MEMORANDUM

TO: J. R. OPPENHEIMER

FROM: B. ROSSI AND H. STAUB

DATE: October 4, 1944

SUBJECT: Notes on the RaLa Method for Observing Implosions

Notations

f_i = fractional transmission of radiation through the gadget in the initial state

f_a = same for assembled uncompressed state

f_c = same for ideally compressed state

S = source strength in curies

V = volume of individual chambers in liters

R = leak resistor of chambers in 10^3 ohms

d(x) = distance in meters of chambers from center of gadget, for which the blast wave reaches the chambers x microseconds after the initiation of the H.E.

τ = resolving time of the detecting equipment

τ_1 = time for the explosion wave to propagate through the H.E.

τ_2 = time of collapse = time from the initial acceleration of the tamper to the maximum compression

τ_3 = sitting time = time for the shock wave to travel back from the center of the gadget to the edge of the tamper (or of the inner part of the tamper, if a heterogeneous tamper is used)

(A) Possibilities and Limitations of the Method

The RaLa test, when first planned, was expected to give accurate information on the time scale of the implosion and on the compression, if a source of sufficient strength is used and a suitable scale for the gadget is chosen.

The results of the first RaLa shot have confirmed this expectation and have made it possible to determine more accurately the conditions that must be fulfilled in order that reliable data may be obtained. These conditions are listed below:

(1) The reduction of intensity from assembled noncompressed to ideally compressed state should be at least 15% of the initial intensity ($\frac{f_a - f_c}{f_i} \geq 0.15$).

This is so because the uncertainty in the exact amount of electron current and the uncertainty in the calibrations will make it impossible to measure the final intensity with an error smaller than a certain fraction of the initial intensity. It is hoped that this error may be reduced to 2%. At present, it is estimated to be close to 4%.

(2) The variation of the input voltage from assembled noncompressed to ideally compressed state should be sufficiently large to make the noise level, the statistical fluctuations and the unavoidable electric disturbances harmless. This voltage variation is proportional to $S\rho$ where S is the source strength and $\rho = \frac{VR}{d^2}(f_a - f_c)$. The present chambers (chambers #1) are 3" in diameter, 11 1/4" in length. Their volume is $V \cong 1.2$ liters. A second type of chambers is contemplated for use with small scale gadgets (chambers #2) which will be 1 1/2" in diameter, 8" long ($V \cong 0.23$ liters). The value of R is limited by the desired time resolution (see below), while d must be sufficiently large to allow time for recording the implosion before the blast wave reaches the chambers. The results of the first RaLa experiment show that for good results on compression the following condition must be satisfied.

$$\rho S \geqslant 220$$

(3) The time scale of the implosion should be sufficiently long so that the details of the phenomenon may be faithfully reproduced despite the finite inertia of the equipment. With chambers #1 and with $R \cong 7.5$ Kw the resolving time of the outfit is approximately 2 μ sec. It is estimated that with chambers #2, with $R \cong 5$ Kw, and possibly with some readjustment in the electronic circuit, the resolving time may be cut down to 1 μ sec. As a working criterion for sufficient time resolution we may take

$$\tau \leq \frac{2}{3} t_3.$$

(4) The absorption of the H.E. represents an uncertain factor, because of the difficulty of calculating its value with any accuracy after the explosion has taken place. It is therefore desirable to keep the thickness of the H.E. below a certain limit. We will establish this limit at 15 cm, for which thickness the transmission is about 54%. The above refers to systems without lenses. For lens systems the allowable dimensions must be computed in relation with the nature of the H.E. used for the lenses.

(5) Further practical limitations are set by the necessity of using a limited number of predetermined sizes for the H.E. castings, as explained in Kistiakowsky's memorandum. It is accordingly suggested that the outside diameters of the tampers be chosen among the following: 3", 6", 10.23".

(B) Suggested Experiments

The RaLa method should be used to investigate:

(1) Influence of the nature of the H.E.
(2) Influence of the mode of initiation
(3) Influence of the nature and thickness of tampers.

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Points (1) and (2) are discussed in Kistiakowsky's memorandum. Suggestions for specific RaLa experiments are set forth in Table I. The dimensions of the tampers and the thickness of H.E. were chosen as a compromise between the wishes of the theoretical department and the limitations explained in section A.

(C) Auxiliary Program

We consider imperative that the following program of auxiliary tests be conducted simultaneously with the main program, even if it involves some delay in the latter.

(1) Experiments have shown the existence of rather violent electric disturbances produced by the H.E. Methods must be found to minimize the effects of these disturbances on the detecting equipment.

(2) The simultaneous use of the RaLa and the magnetic methods is highly desirable, because of the complementary character of the information obtainable from the two methods. On the other hand, there is some indication that the magnetic equipment may interfere with the RaLa observations. This point must be carefully investigated and the interferences, if any, eliminated.

(3) Circuits for the investigation of the simultaneity of detonation must be designed and constructed, on the basis of the work already done by Titterton on this subject.

(4) As soon as Alvarez' group produces a satisfactory electric detonator, the possibility of using it in connection with the RaLa experiment must be investigated. In particular, an effort should be made to minimize the electric disturbances from electric detonators so that they can be used directly on the main charge, without intermediate primacords.

(5) A pulsed x-ray source must be constructed in order to determine the ratio of electron to ion current in the chambers under conditions approaching the actual operating conditions more closely than those obtained with the present pulsed x-ray outfit. It is contemplated to continue using the x-ray equipment for the measurement of the time resolution and for the tests on the purity of the gas filling of the chambers.

(6) The final interpretation of the results requires static measurements of absorption in composite spheres simulating the conditions which exist at various times during the implosion. These measurements should be started immediately and possibly supplemented with experiments on the spectral composition of the radiation, its degradation and scattering.

(7) Work should be started on the development of alternate methods of detection, which may reduce some of the limitations of the RaLa method set forth in section A.

(D) Concluding Remark

The above considerations refer exclusively to metal gadgets with metal tamper. We believe that the RaLa method is also well suited to the study of gas tampers and of hydride gadgets. A decision should be reached as to whether plans for RaLa observations on these types of gadgets should be started immediately or postponed until the first reliable results on the quality of the metal implosion have been obtained.

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