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H-6

19 August 1954

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Lester Machta, Chief
Special Projects Section
Scientific Services Division
U. S. Department of Commerce
Weather Bureau
Washington 25, D. C.

Dear Dr. Machta:

This is in further reply to your letter of 8 July. I have read your report with a great deal of interest and I do not think that there is any undue overlap between the two lines of attack that we are following. Enclosed is a brief report (prepared for the Castle Report) on a simplified version of our procedure. With regard to the further study mentioned in paragraph two, the following remarks on other items in the enclosure will give you a pretty good idea of what we are trying to do on the IBM Model 701 Computer.

3 (a) The initial cloud may be subdivided into any number of horizontal slices within reason. The central concentration may be any arbitrary function of altitude.

(c) a_0 may be any function of altitude.

(d) Radioactivity is normally distributed with respect to the logarithm of the rate of fall of particles. (We are currently assuming that the rate of fall of any given particle does not change with altitude.)

(e) The power law of diffusion may be taken as different from the square law. S is the total distance (instead of horizontal distance) traveled by the central particle. The ratio of S to S_0 is taken as a parameter that is independent of altitude.

Our intention is to vary these parametric quantities in order to obtain the best agreement between observed and calculated fall-out, and to assess the relative importance of the various parameters in the hope of obtaining a better simplified method that will be suitable for operational use. At the present time we are concentrating attention on the Bravo distant fall-out from Operation Castle. We will soon have to give attention to the local Castle fall-out and will then probably find it necessary to make some allowance, as you have done, for the effect of winds during the formation of the "initial cloud".

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Lester Machta 19 August 1954

I hope that we may have an opportunity to get together soon for a conference on this general problem.

Yours very sincerely,

THOMAS N. WHITE, Leader
Radiological Physics Group
Health Division

TNW/ek

Enc. Castle Rept.

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Radio-a[illegible]

A Proposed [illegible] of the Formation of Radioactive [illegible] an Atomic Bomb Cloud (Written by T. [illegible] fea[illegible]ility study)

1. <u>Introduction</u>

1.1 Recent tests at [illegible] radio-active fall-out on distant communities [illegible] ions on the use of the Proving Ground. Tow[illegible] series of shots, those who had given most [illegible] there is one factor that predominates [illegible] fall-out. This factor is the proximity of the fire-[illegible] very strong that if the fire-ball makes [illegible] fall-out will be heavy, and that [illegible] clear of the ground the fall-out will be light. [illegible] the radiation intensities from the material de[illegible] orders of magnitude greater than the [illegible] no contact. It appears that this fact[illegible] yield (except insofar as this affects fire-ba[illegible] conditions (although these are of great importance [illegible] will occur.

1.2 There is als[illegible] that some very special conditions are necessary [illegible] fall-out particle. For example, it appear[illegible] that fall from the cloud formed by a [illegible] contain radio-active material. In the opin[illegible] particles always have the appearance of [illegible] or lesser extent. Other observers have found [illegible] active and inactive particles on the basis of appearance under the microscope. However this may

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be, it is usually noticed that heavy fall-out from NPG shots is associated with considerable fusing of the earth around ground zero.

1.3 Of several methods of soil stabilization that have been tried, none has had any notable effect on the intensity of fall-out from tower shots. It seems somewhat doubtful if any satisfactory method can be found. If one could be found that would also facilitate subsequent decontamination of a tower-shot area, it would be useful even though it were relatively expensive in comparison with, for example, asphalting. The cost of full-scale experimenting in the field tests is very great.

1.4 Even if no satisfactory method of reducing fall-out from tower shots can be found, there is need for a better understanding of the mechanism of production of the active fall-out particles in order to improve the confidence of predictions. The process of gathering information from tower and ground tests is much too slow, provides little information on the effect of the most important factor - burst height - in the critical range, and suffers serious limitations on account of incomplete fall-out coverage and meteorological variables.

1.5 For these reasons there is an urgent need for a laboratory method of investigating the mechanism. It occurred to the writer that an electric arc might have certain properties enough like those of a fire-ball to be used as a tool for investigating the mechanism on a laboratory scale.

1.6 In Section 2 are set forth certain conditions that appear to be necessary in order that a laboratory model might have a chance of providing useful information. The remaining Sections are on miscellaneous topics preliminary to experimental trials. It is intended to perform some preliminary experiments within H-6. If these experiments show the method to be promising, it may be necessary to ask for assistance from other groups, e.g. for high-speed photography.

It is the writer's opinion that if the method [illegible] give useful results, it should be pursued vigorously on a co-operative basis.

