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# Summary of Notes on a Meeting Held at Los Alamos (U) on 25 August 1951

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## A SITE FOR A SUPER TEST

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Edited by
W. Ogle
J-Division Experiment Planning

8 September 1951

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ATTENDANCE

Harold Agnew
Hugh Bradner
Berlyn Brixner
Stanley Burriss
Clyde Cowan
Gaelen Felt
Alvin C. Graves
David B. Hall
Robert Keegan
John Malik
William Ogle
Harold Plank
Frederick Reines
Louis Rosen
Leslie Seely
Newell Smith
Edward Teller
Herbert York
Edward J. Zadina

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## A SITE FOR A SUPER TEST

### I. INTRODUCTION

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A sketch is shown in Fig. 1.

The problem was attacked in the following manner:

(1) DELETED DELETED DELETED

(2) Outline and discussion of measurements one might make on such a test.

(3) Discussion of mode of operation (i.e., ship-based, land-based, etc.) both from a logistics standpoint and in connection with the desired measurements program.

(4) Discussion of possible sites, in the light of (1), (2) and (3) above, plus particular emphasis on radiological safety.

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The time scale was not considered, however, in the discussion of the site.

### II. ESTIMATES OF SUPER PHENOMENA

#### A. Neutrons and Gamma Rays

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Both curves are the result of scaling from past measurements, taking into consideration the difference in nature of the sources.

#### B. Blast

Predicted overpressure vs distance is plotted in Fig. 4, scaled up from 100 kt.



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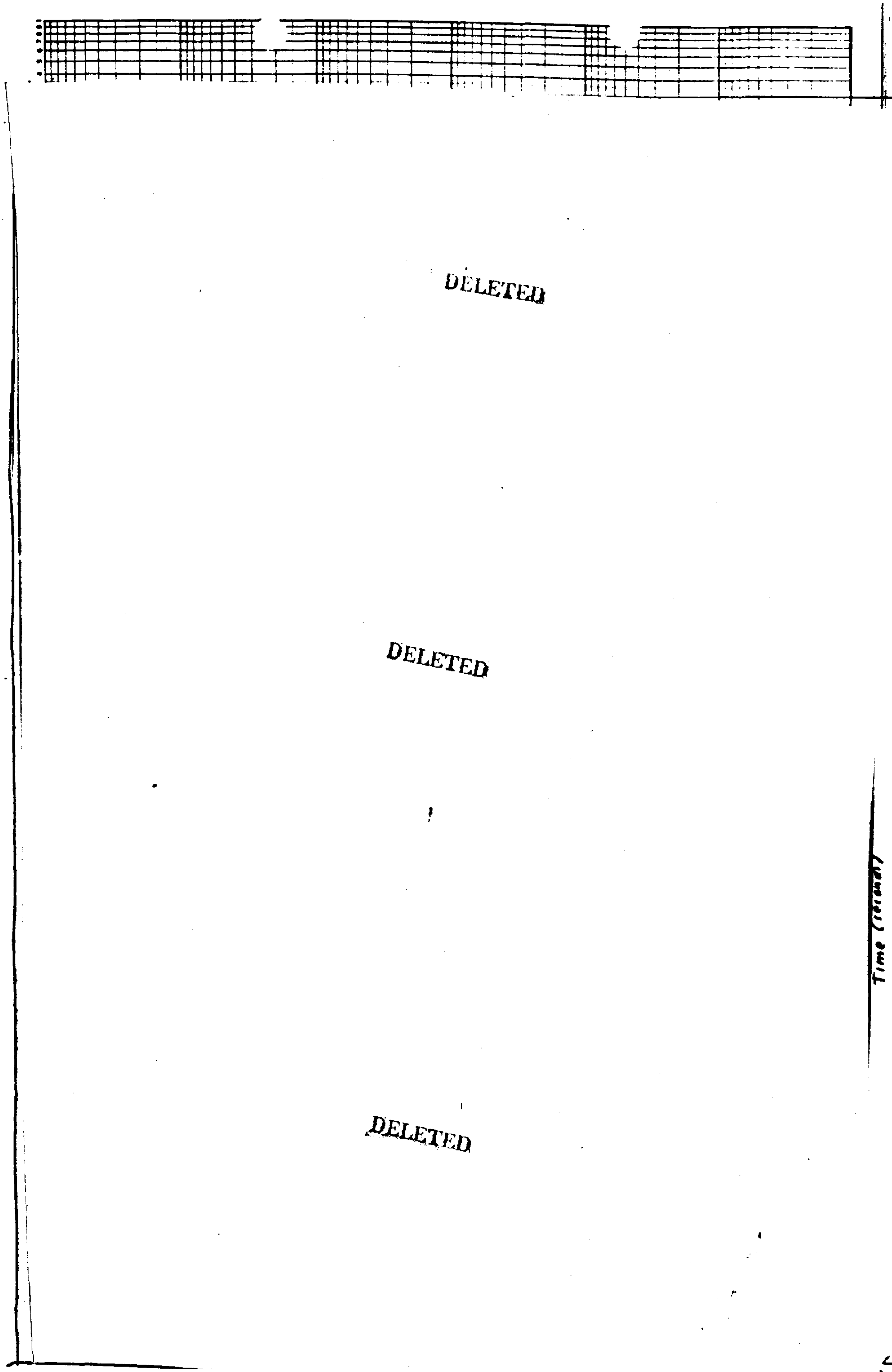
Fig. 1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Overpressure (psi)

