In addition to several crystals grown via the transition of solid I to II, three crystals of benezene II were grown in the diamond cell from the melt at approximately 315°C and ~30 kb. They were cooled to room temperature, and x-ray data were collected on each crystal. Although the cell parameters were identical, each crystal gave data inconsistent with that from the crystal grown from the solid state. Specifically, $h0l$ reflections with l-odd were present—an apparent violation of the extinctions of the space group, $P2_1/c$, assigned to benzene II. Moreover, the diffraction patterns showed an apparent *mmm* symmetry.

In benzene II, the three reciprocal vectors ending at the nodes—001, 010, $20\bar{1}$—are perpendicular to each other to within experimental error. These vectors define an end-centered cell with orthorhombic metric symmetry (Fig. 11). These facts can be explained if we assume that benzene II, when grown from the liquid, is twinned by pseudomerohedry. In Fig. 11 the twin mirror plane is indicated by a dashed line, and it contains b^* and the $20\bar{1}$ reflection. With this mirror, the $h0l$ reflections with l-odd can be generated by reflection from the $h0l$ reflections with l-even. Thus the 100 lattice node reflects into the $10\bar{1}$ node. If the two individuals of the twin are present in nearly equal quantities, apparent Laue symmetry *mmm* would be generated. Twinning was not observed in the crystals grown by the transformation from solid I to solid II. In this case, the cell parameters—at the temperature and pressure of the transformation—may deviate sufficiently from a metric orthorhombic lattice so that the probability of twinning is reduced.

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Underground Nuclear Explosions and the Control of Earthquakes

Abstract. *Underground nuclear explosions trigger significant earthquake activity for at least 32 hours afterward and to distances up to at least 860 kilometers. The proposed Amchitka test may be used to study the feasibility of employing high-yield underground nuclear explosions to release stresses accumulating in the lithosphere. Periodical explosions along active fault zones may be used to prevent disastrous earthquakes.*

Among the numerous events recognized as trigger mechanisms for earthquakes, only two can be attributed to the activity of man—underground nuclear explosions and the injection of fluids into deep wells (*1–3*). The association of earthquakes with underground nuclear explosions has been explored in some detail during the past 2 years.

In an examination of records from the University of Nevada's seismographic station network, Boucher *et al.* (*2*) found that large underground nuclear explosions produced a temporary but significant increase in the seismicity of the surrounding region to a degree dependent on the size of the blast. For explosions of magnitudes equal to or greater than 5.0, a substantial increase in activity occurred for at least 1 day following the test. This activity was confined to an area with a radius of about 20 km around the shot point, with a single exception possibly influencing activity to a distance of 40 km. The earthquakes related to nuclear tests were of small magnitude and always at least 1 magnitude unit less than that of the associated explosion. Attempts to ascertain distant effects of these tests indicated that they are probably minor compared with normal variations in seismicity.

Table 1. Total number of earthquakes at 8-hour intervals after each explosion.

Elapsed time (hr)	Earthquakes (No.)
0–8	67
8–16	42
16–24	56
24–32	63
32–40	38
40–48	36
48–56	42
56–64	43
64–72	26
72–80	27
80–88	35
88–96	32
96–104	37

Ryall and Savage (*3*) studied the seismological effects of the 1.2-megaton Boxcar underground nuclear test of 26 April 1968. They recorded thousands of aftershocks within a 6-week period following the explosion, the aftershocks being restricted to an area 12 by 3 to 4 km and to a depth of 12 km. Most of the aftershock hypocenters were found to lie within 5.5 km of the surface, which is shallower than the hypocenters of natural earthquakes in the Nevada region.

We have compared the list of the Nevada underground explosions from 15 September 1961 to 29 September 1966 with a list of earthquakes occurring within 860 km of 37°04′N and 116°15′W, which is roughly at the center of the Nevada test site (*4*). The explosions and earthquakes within the region and time interval considered totaled 171 and 1109, respectively.

The earthquake list was examined over thirteen 8-hour intervals after each explosion. The expected number of earthquakes in any 8-hour interval, assuming randomness, is 0.2062. The expected number of earthquakes in each 8-hour interval for all explosions, again assuming randomness, is 0.2062×171 or 35.26. The observed numbers for thirteen 8-hour intervals following each explosion are shown in Table 1. Under conditions of randomness, the numbers of Table 1 should be normally distributed around the mean of 35.26 with a standard deviation of $\sqrt{35.26}$ or 5.94. Table 1 shows that this is not the case, the first four numbers averaging almost 4 standard deviations above the mean. It is clear, therefore, that underground explosions trigger earthquakes up to about 32 hours afterward. The data available to us show that in the 32-hour interval after the explosions there were 228 earthquakes, or an increase of about 62 percent over the expected number of 141.

By dividing the area under consideration into several annuli and by comparing, within each annulus, observed versus expected number of earthquakes, we have verified that the seismic effect of the explosions extends to the 860-km limit of our search. It may still be noticeable at greater distances.

