Effect Of High-Altitude Nuclear Explosions On H.F. Communications

BY PERRY I. KLEIN*, K3JTE

Results of the July 9th, 1962 Johnston Island Tests

DURING the summer and fall of 1962 the United States exploded several nuclear devices in the ionosphere above Johnston Island, which is located in the Pacific Ocean, about 750 miles southwest of the Hawaiian Islands. With the support of the International Business Machines Corporation, the Naval Research Laboratory, the Moore School of Electrical Engineering, and Haverford College, short-wave receiving stations were set up in Bethesda, Maryland and in Yeadon, Haverford, and Philadelphia, Pennsylvania. These stations were equipped with high-frequency receivers and with strip-chart recorders, to monitor the signal strength of several broadcast stations transmitting from locations in the Pacific. The transmitting stations monitored included Radio Australia on 7190, 9570, 11710, 11740, and 11810 kc; Radio New Zealand on 15280 kc, Radio Japan on 11725 kc, a station in the Philippines on 12736.5 kc, and WWVH in Hawaii on 5000 kc. The object of this monitoring experiment was to investigate the nature and extent of high-frequency radio propagation phenomena associated with the Johnston Island high-altitude nuclear detonations.

Selection of Monitored Stations and Instrumentation

Radio Australia (Melbourne) was selected as the station of primary interest for several reasons. First, a great circle propagation path between Melbourne, Australia, and Bethesda, Maryland, is only a few degrees from the point at which the nuclear explosions take place. Second, Radio Australia transmits during the time at which the explosions were to occur. Third, Radio Australia transmits on several frequencies, thus enabling frequency-selective phenomena to be observed. The other stations selected (*viz.*, Radio New Zealand, Japan, Philippines, and Hawaii) were chosen to indicate the general propagation conditions in the Pacific area, to investigate the effects of a nuclear explosion on propagation over great circle paths

*Moore School of Electrical Engineering, The University of Pennsylvania, Philadelphia, Pa.

Fig. 2—Strip chart showing the reception of Radio Australia on 7190 kc.

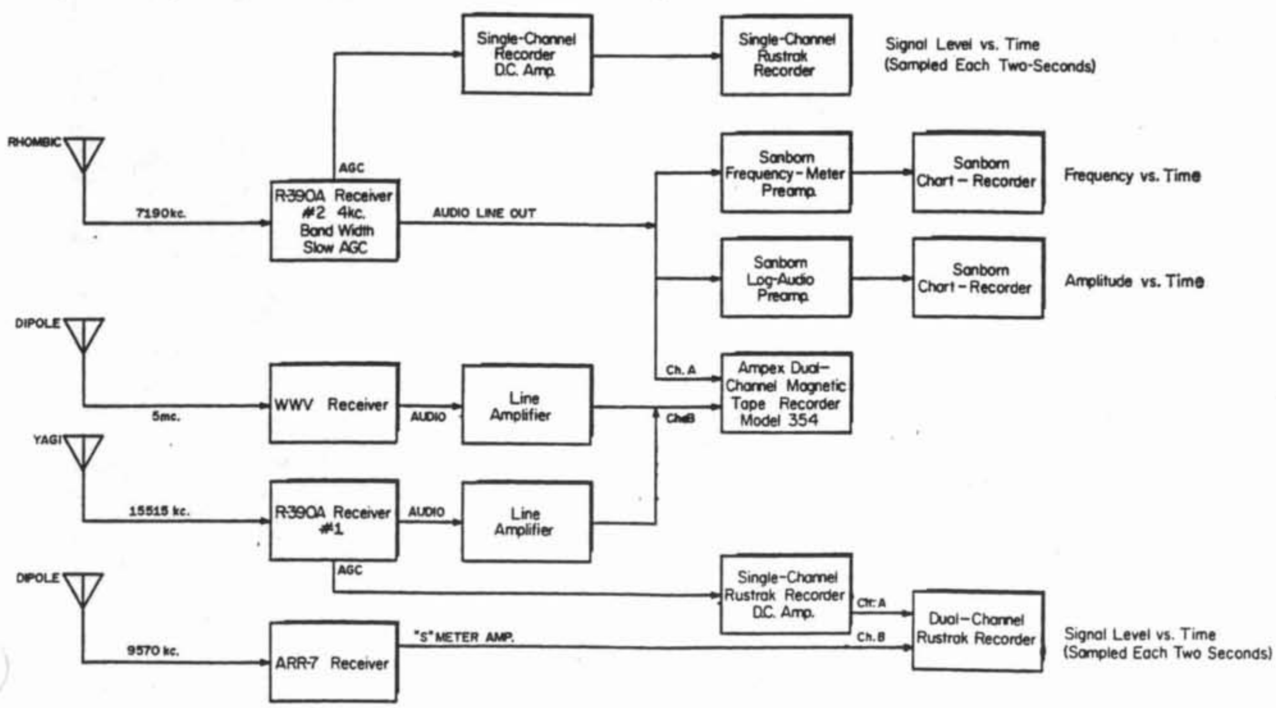


Fig. 1—Simplified diagram of the equipment used at the IBM Communications System Center in Bethesda, Maryland, to monitor Radio Australia.