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10 100

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Distance (miles)

C. Thermal Radiation

Table 1 presents the results of scaling from Greenhouse measurements. This assumes that 1/6 of the bomb energy goes into that portion of the thermal radiation spectrum transmitted by the air. DELETED DELETED DELETED Obviously the numbers could not be more than six times greater.

TABLE 1

Estimated Thermal Radiation vs Distance

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According to the Effects of Atomic Weapons, an intensity below 2 cal/cm$^2$ is not serious.

D. Crater

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Actually the super scaled tower height will be less than George, so the crater will be somewhat larger than this.

E. Fall-out

Table 2 presents Ogle's guesses about the fall-out, based on the assumption that the close-in activity is primarily due to neutron activation of the ground or, as in the case of George, neutron activation of the close-in ground which was then thrown out in a layer which spread over the ground surface. The values at large distances are guesses based on previous observations at those distances.

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TABLE 2

Estimated Fall-out

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Figure 5 is a plot of radiation levels vs distance (for 5 megaton fission yield) from G. Felt's fall-out calculations,* the main structure of which was based on Trinity. It is noted that predicted intensity from this graph is greater than from Ogle's estimates. This is discussed further in Section VI B.

The assumed tower height is 200 ft.

## III. POSSIBLE MEASUREMENTS ON A SUPER

Below are listed the measurements which have been spoken of as a means of assessing performance of a super bomb. They have been given preliminary consideration only, and the list is not intended as a definitive outline.

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### A. Gammas as a Function of Time

It would be hoped by a measurement of this nature to observe $\alpha$ on the first fission bomb, the time between the two primary fission reactions, and if possible the growth of the reaction. At present, it appears that Krause's NRL group would do such an experiment if done, perhaps utilizing several set-ups of the Ganex type, with the outside of the

*See Sec. C of SD-9441, Memo fr Felt to Graves, 28 Jun 51, "Jangle Fall-out Problems", for a description of the theoretical model and the assumptions used.



