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MEMORANDUM TO DR. JOHN VON NEUMANN

SUBJECT: Effects of Large Yield Thermonuclear Weapons Upon the Climate of the World (U)

1. In the fall of 1952 and 1953 the effects of large yield weapons upon the climate of the world were studied. (See inclosures 2 and 3). Since that time, however, additional information has been obtained from atomic test operations, especially from the study of radioactive fallout (see inclosure 4), which may throw some additional light upon this same subject. I have summari below for your ready reference my present thoughts on the effects of nuclear detonations upon the climate of the world:

a. It is believed that if a total of 500 to 5000 megatons are conta burst on dry land or underground, the solar radiation reaching the earth may reduced by 10% (this refers to the 3000 to 7000 Angstrom region of the solar spectrum). The bombs must be in the yield range of from 10 to 200 megatons e The use of 50 to 100 MT bombs would enhance this effect. If the yield of eac bomb is very much less than 10 MT the majority of the particles would remain the troposphere or in the lower stratosphere thus producing a more transient effect. For yields from 50 to 100 MT, a substantial portion of the cloud wil be above 80,000 ft, and the maximum height may go above 150,000 to 200,000 ft thus producing a more permanent effect. [redacted]

2. The following calculations indicate one of the methods used to arriv at the above-mentioned conclusion on the number of megatons required to produ an effect on the world climate:

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a. The specific activity of the fallout from surface burst weapons found to be 0.1 to 0.5 curies per gram extrapolated to the reference time of hour after bomb detonation. At this same reference time, it is assumed that total residual activity of the first shot of CASTLE Test Operation (14 MT tot yield, [redacted] was [redacted] It is believed that 75 to 85 percent of the residual activity of the bomb fell out within 24 hours after s time (see inclosure 4). This means that the total weight of matter in the at cloud due to fission products, bomb material and crater material was in the r of from 6×10^{12} to 3×10^{13} gm. This appears reasonable since it is believe that the CASTLE Bravo crater represents a mass displacement of approximately 1×10^{15} gm. It is believed that the crater dimensions are accurate within a factor of 2.

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b. Information available from Merrill Eisenbud of the NY Operations Office of the AEC shows that approximately [redacted] of the total activity of the IV Mike or CASTLE Bravo shots could be found throughout the world due to long te fallout. This means that [redacted] of the total activity of the bomb remains aloft. It is therefore believed reasonable to assume here that at least 5% o the soil debris sucked into the cloud remains aloft in the stratosphere. This means that 3×10^{11} to 1.5×10^{12} gm of finely divided soil debris remains al in the stratosphere from each 15 MT bomb surface detonated on dry land. Incidentally, this represents approximately 0.0015 to 0.0003 of the total material displaced by the crater. There is some evidence that the distribution of particle radii at such heights (above 60,000 ft) is in the order of 0.5 (see page 2, Incl 2).

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Incl #1

c. According to Tables I of inclosures 1 and 2, approximately 2×10^{25} particles are required in the stratosphere with radii of 0.5μ to reduce insolation by 10% when the sun is at the zenith. This represents 3×10^{13} gm of finely divided dust and soil debris in the stratosphere. Our calculations in paragraph b above showed, however, that each 15 MT surface detonation introduces more or less permanently into the stratosphere 3×10^{11} to 1.5×10^{12} gm of finely divided soil debris. This means that 20 to 100 bombs of 15 MT each are required to reduce insolation by 10% for the case when the sun is at the zenith. As indicated on page 19 of inclosure 3, changes in the solar zenith distance reduce the insolation excessively. Hence, for the average zenith distance of the sun in our latitudes, the insolation may be reduced by 20% or greater for the above mentioned amounts of stratospheric dust. However, there is another effect which works in the opposite direction, and this is the scatter of solar radiation which may be predominantly in the forward direction, especially for particles in the size range of the wave length of light. This would require the presence of more dust aloft. For this reason we assume that the above-mentioned number of required bombs should be increased by a factor of 2. Hence, 40 to 200 bombs would now be required if the yield is 15MT. Therefore, a total of 600 to 3000 MT would be required to reduce insolation by 10%. It should be noted that by "SUNSHINE" estimates at least 25,000 MT would be required in order for the world population to reach the Strontium 90 tolerance level for the world population. Thus the climate effect may precede the carcinogenic effect.

d. It should be noted that if the bombs are exploded in the air, there will be very little dust kicked aloft into the stratosphere. Therefore, the above calculations apply only to surface and subsurface shots on dry land. It is not clear what type of effect shots over water or under water would have upon the climate of the world. My present discussion applies only to the effect produced by soil particles.

e. Finally one may be permitted to conjecture that if there is the appearance of a blue sun due to uniformly distributed, submicron stratospheric dust, the probability may be high that an effect will be produced in the hemispheric or world surface temperatures. If the dust remains in the stratosphere essentially unchanged in concentration for a long period of time (1 to 10 years), it may be worthwhile to look for the beginnings of a moderate ice age. [redacted]

3. This memo classified SECRET-RD in accordance with paragraphs 23b and 56, AFR 205-1.

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