EXTRACT from VOLUME III, pages 11-89 only

SCIENTIFIC DIRECTOR'S REPORT OF ATOMIC WEAPON TESTS AT ENIWETOK, 1951

THE GREENHOUSE HANDBOOK OF NUCLEAR EXPLOSIONS(U)

PART I - THEORY

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GREENHOUSE HANDBOOK I

Los Alamos Scientific Laboratory

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INTRODUCTION

Since the Sandstone tests in 1948, considerable advancement has been made in the design of fission weapons. [redacted] Design work is advancing on even smaller systems. [redacted] The basic soundness of such advanced designs has been amply demonstrated by the five shots of the Ranger program, conducted in Nevada in January and February, 1951. It was hoped that this Handbook might contain the results of the Ranger program, but this has for the most part proved unfeasible.

Concurrently with the development of smaller fission weapons, the Los Alamos Scientific Laboratory has been advancing in its work on a Super bomb. In this field, theoretical studies have advanced to the point where the experimental study of a simple thermonuclear reaction becomes necessary. [redacted]

A full list of acknowledgments for this Handbook would read like a list of the members of the Los Alamos Scientific Laboratory. For

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the most part, material has been quoted from many sources without specific mention. Of particular value in the preparation of this volume have been the Los Alamos Technical Series and the many volumes of the Scientific Director's Report of Operation Sandstone. In addition to those whose names appear as authors of particular chapters of this Handbook, the following have given unusual assistance in its preparation in the way of advice and criticism: David B. Hall, William E. Ogle, Harris Mayer, Frederick Reines, Leslie B. Seely, and Bob E. Watt. Without their assistance, this volume could not have been written.

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Los Alamos Scientific Laboratory
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CHAPTER 1

PURPOSE OF THE TESTS

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The broad objectives of the 1951 Greenhouse test program are three in number, namely: (1) to test fission weapons of advanced hydrodynamical design with the end in view of improving our stockpile, (2) to make an experimental study of thermonuclear reactions in their simplest form, and (3) to enlarge our knowledge of the effects of nuclear weapons. The purpose of this Handbook is to outline how these three objectives will be met.

1.1 TESTS OF FISSION WEAPONS

The Los Alamos Scientific Laboratory has undertaken the development of fission weapons with external dimensions smaller than those of the present stockpile model. [redacted] These results depend, of course, on the assumption of perfect symmetry, on perfect initiation, and on our knowledge of the equation of state

of the bomb. These measurements concern themselves with the determination of air blast, neutrons, gamma rays, and thermal radiation in, as nearly as possible, their pure and undisturbed states. The second broad portion of the effects program concerns itself with the effects these "field variables" produce on objects, animate and inanimate.

The field-variable measurements consist of complete measurements of the gamma radiation, described in Chap. 4, neutron measurements, described in Chap. 5, and blast and thermal radiation studies, described in Chap. 6. The radiation studies, gamma, neutron and thermal, are quite elaborate and, if successful, will essentially complete our knowledge of these phenomena. The blast studies here to be effected are as complete as possible under the circumstances of a tower burst. They should settle the questions of the free-air pressure versus distance curves and the validity of scaling from HE to nuclear explosions.

The effects measurements include such experiments as the biomedical program, the structures program, cloud studies, meteorology, long-range detection, and so forth. These programs are briefly outlined in this Handbook in Chaps. 7 and 8.

1.4 LISTING OF THE EXPERIMENTAL PROGRAMS

In Table 1.1 are listed the experimental programs by number and a brief description of the program objectives. The descriptions of the various experimental programs given in the table are not intended to be complete, but rather to indicate their general natures.

1.5 SHOT SCHEDULE

Below is tabulated the schedule on which it is planned to fire the various shots of the Greenhouse program.

Table 1.2

Shot Schedule

Date (Tentative)	Island	Bomb Model	Approximate Yield (kt)
7 April	Runit	[redacted]	[redacted]
18 April	Engebi	[redacted]	[redacted]
9 May	Eberiru	[redacted]	[redacted]
3 June	Engebi	[redacted]	[redacted]

[redacted]

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The wind directions at the Atoll would make the order Engebi, Eberiru, Runit somewhat more advantageous, as then no cloud would pass over a future shot island. The present schedule is felt to be better in general, however, as it allows more time on the islands where the most work is to be done. Thus, conducting the Runit shot first will permit a checking of instruments and techniques before the heavily instrumented shot on Engebi is fired; it will also permit a longer time for setting up and checking the very complicated thermonuclear diagnostic experimental apparatus on Eberiru.