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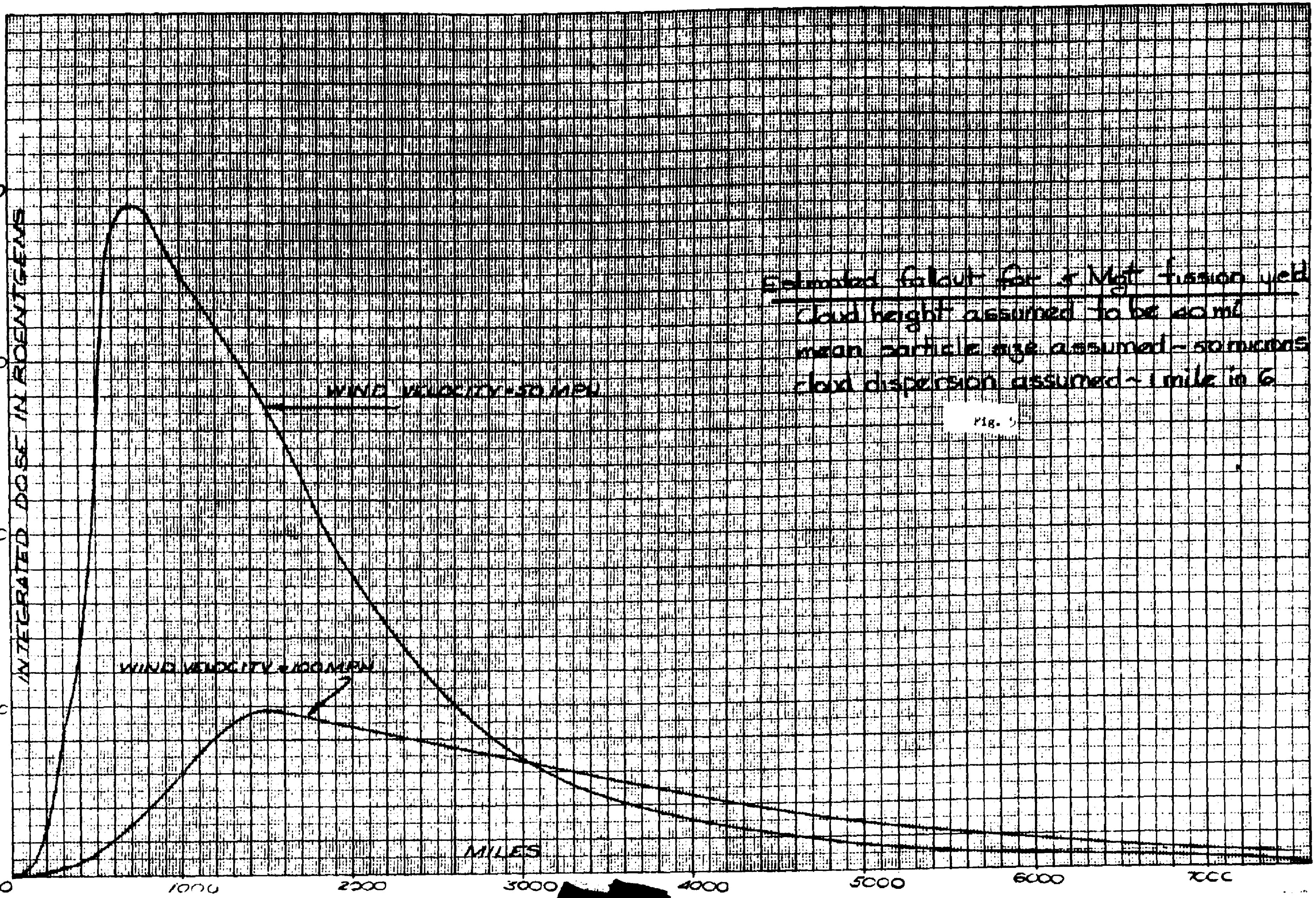


Fig. 5

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bomb itself acting as a converter and with collimators to look at three sections of the bomb. One might want to use an energy-sensitive detector. While it would give much joy to get both $\alpha$'s, the feeling at the moment is that the attenuation in the case is probably too great to follow $\alpha$ on the second bomb in anything corresponding to a constant $\alpha$ region. This is not completely clear, however; for example, if one were willing to put a large collimator and shield right next to the bomb, conceivably one could see it. (According to Teller, there is a chance that some of the sections will not be so heavy as in the original design, thus perhaps lessening the problems of attenuation.)

