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13 May 1945

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TO: Major General L. R. Groves

From: R. C. Tolman

Subject: Report on First Trinity Test

1. Purpose of Test.

This memorandum gives a brief description of results obtained in the first Trinity Test carried out on 7 May 1945. The purpose of this test was to obtain preliminary information, from the detonation of 100 tons of ordinary high explosive, as to the success to be expected from observational methods and from administrative procedures proposed for the final test with nuclear explosive.

The section headings in this memorandum agree with those in my memorandum of 17 April 1945 on the "Program for Trinity Test", to which reference may be made for a clearer understanding of the purpose of the whole program. The present memorandum is written at a time, when the data provided by the first test have for the most part not been worked out, but when it is possible to give an overall picture of the character of the test, and to state which measurements appear to have failed or succeeded.

2. General Character of the Test.

The test was carried out with 100 tons of high explosive stacked on the platform of a twenty foot tower as described in more detail in the previous memorandum. The stack of high explosive was provided with tubes containing radioactive solution to simulate, at a low level of activity, the radioactive products expected from the nuclear explosion.

Measurements of blast effect, earth shock, and damage to apparatus and to apparatus shelters, were made in general at "scaled-in" distances as compared with the distances proposed for the final shot. Measurements to determine "cross-talk" between circuits, and photographic observations were in general carried out at the full distances proposed for the final shot.

The scheduling of the test was advanced from the original date 5 May to 7 May to allow for further introduction of apparatus. On the basis of continuing weather forecasting, the time selected for the shot was 4.00 A.M., and it was actually pulled off with a delay of only 37 minutes to allow the observation plane to get properly ranged for dropping its air-borne instruments.

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The detonation was evidently high order. It led to the production of a highly luminous sphere which then spread out into an oval form. This was followed by the ascent of the expected hot column which mushroomed out at a height of some 15,000 feet, at a level where atmospheric instability was indicated by meteorological observation, and then drifted eastward over the mountains. The illumination and sound were detected at the Almogordo Air Base 60 miles away, by an observer who had been prewarned. Earth shock was imperceptible at 10,000 yards and at the base camp 10 miles away. The explosion seems to have aroused little comment in neighboring towns.

3. Program of Measurement and Observation.

As described in more detail in the previous memorandum, the primary measurements and observations to be taken in the final test may be grouped under the following four headings:

1) Behaviour of the Implosion.

2) Nuclear Energy Released.

3) Damage Effects Produced.

4) Overall Behaviour of the Explosion and its After Effects.

In this preliminary test, which involved neither an implosion nor nuclear explosive, only subsidiary experiments could be carried out in connection with the first two headings.

In addition to the program of primary measurements and observations, there were also programs of measurement in connection with meteorological observations and health control.

4. Organization for Carrying Out the Program.

The organization for carrying out the program was substantially as described in the previous memorandum. Including military personnel, it involved a total of approximately 200 men. In view of the circumstances, that the test was carried out on a very tight time schedule and is to be regarded as a trial run, the organization functioned with considerable success.

The tightness of the schedule was affected by delays in procurement and transportation. This meant that some apparatus arrived only at the last moment, and involved feverish night work for many persons on one or more nights preceding that of the actual test. It is hoped to cure this in the final test, (a) by a more realistic scheduling

allowing for time delays in procurement, (b) by the provision of additional transportation part of which will be assigned to individual groups who will then be responsible for its upkeep, (c) by improvements in key roads which will reduce transportation breakdown, and (d) by the setting of a definite date, sufficiently in advance of the test, beyond which further apparatus cannot be introduced into the experimental area.

In connection with scheduling, it should be remarked that the tightness of the time schedule for this preliminary test has the advantages of emphasizing the need for a less hurried procedure in the final test, and of providing a longer interval of time to prepare for the final test.

There was some criticism in connection with arrangements for intercommunication and timing. Radio-communication was often weak and subject to interference. It is planned to cure this by installing more telephone communication, by obtaining better radio sets, and if possible by obtaining more than a single radio frequency for use. The arrangements for sending time signals to various apparatus stations actually worked well but involved a large amount of last minute work by an emergency group. It is possible that a separate group TR-7 will be set up to take charge of radio, telephone, and timing problems.

