountable, but with the explicit directive that work on these alternate designs does not detract from the effort to fabricate the urchin.

For the essential dimensions of the initiators, and particularly the urchin, the recommendations of Bethe, LAMS-237, will be followed as well as fabrication practice permits. Preliminary specifications for acceptance of service units have been submitted

[redacted] DOE (b)(3)

by Holloway, Morrison, Schreiber (to Critchfield, May 9, 1945).

[redacted] That committee has also approved shielding layers up to three ranges equivalent in thickness and using radii up to .005 inch instead of sharp angles. [redacted]

[redacted] DOE (b)(3)

The fabrication of initiators to meet the specifications and recommendations cited above present a major problem to the CM Division. The activities of that division in the initiator work are coordinated by R. W. Dodson and may be divided into three categories: (1) the procurement and inspection of beryllium in which C.S. Smith serves as liaison with the metal producers, (2) the deposition of protective layers which is done by CM-6 with assistance from Kolodney and, (3) the deposition and testing of polonium. Under item (3) we depend upon CM division not only for obtaining the required density, purity, stability and distribution of the polonium layers, but also

[redacted]

for assembling the initiator, measuring its active content and testing for such redistribution, chemical or thermal effects that may appear after acceptance tests. The allocation of the polonium supply to experiment as well as to service units is, of course, in the hands of the CM Division.

In close cooperation with Dodson our group will design and have fabricated the gross mechanical elements for initiator assemblies and test units, using beryllium that have been inspected and passed by Kehl's group, supply current mechanical drawings of all such assemblies and units, and set up the mechanical testing facilities required to carry out the recommendations of Holloway, Morrison and Schreiber. We shall also duplicate the neutron counter to be used for determining backgrounds in the field, compare it with the field unit, and calibrate it preparatory to labelling initiators that go into the field with the background observed before shipping and with the background that can be tolerated.

The responsibility for design development of the urchin rests with the Engineering Committee comprising Sampson, Serduke, Wilson and Critchfield. Fabrication practice and procurement from the machine shops is done by Serduke. The installation of test equipment and execution of the acceptance tests on initiators is under the direction of Sampson.

Organization

The change of emphasis in our work has resulted in the formation of the Engineering Committee described in the foregoing paragraph and in narrowing the experimental objectives. These changes involve certain reassignments of responsibilities within the group and these will be cited here for the record.

Serduke will continue in his responsibility for fabrication and design

practice on the urchin as well as on other work of the group. In this, he has the assistance of Webster and hopes to acquire another mechanical draftsman.

Sampson will continue in his direction of Sandia Canyon and in addition will be responsible for implementing the acceptance tests on the initiator as mentioned above. For these efforts at present he has the help of Allen, Alexander, Harlow, Sherman and Taylor, and after the completion of work on sectioning of hot shots Rall and Wilkinson will be available to Sampson.

Wilson is a member of the urchineering committee, but he has also the responsibility for the timing tests that are to be carried out, principally on Munroe jets. In these experiments, he has the assistance of Hanna, Rieser and Wright.

Sherr has three responsibilities: (1) the engineering of the melon seed initiator in collaboration with Serduke and Critchfield; (2) liaison with other groups that are doing experiments pertinent to the initiator program, notably, Koski, MacMillan and Newson; (3) sectioning of "hot shots", a technique by which it is hoped to interpret such shots in general, but jet recoveries in particular. Cieslicki, McHale, Rall and Wilkinson are at present engaged in this effort with the understanding that Rall and Wilkinson are to be transferred to background measurements on initiator units as soon as feasible.

Barnes is the group's senior representative for the measurement of activities in jets. For terminal observations he has the assistance of Kline and for timing measurements the assistance and facilities available from Cuykendall and Tuck and their personnel of J-2. Fulbright, on loan from J-7, is the executive of the timing experiment itself and is aided by Kupferberg and Ilfeld of our group in his work.

Goranson continues with his study of physical properties of materials under strong impact loading, adding to his program the study of partial sphere implosions.

A preliminary progress report on this work is included below. The technical personnel in Joranson's section include Bancroft, Courant, Houston, Pierson and Waters of J-10 and Bale, on loan from the machine shop.

Members of J-10 not cited above are H. Joranson, secretary, and Calvert and Foster who are both on loan to Johns at present.

