REPORT TO THE FAMILY COMMITTEE ON THE FEASIBILITY OF THE TENEX AND FLUNEX EXPERIMENTS (u)

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This report is concerned with a survey of some of the experiments being planned and proposed for the test shots in 1951. The primary purpose of these particular experiments is first to determine whether or not the T + D mixture burns, and secondly to secure any information possible concerning the mode of burning. In addition to the experiments usually done on such tests, experiments called: Dinex, X-Ray, Phonex, Annex, Flunex, and Tenex are being considered.

A comparison between the total flux of neutrons near 14 Mev emitted by a standard bomb and one containing a T + D mixture should tell one whether or not the T + D mixture burned. Normalization and calibration of integral detectors might even enable one to tell roughly the efficiency of burning. These results can be achieved by the experiments named Annex and Phonex and certainly should be carried out. Compared with the other proposed experiments they require a minimum of instrumentation and require no time resolution.

The Dinex experiment which is being carried out is planned to give a detailed analysis of the D + T burning. It is planned to achieve this through a detailed study of the time dependence of the 14 Mev fission neutrons and T + D neutrons. We believe that it is highly desirable to have the sensitivity in this experiment so that the 14 Mev fission neutrons are observed before the T + D reaction takes place. There are two reasons for this. The first is that this experiment would then take the form of a neutron alpha experiment. This would allow one to determine the energy production as a function of time and hence the temperature of the bomb at the time the T + D mixture burns. In case of a fizzle this would be extremely valuable information. The second is that in case of a successful T + D reaction it would be very desirable to see the breakaway of the T + D reaction. [redacted]

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This experiment has two vulnerable spots. One is that a shielding factor greater than 10^6 is required and this may be difficult to achieve. Another weakness is that it requires the transmittal of a signal from the immediate vicinity of the bomb by means of cables. It is feared that the intense radiation may introduce spurious signals or short circuit the cable.

In spite of these difficulties we believe that this experiment can be the most informative experiment and should be pursued with the greatest effort. In fact, we feel that no other experiment should compete in any manner with the work done on this experiment.

In order to circumvent the possible flaws in the Dinex experiment, the Flunex experiment was proposed. It consists of a fluorescent material used as a detector and a lens system is proposed to transmit the fluorescent radiation to a distant place. At the distant station the radiation would be converted into an electrical impulse by means of a photo-tube. The distant station could be at the foot of the tower or at a greater distance if necessary.

In making this survey we have assumed that secondary experiments should fulfill certain requirements. First, the outcome of a secondary experiment should be completely independent of the main experiment. It should be, even at the price of resolution, much less complex and more certain of success. Also at this late date it should be of such a nature that very little basic research on instrumental development be required. The Flunex experiment is independent of the results of the Dinex. It needs less shielding. However it is not clear as to what the signal would represent. It seems to us that a great deal of experimental research would be necessary in order to interpret the response of the detector. The time response of the detector would be satisfactory. However reports have recently appeared which note a long-lived fluorescence which follows a very high level fluorescence.

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The problem of transmitting a light signal of the expected intensity over a distance of 100 to 800 meters is probably not impossible. However, because of the radiation present, an evacuated tube would be required.

We recommend that the Flunex proposal be dropped at this time because of the difficulty in interpreting the signal received and the instrumentation required. We would suggest that the problems of the fluorescent material and optical system, as problems, be farmed out. The understanding being that the "contractor" will do the job with no idea of actually taking part in the coming tests. If during the tests, it is found that signals cannot be transmitted by cables, then the problem should be reconsidered and a decision reached based upon the results obtained by the "contractors".

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In the event the T+D mixture does not burn it would be very informative to know to what temperature the mixture was raised by the radiation. In the event it does burn it is important to know at what temperature the reaction took place and its duration. Unfortunately, unless the reaction does go it seems impossible to measure directly the temperature of the T+D mixture. The X-Ray experiment hopes to be able to measure the temperature in the matter near the T+D mixture as a function of time. If these temperatures as a function of time agree with calculated values, then it is hoped that one will be able to deduce the temperature of the T+D mixture. If it were not for the one fact that the X-Ray experiment gives some information concerning the temperature whether the T+D goes or not, we would recommend that it be dropped in favor of the Tenex experiment. We say this because the X-Ray experiment does not directly measure what one wants to know and seems to be the most complicated and least understood of any of the "main" experiments. If the Dinex experiment worked as desired we would say drop the X-Ray experiment completely.