On the basis of predicted pressures and gamma intensities, it appears that a recording shelter would be feasible at $\sim$ 2500 - 3000 yds; this would have to be a stronger structure and with more gamma-ray shielding than in the past, but not orders of magnitude different. There is also the possibility that a remote recording scheme, using relay stations, will be ready in time. The question of cable attenuation has yet to be looked into--it is conceivable that even at 2500 - 3000 yds and with a large initial signal, amplifiers would be necessary. (Since the resolving times we are interested in here would be very much less, this may not be a serious difficulty.) Recovery of film from a close station will also be a problem.

(Teller agreed that $\alpha$ from the first bomb would be interesting, but if one uses TX-5, for example, we already know its $\alpha$.)

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B. Internal Threshold Detectors

As in the past, it is hoped to obtain an efficiency determination by radiochemical analysis of cloud samples collected by aircraft. While the difficulties may be quite serious for a super situation, as discussed below, the method is nevertheless a powerful one which will almost certainly be employed.

Site location has a bearing on the experiment only with regard to: (1) provision for reasonably situated take-off and landing bases for the sampling aircraft (a condition not hard to satisfy for almost any site or mode of operation); (2) composition of the soil or other media in connection with contamination in the sample.

The most serious difficulty as regards a super is that of collecting a sample containing an adequate fraction of the bomb from a device which blows itself apart so well. Another difficulty is, of course, the well-known one that the isotopes produced by the reaction then undergo an $(n,\gamma)$ process so that the errors in determining amount of burn-up become extremely large.



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Plank explained the first difficulty: In radiochemical analysis for efficiency, one simply determines the number of fissions which a sample represents and then, knowing the fraction of the bomb in that sample, can determine total number of fissions. It is primarily a question of background, ascertained by a chemical blank, which makes the accuracy of the determination decrease with lesser fraction of bomb in the sample. Because the size of the uranium blank of a particular sample is not known accurately, radiochemical efficiencies become increasingly uncertain as the ratio of the average blank to total uranium found increases. For this reason, samples less than $\sim 5 \times 10^{-13}$ of a super will yield unreliable radiochemical efficiencies.

Unfortunately, there appears to be a correlation between average fraction of the bomb collected and the yield which indicates that sample size follows an inverse logarithmic function of the yield. If one plots the logarithm of the average sample size, S (in terms of fraction of bomb it contains), from Greenhouse measurements vs the yield, E, the points fall along a straight line, as shown in Fig. 6.