Experimentation on Initiators

Preliminary results have been obtained in each of the three major experimental activities of the group mentioned above under Wilson, Sherr and Barnes, but each is in such early stages that no report will be made here. The work in liaison with Koski, MacMillan and Newson is progressing and will be reported by them. Particular concern about the melon seed mechanism has arisen from some of D.P. MacMillan's results because of the apparent formation of spalls, and this phenomenon will be studied further.

The study of active shots for recovery has been discontinued for all practical purposes except insofar as they can apply to the study of jets. Sectioning of the active targets may help in the interpretation. All experiments using polonium have an uncertain future because of the limited supply of that element and also because of the high priority in the CM division on fabrication problems.

Recovery

Part 1/3)

Although terminal recovery of steel balls is an accomplished fact, the expansion of the internal cavity makes the technique of little value to studying the action of initiators. A possible exception is the proof of the formation of jets the traces of which may be in evidence and this is being followed up.

Another type of experiment that indicates the doubtful utility of lens recovery shots in studying initiators is the determination of temperature at the initiator position.

PRELIMINARY PROGRESS REPORT

May 19, 1946

Physical Properties Under High Impact Velocities - Written by Lt.Comdr, R. W. Goranson

Some measure of success in extending the pressure range for static measurements was obtained in 1939 and 1940 but it was also found that any very large extension would not be very practical. In consequence attention was directed toward dynamic or impact methods wherein creep of material would not limit the accuracy of measurements and elaborate systems of vessels for containing pressure would not be necessary. Some tests of the feasibility of this method were obtained in developing methods and tools for the study of structure response to underwater explosions.

Within the "elastic limit" isentropic properties will be obtained; beyond this region they will satisfy the Rankine-Hugoniot hydrodynamic relations. These relations can be obtained from a measure of any two of the four quantities, density, material velocity, shock wave velocity and peak pressure in the shock wave.

A striking velocity of 3000 ft per second should produce shock waves of the order of one-half megabar (10^{12} dynes / cm^2). In order to extend the calibration constants of the piezo-electric probes it was decided to make measurements of the last three quantities by using a gun projectile to produce the impact. To that end a 6"/47 smooth bore gun was set up at Sandia.

Failure of the trip circuits was caused by gas leakage across the sealing bands, and none of the projectiles designed for us was satisfactory in this respect. Considerable time was lost in determining the cause of failure and in attempting to correct it. Pending the manufacture of a satisfactory gun projectile trials were begun with 3-1/2 inch plane wave lenses and pentolite.

As might be anticipated, considerable difficulty has been encountered in perfecting the experimental technique, and some further refinement will be required before reliable quantitative data become available. The present procedure is to prepare a specimen in the form of a cylinder about 3 inches in diameter and 3 inches long. Two piezo-electric crystals are embedded in this specimen in such a way that any change developed between their surfaces will appear on conductors brought out through the back face of the cylinder. These crystals are so arranged that the shock wave reaches them successively, and are placed so as to avoid interference effects from the free surfaces of the specimen, and from each other.

Two difficulties may be anticipated. In the first place it can hardly be expected that the crystals will remain integral for more than a small part of a microsecond after the shock wave has reached them. In spite of this fact, it seems reasonable to suppose that, even if the piezo-electric material is broken into small pieces, it will continue to develop electric polarization in response to stress, and that it will thus appear to be piezo-electric as long as the constituent particles maintain their original orientations. This state of affairs may persist for some little time, since the motion believed to exist in the shock wave is not of the type which might be expected to produce immediate rotation of the crystal fragments. The extent to which the crystal is preserved is thus seen to depend largely on the excellence of the machine work by which the specimen is prepared.

The second difficulty lies in successful insulation of the electrode from the near surface of the crystal. At first it was believed that mica could be used for this process, but aluminum oxide has proved superior. The aluminum oxide is prepared electro-chemically on the surface of a thin aluminum tube, and this tube is then inserted between the electrode and the rest of the target, which is at ground potential

Of six targets thus prepared, only one produced the type of signal which would be expected, i.e., without distortion, though the others agreed in a qualitative way. In any event, it was always possible to determine the arrival times of two distinct disturbances, and the corresponding wave velocities computed. Determination of the pressures characterizing these two disturbances has proved somewhat difficult, and tentative values only are available. Unfortunately, in the case of the record which appears quantitatively the best (see Fig. 1), there was considerable doubt as to the calibration of the recording equipment.