2. <u>General Similarity Requirements - [illegible]</u>

2.1 In order to have an instructive [illegible] model, it appears that the following conditions must be met:

a. The "fire-ball" [illegible] of a sandy surface with which [illegible] in contact for a [illegible] of the order of a few seconds.

b. The production of the "fire-ball" [illegible] sufficiently sudden and violent so that [illegible] up, and sucked up towards the "fire-ball" [illegible] does not contact the surface. This is needed to [illegible] the "air-burst" phenomena.

c. The "fire-ball" [illegible] finely dispersed radioactive material [illegible] attachment to [illegible] under unknown conditions, [illegible] conditions.

d. The "fire-ball" [illegible] then rise quite rapidly, without excessive dispersal. When [illegible] as to contact a dusty surface, it must carry a perceptible [illegible] of dust up with it. It is not essential that it should be [illegible] of carrying up particles as large as [illegible] size), but it should be able to carry [illegible] enough to fall back to the "ground" in a [illegible] (preferably less than one hour). This [illegible] possible to distinguish "fall-out" [illegible] by condensation or adhesion on the surface.

e. Other conditions [illegible] addition to the above. Some similarity in the relationship of [illegible], energy, and volume, with time, may be needed. However, it seems that there is not much chance of producing a useful [illegible] tool [illegible] the first four conditions can be met.

3. Consideration of Thermal Shock

For elevation [illegible] thermal [illegible] arrival of the blast wave, we need to deliver [illegible] cal/cm² in [illegible], where h is the height of the fire-ball above ground, [illegible] the [illegible] velocity over this distance.

Radiation rate [illegible] $\sigma T^4 (r/h)^2$ [illegible] EAW p. 18[illegible])

$$q = \frac{\sigma}{h^2} \int^{[illegible]\, h/v} [illegible]\, T^4(t)\, r^2(t)\, dt$$

If we assume T const at [illegible] $^{\circ}$K, [illegible]

$v = 3 \times 10^4$ cm/sec [illegible] value) [illegible]

$$q = \frac{\sigma}{h^2}\, [illegible]$$

$$\frac{r^2}{h} = \frac{10\,[illegible]}{\sigma T^4}\, [illegible] \approx 5000 \text{ cm.}$$

Under these assumptions, [illegible] before the shock arrives.

We need to consider [illegible] can exceed 3×10^6

T	$10^{-12}\ T^4$	[illegible]	[illegible] $\times 10^{[illegible]}$
10^4	10^4	[illegible]	10^4
2.10^4	16.10^4	[illegible]	[illegible]$.10^4$
5.10^4	6.10^6	[illegible]	6.10^5
[illegible]$.10^4$	2.5×10^7	[illegible]	[illegible]$.10^6$
12.10^4	2×10^8	[illegible]	[illegible]$.10^6$
30.10^4	8×10^9	[illegible]	$8 \times 10^{[illegible]}$

Apparently a temperature of the order of 10^5 $^{\circ}$K [illegible] needed.

(from EAW)

Further, it appears that [illegible] thermal [illegible] of 10 cal/cm² can occur only under circumstances where the fire-ball [illegible] the ground. From EAW:

Distance (m)	[illegible]/cm² in 10^{-3} sec
1	$10^{[illegible]}$
10	$10^{[illegible]}$
100	10

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If d is the diameter of a particle in [illegible] then the elevation in temperature from 10 cal/cm² is of the order of $10^{[illegible]}$/d [illegible]. It appears that particles less than ~10 μ could be melted.

4. <u>Notes on Arc Requirements</u>

4.1 Suppose that an arc [illegible] produced by the discharge of a condenser thru an otherwise non-resistive circuit.

Energy discharged = 1/2 CV^2 joule

$= \frac{[illegible]}{[illegible]} CV^2$ cal

If 1% is radiated, the energy /cm² at a distance r cm is

$\frac{1.2 \times 10^{[illegible]}}{4 \pi r^{[illegible]}} CV^2$ cal/cm²

$\approx 10^{[illegible]} \frac{[illegible]}{r^{[illegible]}}$

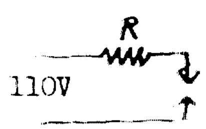
To get 1 cal/cm² at [illegible] distance [illegible]

CV^2 [illegible]

e.g. 1 farad charged to [illegible] volts.

<u>[illegible]</u>

4.2



Arc [illegible] sec. [illegible] (from Finkelnberg) 30 amp, 55 volt, giving [illegible] 1600 joule, [illegible] $4 \cdot 10^{[illegible]}$ cal in radiation [illegible] distance.

This should [illegible] for a first try.

4.3 <u>High-current carbon arc references</u>

Finkelnburg, J. App. Physics 20, [illegible] describes steady state characterist as compared with low-current arc. [illegible] characteristics.

Phys. Rev. 83, 253 (1950) Measurements to complete the theory.

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4.4 Initiation of Arcs

Brit. J. App. Physics [illegible], 371 (195[illegible]) gives a starting circuit, somewhat complicated, useful for [illegible].

5. Alternative Method

There may be some advantage in using an exploding wire (fuse effect) instead of an arc. It would seem that, for a given temperature attained (well above the boiling point of the metal) the energy [illegible] into shock might be greater. The intuitive argument favoring this view is that, with a given volume to start with, the final high temperature volume of the metal would be greater simply because the initial mass would be [illegible] 4 times greater. A larger "fire-ball" would be produced from the same [illegible] volume of energy. Also the fuse method would ensure that the [illegible] would be rich in metal from the earliest stages. In fact if the energy [illegible] be pumped in fast enough, the mechanism might be much more analogous to the bomb fire-ball growth mechanism.

Did Kapitza publish [illegible] exploding wires by short-circuiting big generators? Look up some of the references given by 621.3178 L37e on fuse theory.