The organization is a temporary one set up specially for the Trinity Tests and involves the placing of heavy responsibilities on younger men, including SED boys. This means a certain looseness in the organization, and inexperience on the part of some of the operators. In spite of this, the organization functioned as well as could be expected, and has now been through a good shakedown preparatory to the final test.

The following individual failures of personnel came to my attention. Two operators, probably SED boys, failed to push buttons at the north and south 10,000 yard stations to actuate cameras. This will be cured by putting these cameras on automatic controls. One operator failed to close a switch for the blast operated flash bombs. Two operators became unduly alarmed when their jeep broke down in the middle of the night and spent so much time in ineffectual attempts to make repairs that they failed to put water into an impulse gauge. This should be cured by better transportation and roads. Certain responsible persons went into the area without authorization to distribute mice for biological experiments with consequent damage to electrical connections.

We may now turn to a brief but more detailed description of the different measurements and observations that were made, using the same headings as in the previous memorandum.

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5. Behaviour of the Implosion.

a. Detonator Simultaneity. No measurements of detonator simultaneity were made in this test which did not involve thirty-two detonation points as in the final bomb. Such measurements are standard at Los Alamos and Kingman.

b. Time Interval between Detonator and Nuclear Action. No measurements of time between detonator and nuclear action were possible.

c. Determination of α for the Nuclear Reaction. The cable and recording apparatus to be used by Wilson in the measurement of α were tested for "cross talk." The accidental signal level was a few millivolts so that the final apparatus will be designed to give its true signal at a level of about one volt.

6. Nuclear Energy Released.

a. Delayed Neutrons. The equipment of Williams for measuring delayed neutrons was installed at a "scaled-in" distance and suffered no damage.

b. Delayed Gamma Rays. The apparatus of Moon for measuring delayed gamma rays was installed and gave records. Tests were made on equipment for Segré's method which withstood air blast and earth shock.

c. Conversion of 49 to Fission Products. The Hanford slug was successfully dissolved and introduced into the pile which then had a beta ray activity of 1000 curies and a gamma ray activity of 400 curies. On the basis of simple scaling-up of the RaLa shots it would be calculated that 10% of this activity would remain in the soil within a 300 foot radius after the shot. Actually only 2% was found in that radius, indicating as might be expected that simple scaling laws do not properly allow for the increase in updraft with increased charge. A distribution formula for the activity as a function of distance was determined. It was also determined that the local distribution in the soil was such as to permit alpha particle counts without difficult chemical separation. The rocket method for obtaining soil samples from the crater was tested and found satisfactory, and the use of shielded tanks in connection with the final sampling was also tested.

7. Damage Effects Produced.

a. Blast Pressure at Ground Level from Piezo Gauges. Eleven quartz blast gauges were installed and nine records obtained. These have not yet been analyzed in detail. Some of them show cross talk, but a certain amount of reliable data will certainly be obtained.

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b. Blast Pressure at Ground Level from Condenser Gauges. Eight condenser gauges were planned for use, but only one actually was installed and it gave no record. In view of the success of a similar airborne gauge, some success in the final test is to be expected.

c. Blast Pressure at Ground Level from Excess Velocity. Six receivers were installed to pick up the blast wave and record its time of arrival. These worked well on the small calibration shot but gave evidence of much "cross talk" hash on the main shot. It is not yet known whether the records can be satisfactorily analyzed. Improvement might be introduced by lowered sensitivity for the main shot as compared with that needed for the calibration shot, and by leading the signals into separated rather than a single amplifier.

Forty-seven flash bombs to be operated by arrival of the blast were installed. Photographic observation was then to be used to determine blast pressure from excess velocity. Only two flash bombs went off due to personnel failure to close a switch.

d. Peak Pressure at Ground Level from Paper Gauges. Twenty-nine box gauges, each with twelve holes covered with aluminum foil, were introduced to measure peak pressures at different distances, and functioned successfully.

e. Blast Impulse at Ground Level from Piston Acting on Fluid. Five instruments of Los Alamos design were planned, and one satisfactorily installed, for measuring blast impulse by following the action of a piston in forcing water through a set of constrictions. A good record was obtained but without timing marks; it can probably be analyzed as a consequence of the constancy of speed of the motor used to drive the recording disk. One instrument of British design did not operate entirely satisfactorily, perhaps from sand in the bearings, since it showed a velocity which increased during the passage of the blast wave.

f. Blast Pressure at Higher Levels from Condenser Gauges. Three condenser gauges for measuring blast pressure were dropped over the target from a height above ground of 15000 feet by the observation plane. One radio receiver in the plane was known to be out of order from a fire, and one recording instrument failed. The other gave an excellent pressure time record. The three parachutes had to be dropped in salvo instead of successively as planned owing to failure in bomb release mechanism. The plane used was a B-29 assigned to the project. Hardly any shock was felt by the plane when the blast wave reached it at a distance of about four miles.