which are far from the test area, and to investigate the possibility of ionospheric disturbances which might occur at magnetic conjugate points.

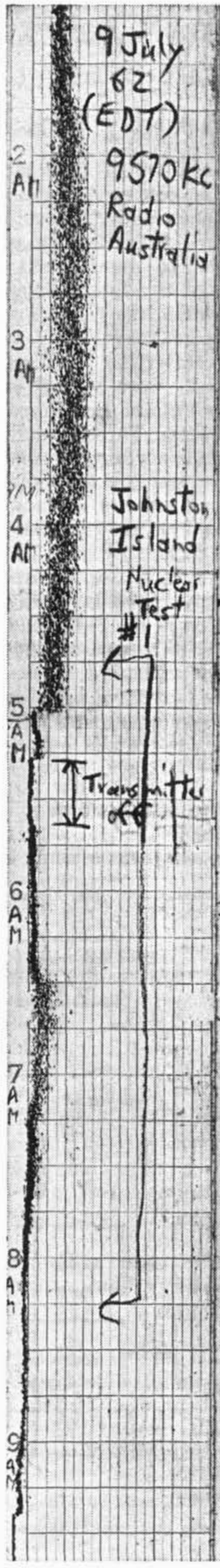
The instrumentation consisted of h.f. receiving equipment, with a.g.c. voltage monitored on strip-chart recorders which sampled the a.g.c. voltage every two-seconds. At one installation (fig. 1) one channel of a two-channel magnetic tape recorder was used to record the audio signal of Radio Australia beat against a beat-frequency oscillator. The second channel recorded audio time signals from a WWV/WWVH receiver and also the transmitted countdown for the nuclear tests. One channel of a two-channel Sanborn Strip-Chart Recorder monitored the amplitude of the Radio Australia beat-note. The second channel measured the frequency of the beat-note. Dipoles, end-fed long wires, a rhombic, and a yagi were used as receiving antennas.

The July 9 Johnston Island Nuclear Experiment

The first successful high-altitude nuclear detonation of the 1962 test series occurred at 5:00 AM EDT on July 9, 1962. The explosion was equal to about 1.5 megatons of TNT and occurred in the *F*-layer of the ionosphere, at an altitude of about 400 kilometers. The equipment used during this test is shown in fig. 1. This equipment was located at the IBM Communications Systems Center in Bethesda, Maryland. In addition to this station, a second station, located in Yeadon, Pennsylvania, was equipped with a Collins 51J-4 receiver and a General Electric Strip-Chart Recorder.

Before detonation, Radio Australia transmissions on 7190, 9570, and 11710 kc appeared normal in signal strength and fading rate. Within 0.1 seconds after detonation, the signal level on 7190 kc dropped 45-50 db (fig. 2). A residual signal from Radio Australia was heard slightly above the noise level. An oblique sounder[1] and an amateur station in California were heard on the frequency immediately after detonation. They could not be heard before the instant of detonation. Several possible reasons can be offered to explain the appearance of these two stations. First, Radio Australia may have been strong enough before the detonation to prevent the sounder and amateur station from being heard, particularly since the automatic gain control was used in the receiver. A second possibility is that both the sounder and the amateur station began transmitting at the instant of detonation. Still a third possibility is the proposition

[1]An oblique or backscatter sounder is a high-frequency radar-type device which is used as an ionosphere sounder at various radiation angles to determine propagation conditions of the ionosphere.