While it is clear from the available evidence that man can affect earthquake activity, Carter (*5*) reports on conflicting views and feelings among scientists, engineers, and politicians regarding the proposed underground nuclear test at Amchitka Island, Alaska. There is some concern that this test may trigger an earthquake as disastrous as that of 1964 and some propose to limit underground nuclear tests to low-yield systems or to ban them altogether.

It would seem to us that properly spaced and properly timed deep underground nuclear tests could be used, possibly together with previous fluid injection in appropriate quantities, to release stresses in the lithosphere and therefore limit the severity of earthquakes. Stress in the lithosphere is built up by convection in the upper mantle, energized mainly by radioactive decay. It is to be expected that the longer the stress builds up, the more severe will be the earthquake activity releasing it. If so, it might be convenient to place a number of high-yield (1 to 10 megaton) nuclear devices in deep (3000 to 5000 m) wells appropriately spaced (20 to 50 km) along an active fault zone and release the accumulated stress by activating the de[illegible]. [illegible]his procedure could then be [illegible] [illegible]t appropriate time intervals [illegible]5 [illegible]rs), thus preventing large [illegible] accumulation and disastrous earthquakes.

The proposed Amchitka test provides an excellent opportunity to evaluate our suggestion, if the nuclear device will be placed at sufficient depth and if the test were to be followed a few months later by a second identical test at the same location and depth. If nuclear devices have indeed a potential for earthquake activity control, the second test should trigger much less activity than the first one.

While the western end of the Aleutian Island Arc appears to be an excellent laboratory to test the feasibility of using nuclear devices for earthquake control, actual application should exclude all inhabited seismic areas which have been free of major earthquakes for 25 years or more and should be initiated in areas recently (less than 10 years) affected by major seismic activity. It should then be continued at appropriate time intervals (10 to 25 years).

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Atmospheric Temperature: Successful Test of Remote Probing

Abstract. *The Nimbus III satellite carries the satellite infrared spectrometer (SIRS). It measures the radiance of the earth and the atmosphere in seven narrow spectral intervals in the 15-micrometer carbon dioxide band and in one interval of minimum absorption at 11.1 micrometers. Seven simultaneous equations are solved to obtain the vertical temperature profile; the eighth measurement is used to determine the boundary condition (cloud or surface temperature). Results agree with those obtained from conventional radiosondes.*

The launch of the Nimbus III satellite 14 April 1969 has introduced a new era in the application of satellites to meteorological observations. The satellite infrared spectrometer (SIRS) has measured infrared spectral radiances from which temperature profiles have been retrieved.

The proposals of King (*1*) and Kaplan (*2*) pointed out that one might infer the temperature structure of the atmosphere from measurements of the earth's radiance in the absorption band of carbon dioxide centered at 15 μm (*3*). The SIRS was designed to measure simultaneously the radiances in the vertical direction from seven narrow intervals in the carbon dioxide band and in one interval in the 11.1-μm window (Table 1). The field of view is approximately a 200-km square and the radiances are sampled every 8 seconds.

The device is a conventional diffraction-grating spectrometer with special detectors (*4*) and electronics (*5*) for each channel (*6*). Included in the design is a means of checking the instrument's calibration in orbit. A zero-signal measurement, an internal blackbody radiance measurement, and a wavelength test are provided in sequence. Satisfactory calibration was accomplished each 32 minutes during the first week in orbit, and thereafter each 256 minutes.

The response calibrations before flight were standardized against the Canadian National Research Council low temperature blackbody (*7*). The absolute accuracy of the earth radiance measurements is believed to be ± 2 erg $\sec^{-1}\mathrm{cm}^{-2}\mathrm{sr}^{-1}\mathrm{cm}$. The measurements compare within about 1 erg $\sec^{-1}\mathrm{cm}^{-2}\mathrm{sr}^{-1}\mathrm{cm}$ with those made by the Nimbus III infrared interferometer spectrometer (IRIS) (*8*). The relative accuracy between simultaneous measurements in the various spectral channels appears to be better than 0.5 erg $\sec^{-1}\mathrm{cm}^{-2}\mathrm{sr}^{-1}\mathrm{cm}$. Standard deviations of the zero and the internal blackbody radiance measurements were less than [illegible] erg $\sec^{-1}\mathrm{cm}^{-2}\mathrm{sr}^{-1}\mathrm{cm}$ after the launch.

The method of reducing the data was discussed by Wark and Fleming (*9*) and by Twomey (*10*). Subsequent efforts have substantially improved the interpretive schemes.

In brief outline, the derivation of a vertical temperature profile for cloudless areas involves the solution of the integral form of the radiative transfer equation,

$$I(\nu_i) = B[\nu_i,\ T(p_s)]\ \tau(\nu_i,\ p_s) - \int_{1}^{\tau(\nu_i,\ p_s)} B[\nu_i,\ T(p)]\ d\tau(\nu_i,\ p), \quad (1)$$
$$i = 1, \cdots, 7$$