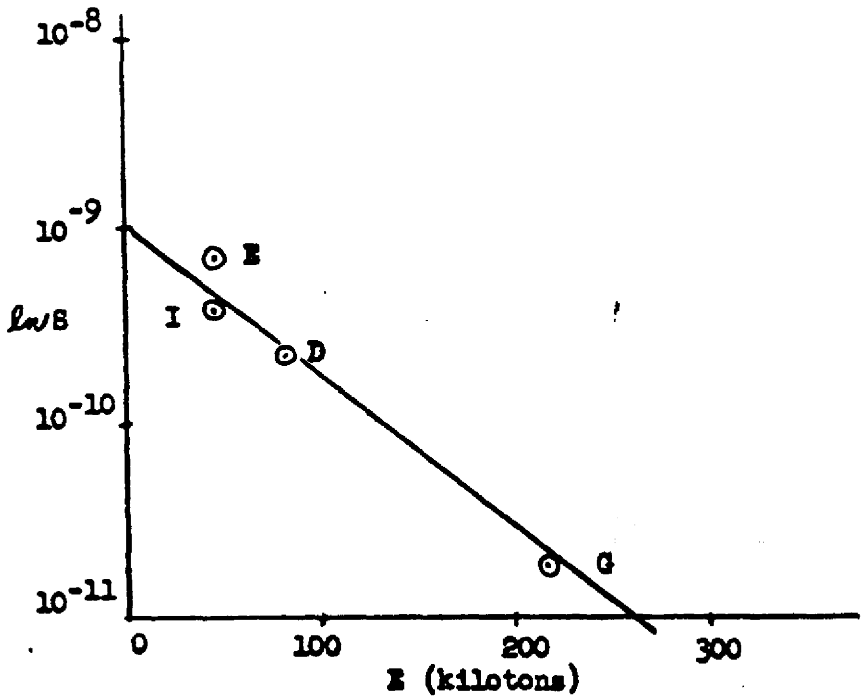


Fig. 6

Correlation Between Average Sample Size and Yield (Greenhouse)

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Reines suggested there are other factors to consider, e.g., the time the plane remained in the cloud, where it was, etc. Plank said that they have correlations on other shots--there is possibly a factor of 10, perhaps 100, to be gained by altitude, i.e., the nearer the plane is to the puff the better samples obtained (this is not to say the plane should go through the puff). Drone aircraft are difficult to control, and it is hoped to improve the situation a great deal by using manned aircraft and sampling for longer time intervals. It is also hoped to pick up a factor of $e^2$ by using better and larger collectors.

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It was suggested that, in view of the difficulties, the work on rockets should be resumed. Plank explained that the fact that super tests were contemplated was a large reason for discontinuing work on both the rockets and the filter-bomb idea: the problem of landing and recovering such devices in connection with an island or underwater shot is quite serious and waterproofing them very difficult. In addition, the temperature of the ball of fire in the early states is so high as to burn up the rockets. For example, on a 20-kiloton bomb the rockets might have been shot through the cloud successfully at 20-30 seconds; on George, they would not have survived.

C. Neutron Measurements: External Threshold Detectors<br>Nuclear Emulsion Plates

Both these experiments have difficulties which may preclude their being done: (a) the requirement for real estate and stations, (b) the intensity is a problem due to the high attenuation of the bomb parts and the fact that the detectors must be out at a great distance because of the crater size, adding an additional problem of air attenuation. Thus, the interpretation of the data, if any are obtained, will be extremely difficult.

The number of 14-Mev neutrons which come out is estimated to be somewhere between that of Item and George, which is rather small, and therefore the measurement would have to be done under the same conditions but with a much larger blast problem. (Rosen obtained good plates at 1200 yds on the George shot, but this was about the maximum distance.) Delayed neutrons should not be too much of a problem; Hall stated that 1 Mev is about the highest energy observed in delayed neutrons. Teller raised the question of delayed fissions, which might play havoc with this experiment. However, since the Phonex experiment uses collimation, it would not see a very large proportion of the bomb materials.

Another difficulty is the problem of recovery, especially in the case of the nuclear emulsion plates which must be recovered soon because of pealing in a vacuum.

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This makes observability easier but interpretation harder.

D. Photography

a. Ball of Fire

According to Reines' crystal-balling, the ball-of-fire determination may give the yield to within a factor of 2, this even if the ball of fire sits on the ground. The guess as to where one could put cameras and get this: $\sim$ 10 - 20 miles.

b. High Resolution

Purpose: to study the travel of the reaction by photographic observation of the light emitted by a series of holes in the sides of the device, the difference in time of light appearance in the holes and time of appearance on the surface being a measure of the temperature of the hydrogen.

Difficulties: (1) Do the holes close up or move before anything can be observed? (2) Can the surface be seen at all through the ionized air? (3) In order to be successful, both the camera and the bomb must be stable relative to each other because of the small field of view. (4) The fall-out problem will be somewhat serious with regard to film blackening.