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g. Earth Shock. Six converted geophones were used for measuring velocities of earth motion and gave satisfactory records, which have not yet been analyzed. Survey is now being made to determine the permanent displacement of stakes driven into the ground around the point of explosion. The crater was about 5 feet deep and 30 feet in diameter which was smaller than expected. This may be partly due to the effect of the heavy concrete footing for the tower.

8. Overall Behaviour of the Explosion and its After Effects.

a. Size, Shape, Behaviour and Path of the Ball of Fire. Three out of three Fastax cameras (1000 frames per second) at 800 yards, and two out of two at 10,000 yards, operated satisfactorily. Two Mitchell cameras at 10,000 yards operated satisfactorily, one for 30 seconds and the other for the full 1000 seconds planned. Films have been sent out for development.

b. Radiation and Temperature of Ball of Fire. Two out of two Hilger spectrographs were in operation; there was some uncertainty about the focussing of one of these. The films are being developed. The Bausch & Lomb spectrograph, and the movie camera with filters were on low priority for this test and were not installed. The drum camera with photo cells gave no record because of "cross-talk". The thermocouples and galvanometers appeared to function satisfactorily.

c. Behaviour of Hot Column. Three Fairchild Aero Cameras were installed. The two at 10,000 yards north and south did not operate because of personnel failing to push the necessary buttons. The one at 35,000 yards continued to take pictures until 9.00 A.M.

d. Mach Wave and Air Velocity. The proposed photographs of a suspended primacord were not obtained owing to failure to get the balloons up from which it was to be suspended due to poor quality balloons which burst and low helium supply. Photographs of a horizontal stretch of primer cord appear to have been obtained. The primacord detonation was dimmed rather than brightened by the blast.

9. Meteorological Observations.

Meteorological observations are being continuously undertaken to obtain a good idea of behaviour in the particular location. They would be greatly assisted by the proposed installation of a teletype weather service which has still not come through.

In connection with the present test, excellent meteorological service was provided. On 23 April it was successfully forecast that 7 May would fall in a good weather period. On 3 May, successful forecast was made as to the surface wind direction, upper air flow and visibility to be expected at 4.00 A.M. on 7 May. Similar forecasts were made on 5 May, and at 5.00 P.M. 6 May which gave 4.00 A.M. and also 9 to 10.30 A.M. as operationally possible.

Temperature, humidity and wind velocities at all levels up to 30,000 feet were measured with the help of radio-sondes and radar at 1.30 A.M., 3.00 A.M. and 4.37 A.M., on 7 May, before and just after the explosion.

P. E. Church arrived in time for the test and was helpful in discussing meteorological methods and problems.

10. Health Control.

Radioactive monitoring was carried out by Hempelmann during the processes of slug solution and introduction into the pile. Monitoring after the explosion in the neighborhood was carried out by Hempelmann and checked by Anderson. The level of activity in the final crater was low enough to be safe for several hours exposure.

The dissolving unit is to be covered with fresh earth and surrounded by a guard fence.

11. Conclusion.

The test appears to me to have been successful as a trial run. In the final test, it is to be hoped that a larger proportion of the measurements will be successful, but even if this were not the case sufficient data would be provided to answer a considerable proportion of the necessary questions.

There is common agreement, among those concerned, as to the steps suggested which should be taken to insure greater success in the final test. Among these suggestions, one of the most important is that of setting an advance date beyond which further apparatus, especially electrical apparatus, cannot be introduced into the experimental area. This will allow time for plenty of dry runs, and elimination of "cross-talk". Improvement in transportation equipment and key roads should be sought. Special attention should be given to the early procurement and testing of those very important kinds of apparatus that could not be tried in the present partial test.

Richard C. Tolman

Richard C. Tolman
Vice-Chairman, NDRC

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