In the event that the T+D mixture burns it seems as though the actual temperature of the T+D mixture can be measured in the Tenex experiment by observing the natural width of the T+D neutron group. This natural width results from two causes: rate of burning and relative motion of the T+D atoms (i.e., thermal agitation).

The rough details of this experiment are presented in the following pages.

The Tenex experiment is planned to record the production of T+D neutrons. The neutrons produce recoil protons in a hydrogeneous radiator. These protons are recorded by means of an electron multiplier tube which is connected to a commercial scope. The time of flight principle dilates the time scale and gives an energy selectivity. The time dilation enables use of commercial cable and recording equipment and the energy resolutions remove the necessity of a spectrometer or absorber for the protons. It is conceivable that it might be better to use a thin stilbene crystal in conjunction with a photo-tube as a detector. However we have been told that such an arrangement is more sensitive to gamma rays than is the one proposed. We have considered a fission detector but do not think it is feasible since it is very difficult to get an amount of fissionable material comparable with the hydrogen in a radiator.

It is our opinion that the Tenex experiment as presented can be done. It is expected that detailed refinements will be added by those actually carrying out the experiment.

The intensity of the "14" Mev T+D neutrons at 100, 400, and 800 meters is obtained as follows.

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where Δt is the time interval during which the T+D neutrons will arrive at each station. The following table gives the time spread in arrival of "14" Mev T+D neutrons due to thermal agitation of the T+D mixture:

Temp. of T	100 Meter Station	400 Meter Station	800 Meter Station

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The time it takes for the T-D mixture to burn should be added to the above times.

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Also, we take a CH_2 radiator 20 mg/cm^2 as proposed for the Dinex experiment. This has an energy thickness of about 2.8 Mev for 14 Mev protons. The radiator thickness can be increased by a factor of 2 or 3, increasing its efficiency by just that amount but it does not seem necessary to do so except at the far station. It seems feasible to use a radiator of one cm^2 area and detect the knock-on protons with an electron multiplier tube of the Allen type with a collection efficiency of 50%. It is proposed to follow the Dinex experiment closely in this respect.

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In order to obtain the shape of the curve reasonably well, it is felt that a range of a factor of 10 in intensity is required. To be perfectly safe we arbitrarily extend this to a factor of 100, giving as minimum signals:

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Superimposed on the desired signals is the background due to fission neutrons, gamma-rays, and scattered neutrons. Each of these backgrounds will be taken up in turn and an estimate of their magnitude made.

The fission neutrons are most easily disposed of because of their "time absorption".

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Time of Flight Table

Neutron Energy in Mev	Neutron Velocity in Meters/Second	Δt in Shakes for 100 Meters	Δt in Shakes for 400 Meters	Δt in Shakes for 800 Meters

[redacted]

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A more troublesome background than fission neutrons promises to be produced by gamma-rays. [redacted] This peak yield held up for a time long compared with the times in which we are interested, so we shall assume it to be constant, hoping to err on the pessimistic side. It is claimed (Dinex experiment) that an electron multiplier tube has a discrimination for protons over gamma-rays of $(10)^4$. The following table

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compares the expected signals due to gamma-rays and T-D neutrons with no shielding.

[redacted]

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At the far station one should increase the radiator thickness by a factor of two or three. [redacted]

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If some collimation at the detector is not employed it is conceivable that an appreciable time broadening can be introduced by small angle elastic scattering of "14" Mev neutrons. Single and multiple scattering can introduce an appreciable increase of path length, and since a meter of path is equivalent to two shakes an appreciable time broadening could occur.

If one constructs a collimator 1/2 inch in diameter and 2 meters long then, at the 800 meter station where the scattering effect would be most important the detector sees a circle of 10 meter diameter at the tower. Except for large angle scattering taking place within 10 meters of the tower, single scattering can introduce on the average a time increase of less than one shake. Whereas, those neutrons suffering multiple scattering will amount in number to only one percent of those not being scattered. Under these conditions it is felt that scattering effects can be neglected.

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It is our understanding that there are commercial oscilloscopes available having one-half shake resolution and requiring 1/10 volt input. Even with the attenuation in the cables we believe this instrumentation to be adequate. In collecting information for this survey we found that King, Watt, and Nereson are interested in carrying out this experiment. It appears that the use of these individuals will not impair the work on the other main experiments.

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