According to Brixner, such photography could not be done at a distance of 20 miles because of air turbulence. He thought it should preferably be not more than five miles away, although some useful results might be obtained at 10 miles. As for fall-out at this distance, it is not believed this is an unsurmountable problem.

c. Bhangmeter

No comment.

E. High-Resolution Spectroscopy

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One might look either at the ball of fire itself or at the sun through the cloud at a later time. The experiment might be feasible at a distance of 10 - 20 miles.

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Difficulties: (1) Most of the lines do not seem to be in the right part of the spectrum (i.e., the visible or detecting range of the instrument).

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(3) NRL's Greenhouse-George records have so far given no indication of such lines.

F. Effects

This is mentioned because in all probability we shall not be able to avoid making a few such determinations. It is hoped that they can be kept to the minimum, e.g., measurements of blast and thermal radiation as functions of distance.

G. Others

In this category are included ideas which have been mentioned in a very preliminary fashion and which have received no real consideration from the practical point of view. Among them are the x-ray experiment, a suggestion by Alvarez for a temperature measurement, neutrino, neutron-neutron scattering, and electromagnetic effect experiments.

IV. MODES OF OPERATION

In Table 3 are listed the experiments of Sec III, with comments as to their feasibility as a function of the three types of operation discussed below.

A. Airplane

It has been suggested that the bomb be put in a drone plane and detonated along with the plane. At first glance, this has an operational advantage in that the bomb could be assembled in the plane at a convenient field, detonated over the Pacific with no particular worry about a site. A plane of the C-124 type has been spoken of; this can carry up to 75,000 lbs to an altitude of 10,000 ft, and could be ready within six months.

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On the other hand, as can be seen from Table 3, most if not all of the diagnostic measurements are ruled out by such an approach. Further, there is the argument that drones are quite difficult to control: there has not been an operation in the past where all functioned properly,



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## TABLE 3

**Feasibility of Experiments as a function of Mode of Operation**

| Experiment | Airplane | Ship at Sea | Land (includes ship beached) |
|---|---|---|---|
| γ (t) | Most difficult, conceivably possible. If collimation needed, undoubtedly out. | Not quite so impossible as w/plane, but still difficult. If 2 ships used, cable connection close to impossible. Again, collimation questions. | Best chance |
| Internal threshold detectors | Probably favored, since no ground contamination problem. | Not much different than in case of land -- have ship materials to consider (e.g., Fe). | Comparable with ship operation. Not so good as air. |
| Neutron Measurements: External TD's | Probably out | Clearly out -- no chance for recovering | Best chance |
| Phonex | Out because of collimators | Out because of collimators | Best chance |
| Photography<br>a. Ball of Fire | Probably favored by air | Not so dependable as for air. | Possible. No so good as air. Better if tower shot. |
| b. High-resolution | Probably out | Probably out because of ocean swell | Best chance |
| c. Bhangmeter | Probably favored by air | Not quite so dependable as for air | Not as dependable as air. |
| High-resolution Spectroscopy | Possible | Probably possible | Still possible, perhaps not so nice as with air. |
| Effects | Possibly benefited by plane fm point of view that burst ht could be made tactical + rad contam could be studied | Questionable -- perhaps could measure blast and thermal radiation from 1 or 2 points | Okay |
| Others | Probably impossible if instrumentation at all complicated | Unknown | Probably possible if desired. |

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and the odds on drone failure have been $\sim$ 20%. Since this would have to be an entirely new control system in a plane modified for the purpose, one must expect it to be even less reliable. Largely for these reasons, the idea of such an operation was dropped.

B. <u>Ship at Sea</u>

A combination of ships might be used, one with the bomb in it, another one for the instrumentation. (The idea of having the ship in a lagoon or beaching it alongside an island is regarded as essentially a land operation; it is therefore discussed in Par. 3, below.)