CHAPTER 2

DESCRIPTION OF THE MODELS

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2.1 INTRODUCTION

[redacted] The purpose of this chapter is to describe the physical characteristics of these bombs and to give the predictions of their behavior. The predictions will be given for the most part in the form of graphs which depict the results of calculations made by various sectionsof T-Division. Every member of T-Division has had a hand in these calculations at one point or another, so the author acknowledges his debt to this division as a whole rather than listing individual names.

2.2 THE MODELS TO BE FIRED

[redacted]

[1] At the time of writing the decision is not firm whether the Booster will be fired. Because this shot may be fired, we shall discuss it here.

2.3 PHYSICAL DIMENSIONS

The physical dimensions of the three bombs are given in Table 2.1. In all cases the numbers apply to the dimensions to which the bomb is made and hence describe its configuration before the detonators have fired.

2.4 OPERATION OF THE FISSION BOMBS

The Hippo calculation is a detailed numerical solution of the equations which describe neutron production and diffusion, energy production, and the radiation hydrodynamics of a nuclear reaction.

Many of the results of these calculations can accordingly be extrapolated with fair confidence to the

TABLE 2.1

Fig. 2.1

Drawing of Metal Parts

Certain selected results of this Hippo problem are presented in Figs. 2.2 to 2.12. These figures are for the most part self-explanatory.

we show in Fig. 2.2 the initial configuration of material for the Hippo problem. Figures 2.3, 2.4, and 2.5 show various aspects of the hydrodynamical expansion.

Figure 2.6 shows the alpha as a function of time.

$$\alpha_x = \frac{d}{dt} \log \text{(total number of neutrons)}$$

and

$$\alpha_I = \frac{d}{dt} \log \text{(fission rate)}.$$

In both cases the curves without points represent the results of the first run. The calculation was then repeated using shorter time intervals for the neutron equations and the curves with points were obtained. Except for the fact that the wiggles are not physically real (they have their origin in certain mathematical approximations) the curves with points indicated on them are felt to be the better representation of what happens.

Figs. 2.2 to 2.12

Selected Results of Hippo Calculation

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Figures 2.7, 2.8 and 2.9 show neutron distributions in the assembly at various times.

Curves are shown for each of these groups.

In Fig. 2.10 the way in which active material is burned up is depicted. This figure shows the fraction of unreacted material left as a function of position in the bomb for various times. Figure 2.11 shows the over-all average of this same thing, i.e., the over-all efficiency as a function of time. The curves of Fig. 2.10 could be integrated to give the relative numbers of fissions in the various regions as functions of the time. Such an integration has been performed at a time corresponding essentially with the end of the reaction.

Because of uncertainties of certain numerical data which go into t Hippo calculations, such as inelastic-scattering cross sections and the like, not all of the numerical results are correct.

Nevertheless it is felt that the results included here may of value in interpreting the results of many of the experiments of the Greenhouse program.

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Actual predictions for the weapons to be fired are listed below:

TABLE 2.2[2]

Predicted Values of Alpha, Transit Time, and Yield for the Greenhouse Models

In order to facilitate interpretation of data in the case of atypical fission reactions a series of curves have been included which give

[2] The predicted alphas and yields given here are approximate values. More reliable numbers will become available when calculations now being run are completed. but this will probably not be much before actual shot time.

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initial density distributions, neutron distributions, expected values of alpha and yield as a function of initiation time, etc. These figures are largely self-explanatory and are presented in Figs. 2.13 to 2.19 inclusive.

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Fig. 2.13

Relative Neutron Density

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Fig. 2.14

Relative Neutron Density

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Fig. 2.15

Initial Density vs Radius

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Fig. 2.16

Initial Density vs Radius

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Fig. 2.17a

Alpha vs Initiator Time

Fig. 2.17b

Yield vs Initiator Time

NOTE: Fig. 2.17b will be available ~ 1 Apr 51

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Fig. 2.18a

Alpha vs Initiator Time

Fig. 2.18b

Yield vs Initiator Time

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NOTE: Fig. 2.18b will be available ~ 1 Apr 51

Fig. 2.19

Alpha and Yield vs Explosion Time

[redacted]

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