The recording technique is not of the simplest. Excellent oscilloscopes and associated equipment have been provided by the Electronics Group, and this has in general proved both satisfactory and reliable. There remain certain difficulties associated with transmitting the signal undistorted from the crystal to the oscilloscope. The recording system has to respond faithfully in about 0.1×10^{-6} seconds in order to obtain adequate records. It has been found possible, in principle at least, to achieve this by the use of coaxial cable and compensating terminal networks.

One of the chief sources of difficulty lies in preventing the charge developed by the piezo-electric crystal from producing a potential high enough to break down the electrode insulation. The capacity of the crystal and electrode to ground is about 300×10^{-12} farads. At a pressure of 10^6 pounds per square inch, a potential of 1500 volts might be expected. To avoid this a large condenser ($.05 \times 10^{-6}$ farads) has been placed in shunt with the crystal. It is believed that residual inductance of this condenser may either render it ineffective, or result in as yet undetermined signal perturbations, or both.

In order to measure material velocity (using H.E.) displacement - time

curves were obtained by means of a pin contactor technique devised at Norfolk and somewhat similar to that utilized by Froman. Froman's values (LA-182) could not be utilized because they do not describe a function of material velocity but rather the transfer of momentum from explosive to plate. To measure particle velocity in this manner the reverberation time should be longer than the time required to make such measurements.

As anticipated, from the intensities obtained with these plane H.E. waves, the velocity of the elastic wave in steel is higher than the shock wave velocity by about 15 per cent. i.e. about 5.75[1] and 5.00 km/sec. respectively.

The slope of the displacement - time curves, measured over a total displacement of one millimeter or under, was 0.568 km/sec. which, since it is at a free surface, should represent twice the material velocity.

Proposed Future Work

In accordance with a recent request this section will proceed at once to design, set up and attempt measurements of convergent shock waves in an imploded partial sphere.

Preliminary mechanical and machine design of the targets has exceeded expectations and it is believed that an extension of such design can be successfully applied to hemispherical targets.

1) This value is higher than that given by Metropolis. His value of 4.63 is the ordinary bar velocity and is not corrected to take account of the rigidity of the material.

SECRET

Some more work will however be required to establish the calibration of the crystals and to determine the proper net work for least distortion of the signal. It has just been established that the present terminating networks are such that considerable oscillatory high frequency overshoots are possible and need correction. In addition preliminary shots with high voltage detonators will be required in order to determine and correct for any interference from the 7500 volt surges.

These latter tests can be carried out with plane wave lenses. It is proposed therefore, to continue also investigation of the relative properties of different materials such as tuballoy, cadmium, beryllium, lead, etc., with plane lenses in so far as our limited shop facilities will permit both kinds of tests.

Shock fronts after traveling 1.9365 inches in C.R. steel.
Pentolite charge (Plane lens)
4 May '45