Again the advantage would appear to be operational, in that the bomb could be assembled on the Pacific coast, detonated almost wherever one chose. However, it is not quite that simple, since the shot must take place fairly close to land which has an air strip because of the sampling planes. It is also believed that the advantages of assembly in a West Coast navy yard have been overestimated, since this is a small part of the over-all job of conducting a test. Again, Table 3 points up the fact that most of the experiments are seriously jeopardized by such an operation. Anything which requires collimation is particularly unfortunate because of the ocean swell, and cables between the zero and instrumentation ships would present a real problem.

It is thought that the fall-out situation would not be materially changed, since the particle sizes resulting from land and ship material are probably not greatly different. One point is that an island might be saved by blowing up a ship instead, but this is not clear.

The group agreed that the advantages of a ship at sea did not outweigh the disadvantages.

C. <u>Land-Based Operation</u>

The idea of a beached ship vs a land shot was discussed at length. It would appear to be largely a matter of whether one wanted the shot at the edge of a land mass or further inland. DELETED

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DELETED Deck cranes on the Curtiss handled Rosen's collimator, which weighed 28 tons, so there appears to be no problem there. From discussions with Potts, Burriss did not think there would be additional cryogeny problems one way or another. The total amount of hydrogen for which transport capacity is planned is 9 $m^3$ (weight $\sim$ 1 ton) about 4 or 5 $m^3$ of this the maximum which will probably be used (including that for cooling), the rest essentially for safety.

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Lines of instrumentations would be somewhat restricted in direction in the beached-ship type of operation. With collimation, also, the ship would have to be beached quite early to get the collimation set, and would have to be anchored very thoroughly. Again, the location might be restricted by the requirement of a suitable beach. There is also the fact that if a tower shot is desired (some height being perhaps desirable to avoid gamma-ray scattering, etc.), it would be easier to have it on land -- a tower on a ship is possible, up to perhaps 90 ft in height, but would mean essentially rebuilding the ship.

It would appear, therefore, that a land shot presents appreciably more flexibility, advantages and ease of operation than the beached ship.

## V. FURTHER DISCUSSION OF TIME SCALES

During the discussion of experiments and types of operation, Teller reiterated that he did not wish to see a large measurements program interfere with the test's being done as soon and as expeditiously as possible. As noted above, the actual weapon assembly is a small part of the task, particularly since it appears that a large amount of welding will not be necessary. It was explained further that the operational work, the building of power plants, facilities, shelters, etc., is a large portion of the job. Asked how one might speed up the operation, Graves replied that if all one wanted to do was to detonate the bomb, listen to it and say whether it was a large or small bang, this could be done very easily; but if experiments are added, if a yield measurement by radiochemical methods is desired, for example, this slows it down; if alpha or double alpha is desired, it is slowed down a little more. If one sets a time scale this prescribes the experiments; if a certain set of experiments are asked, this fixes the time scale.

As for the experiments listed in Section III, the following is Ogle's rough estimate as to when they could be ready:

TABLE 4

| Experiment | Time Required for Development |
|---|---|
| Gammas as f(t) | 12 months |
| Internal threshold detectors | 6 months ← !!! |
| External threshold detectors and Phonex | 9 months |
| Photography | 0 |
| a. Ball of fire | |
| b. High Resolution | 6 months |
| c. Bhangmeter | 0 |
| High-resolution Spectroscopy | 6 months |
| Effects | 6 months |



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It would appear from Table 4 that if a test could be made in May of 1952, all the experiments could be done except the $\gamma(t)$. Ogle indicated that might even be possible; at least one would try to do something of that nature. Graves, Burriss and Reines thought these dates could only be realistic at a place like Eniwetok, where facilities already exist; Ogle thought they could be so for Bikini, but most of the group believed this could only be accomplished by "pouring on the coal".

VI. SELECTION OF A LAND SITE

A. The Possibilities

Eniwetok, of course, is the most advantageous from the point of view of operations. Bikini is probably next in this regard. Both may be questionably located from the standpoint of fall-out on Kwajalein and small atolls in the vicinity, in view of the unpredictability of the upper winds and the fall-out predictions presented in Section I.

