APPENDIX B

DETECTION OF HIGH ALTITUDE TESTS

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No experimental evidence exists so far on the effects of atomic weapons tests at very high altitude (100,000 feet or more). Two tests will be made during the HARDTACK Series, one at 125,000 and one at 250,000 feet. It is not certain whether these tests will succeed because they require the successful firing of the rocket containing the atomic weapon to be tested, followed by proper fusing of the weapon itself in an unusual environment. If the tests are successful, we shall have a good deal of experimental information on the effects of high altitude explosions although much more will be required for complete knowledge. For the present, we must rely entirely on theoretical calculations, and even these are far less accurate and complete than they could be made if more time were available. Some of them in fact are estimates rather than proper calculations, and all of them should be regarded with caution until confirmed experimentally.

In spite of these uncertainties, it is already clear that there will be a number of easily observable and characteristic effects on the ground if stations are available within a reasonable distance (500 miles, say) from ground zero, [redacted]

If satellites are available, equipped with appropriate observation equipment, observation and identification of high altitude nuclear tests will be easy.

I. Effects on the Ground

The following effects of a high altitude test are predicted; there probably will be others as well.

1. Electromagnetic Signal. [redacted]

2. Radio and Radar Blackout by X-Rays and γ-Rays. At distances up to about 600 miles in all directions from the test, the air will be strongly ionized by the X-rays from the bomb. This will lead to a blackout of the reflection of electromagnetic waves from the ionosphere which is normally observed for frequencies up to 1-10 megacycles. The blackout will last for a few minutes and can be observed either by means of direct vertical ionosphere echoes or by means of beams from one station to another. In combination with the EM signal under 1, it identifies nuclear tests at high altitude rather uniquely.

This blackout effect will be strong for tests from 200,000 feet up, including those conducted above the atmosphere. It will be observable down to about 70,000 feet test altitude. (At the lower altitudes the ionization is mainly due to γ-rays rather than X-rays.) It is slightly sensitive to yield.

3. Radar Blackout by Fission Product Cloud. The fission product cloud, through its γ-rays, will cause much stronger radar blackout than the direct X-rays and γ-rays from the bomb, but only in the direction in which the cloud travels. Blackout of radar reflection up to several hundred megacycles for some minutes is predicted, and for 1-10 megacycles the blackout will last for many hours or even days if the radar beam intercepts the cloud. The rate of spread of the cloud at the very high altitudes involved cannot be predicted at present. [redacted]

The γ-ray activity of the cloud is proportional to the fission yield so that this blackout effect is strongly dependent on yield. It will certainly be strong for altitudes between 100,000 and 300,000 feet. At still higher test altitudes, the effects may either be greater (Argus effect) or smaller. Between 50,000 and 100,000 feet the blackout effect will still exist but will extend over a smaller area at any time.

4. Acoustic Signal. This signal will be of long period (over 100 seconds), and of similar strength as the long-period signal from a surface burst. [redacted] The short-period signal observed for ground shots will be very weak.

5. Seismic Signal. There may be a long-period, seismic signal which might be observable.

6. Light. At 500 miles distance, the light from a one-megaton bomb in the first millisecond will be about 20 times stronger than direct sunlight in one millisecond. This is so provided the bomb is in the direct line of sight. At 500 miles, this implies a test height of at least 200,000 feet, for smaller height the light is observable only at smaller distance. Within the horizon, the light can be observed even if there is cloud cover. It can be used to determine the yield.

7. Argus Effects may be observable, especially for explosions above 400,000 feet.

II. Effects Observable in a Satellite

About 10 satellites, in suitably spaced orbits about 1000 miles high, could keep the whole earth under surveillance. [redacted] The light could be observed for any height of detonation down to sea level, and could serve as a measure of yield, with the altitude deduced from a combination of light with gamma-ray and neutron intensity. From explosions above 200,000 feet, appreciable X-rays would also be received. There could be further effects due to the Argus phenomena, and these might be even larger and of much longer duration.

III. Importance of Effects Tests at High Altitude

In the foregoing it has been shown that high altitude is not a good place to "hide" a weapons development test. On the other hand, the phenomena at high altitude are themselves very interesting for military applications, and some consequences for civilian communications. Only rather fragmentary knowledge on these phenomena will exist after HARDTACK even if the tests are successful, especially because there has not been enough time to prepare instrumentation for the tests. It therefore seems important to conduct further high altitude tests even if these are not directed toward weapons development. A moratorium might provide for such tests to be carried out with stockpile bombs.

Among the important problems are (1) Project Sunlamp, i.e. emission and propagation of nuclear radiation from the weapon, (2) electromagnetic, visible light and X-radiation, (3) heat and shock waves, (4) radio and radar blackouts, (5) disturbance of the ionosphere and the ozone layer, (6) the fission product cloud and the radar blackout produced by it, and (7) the Argus effects.