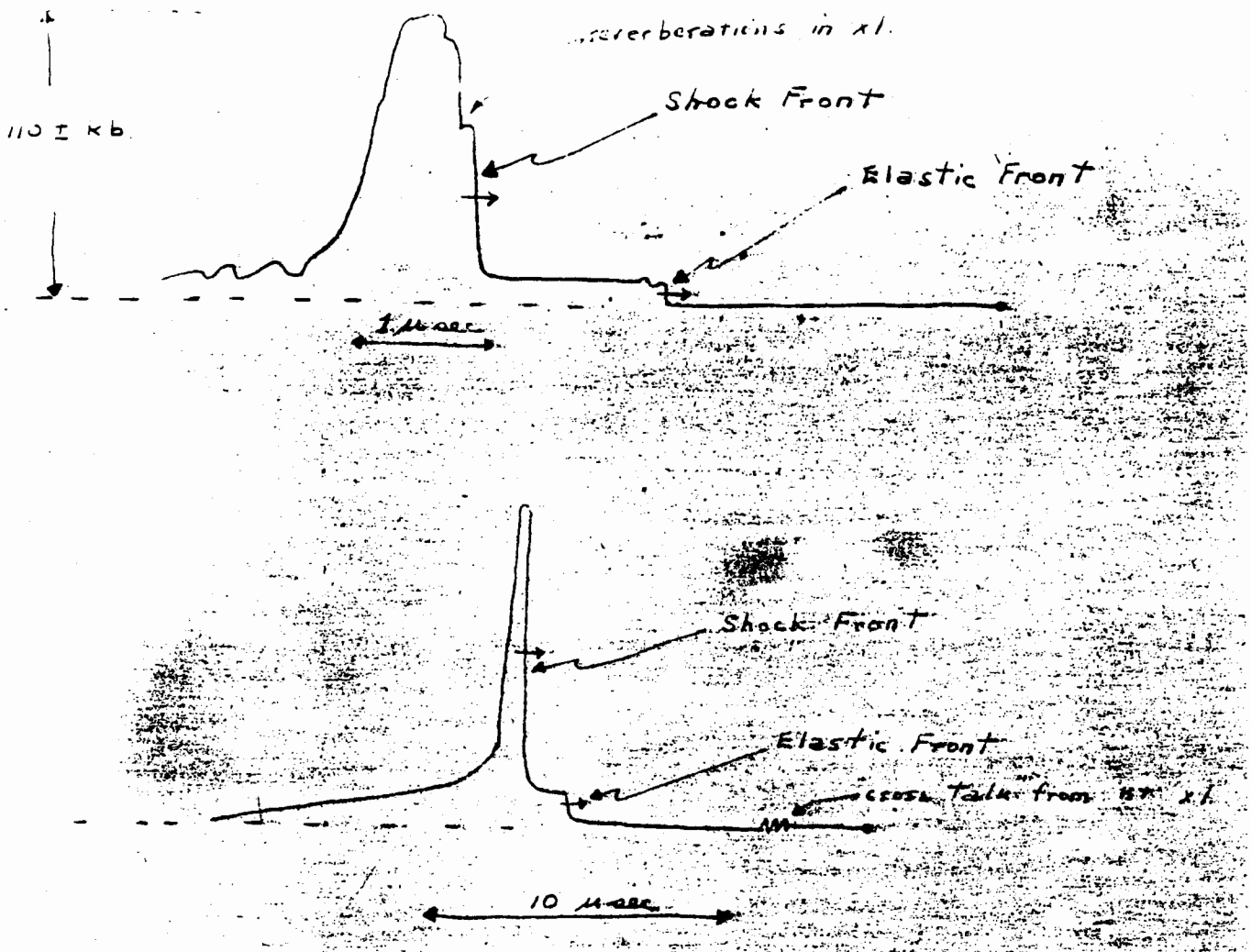


Fig. 1

GROUP G-11 - J. L. Mack, Group Leader

May 20, 1946

The manpower shortage in the group has reached the point where we have to decline or postpone a large fraction of the development work presented to us.

2. Kingman Test Instrumentation - Brixner

A general review has been made of reported motion picture operating and processing difficulties, and recommendations have been made to Shapiro.

An optical system has been worked out with Waite for putting the image of a clock face in the corner of a 5" x 5" aero-camera field.

3. Trinity Test Instrumentation - Mack

At the 100-ton test May 7, the instruments for nine of the eleven experiments accepted from LAMS 165, and the total radiation experiment, were tried. Since the primary purpose of the shot was to test the instrumentation rather than to obtain data, the instruments that needed modification to give usable records for 100 tons were modified only when this procedure was convenient. Although not all the records are yet available, eight of the ten experiments seem to have gone through essentially as they were intended to. The causes of failure of the other two are known.

The prospective TR progress report will probably be issued next month.

The number of photographers for TR is being increased from one to two.

4. Sweeping-Image Cameras - Brixner

Martin has used our unfinished general report on these cameras to obtain information on the variability of the image velocity.

We have supplied to Bradbury five new universal cameras, except for two superstructures made by his group. The recently procured Bausch and Lomb cinephor lenses are evidently an improvement over the previously used field lenses.

5. Oscilloscope Cameras - York, Wanlen

York's recent progress report, leaving undone only low-priority experiments, is now available as LAMS 241. Writing speeds up to 15 inches per microsecond have been attained with 6 kv on P5 screens.

6. Armored Still Cameras - Mack

We are still working with Moski to make the long-focus armored stereo-cameras increasingly useful at high magnification and long stereo-base for large-scale shots.