A study of maps of the South Pacific and other fairly isolated regions does not reveal any striking possibilities. Little America was discussed briefly. There may be other Pacific islands under US mandate which could be suitable, but they will probably present about the same problems as Eniwetok and Bikini, and would entail some negotiating to have them turned over to the AEC.

B. Fall-out Hazards

In view of the obvious advantages of Eniwetok and Bikini, the problem of fall-out was re-examined in order to determine whether a hazard would in fact exist to Kwajalein and neighboring atolls.

Data from Sandstone as to fall-out on Kwajalein are very meager: so far as can be learned, there was fall-out, but not appreciably above background.

Dog

The Greenhouse-Easy fall-out (hodographs indicated that the material went ~ 60 miles before it fell out) gave an integrated intensity on Parry of ~ 3 r.

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It was suggested that one need not pick an unpopulated area with large radius, but rather only a sector in the direction of the prevailing winds. This is not felt to be a safe procedure, however, in view of the behavior of the upper winds. For example, there was a 360° rotation in wind direction during the George shot at Greenhouse.

In an attempt to reconcile the result of 6 r quoted above with the much larger numbers obtained from Felt's calculation, the latter was explained in detail by Felt. Since the calculations were actually done



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for the Jangle Operation, the main structure was based on Trinity, the only operation which was applicable in that case. (See the reference of Footnote 1 for a complete description of the assumptions used and procedure followed.)

The curves resulting from this calculation having been fitted to the peak Trinity intensity (the hot spot at about 25 miles), their predictions then run high at larger distances for other shots, as compared with measurements. Results also depend on the assumed cloud height and wind velocity, since these are important parameters.

A calculation made by Teller based on Trinity data and using $1/r^2$ as the fall-off with distance gave a figure of 25 r as the integrated dose to be expected on Kwajalein. Further discussion indicated that the hazard to Kwajalein would indeed not be so great as predicted by Felt's calculations.

It was Teller's opinion that a shot on Eniwetok was not out of the question, in view of the distance between that atoll and Kwajalein, if one chose a time when the wind was in the opposite direction and made advance preparations to evacuate Kwajalein. He pointed out that this is a military installation, so that evacuation would not be exceedingly difficult. As for the small atolls populated by natives, he believed that, since monitors would have to be stationed in these points in any event, they could also be evacuated if readings indicated the necessity.

As soon as it became clear that the fall-out problems were not insurmountable for an assumed shot at Eniwetok, the group agreed that Eniwetok was the most feasible site for the super.

It is not believed that a shot at Eniwetok would deny us the use of that proving ground for some serious time afterward, in view of the rate of decay of the radiation. The blast damage may not be a major problem, either. There is, of course, always the remote possibility of the shot's sending a tidal wave over Parry; it was pointed out, however, that this would happen only in the case of overcomplete success.

Bogallua was suggested as a logical site, since it is the furthest island from Parry and already has wiring facilities and the like. Probably all members of the operation would be evacuated from Eniwetok Atoll before the shot, with the exception of the firing party, necessary monitors and security personnel. It is believed that there would be no appreciable danger to people in a suitable structure at $\sim$ 20 miles.

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VII. SUMMARY OF CONCLUSIONS

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2. Eniwetok is superior to Bikini as a site, since facilities already exist there and at least six months of construction could probably be saved.

3. A shot in June, 1952 at Eniwetok is not out of the question, either logistically or from the point of view of measurements. It will require, however, that work start almost immediately and proceed rather faster than a normal pace.

4. The actual time for the operation will be settled in a Division Leaders' Meeting in September. In the meantime, J-Division will start an investigation of the logistic problems involved in a wholesale evacuation of Kwajalein; they will also do what is possible in the way of getting the measurements program started.

Notes Edited by:
W. E. Ogle/djw/ak

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