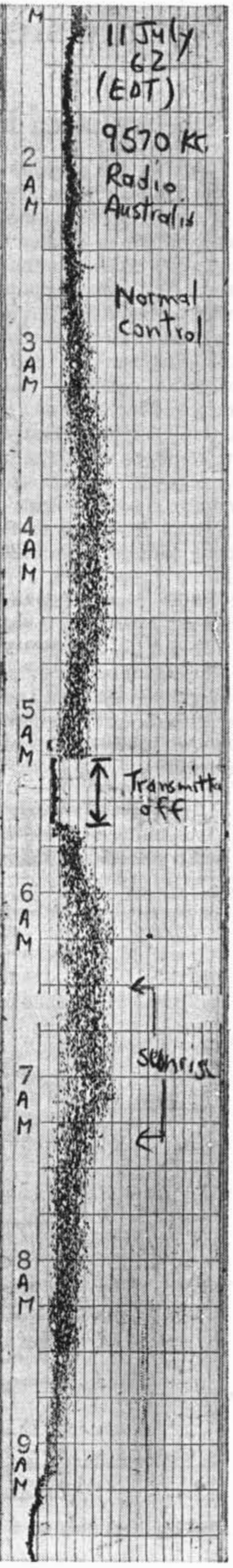


Fig. 3—(Left) Strip chart showing reception, the morning of test, for Radio Australia on 9570 kc.

Fig. 4—(Right) Strip chart showing same station on 9570 kc two days after the test detonation.

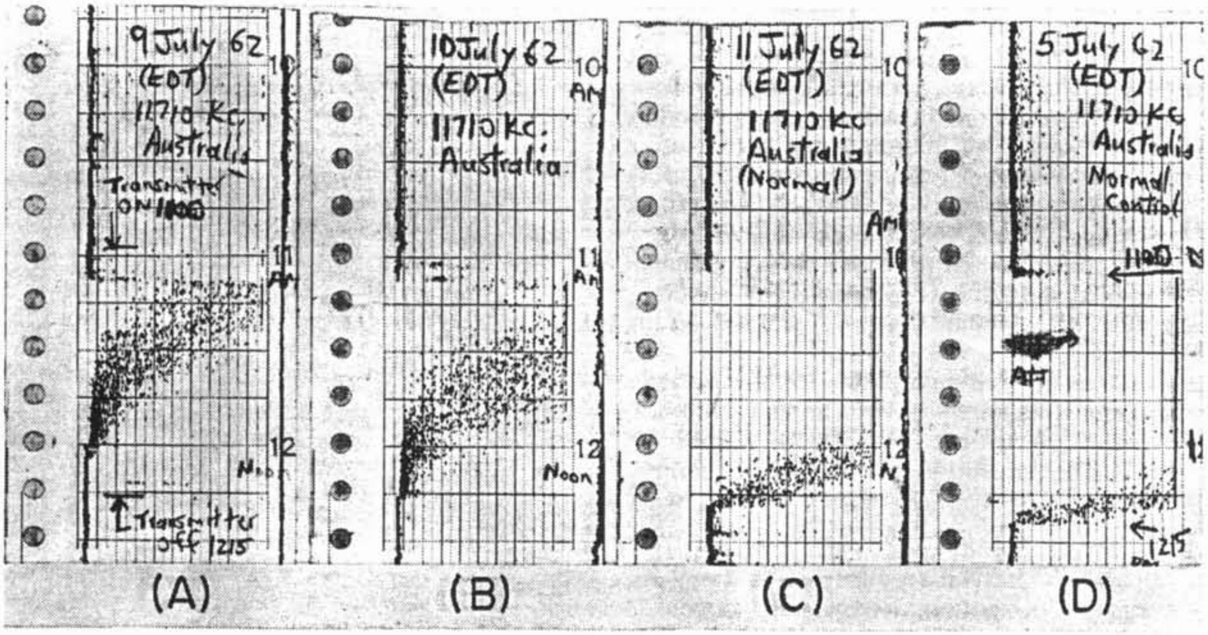


Fig. 5—(A) Strip chart showing reception of Radio Australia on 11710 kc six to seven hours after detonation. (B) Thirty to thirty-one hours; (C) Fifty-four to fifty-five hours and (D) normal control on 11710 kc.

that ionospheric propagation was altered by the nuclear blast, enabling the sounder and the amateur station to be received after the explosion. Insufficient data were obtained to further substantiate this theory.

Immediately after detonation, the Australian signal increased at a rate of 2.5 db per minute for approximately 14 minutes and remained steady after 14 minutes at 30 db above the noise level. The signal appeared weaker than normal for the following three hours until the station ceased transmission. Fading rates appeared normal.

Radio Australia on 9570 kc dropped to noise level at the time of detonation, recovering slowly but not completely during the following 15 minutes (fig. 3). From 1.5 to 2.25 hours after detonation, the signal gradually increased and then decreased, apparently affected by local sunrise. The signal remained weak for four hours until the normal fade-out time. Twenty four hours after detonation, signals were slightly weaker than normal. Forty eight hours after detonation, the signal level appeared normal (fig. 4).

Radio Australia on 11710 kc dropped to noise level at the time of detonation and the signal increased during the following 15 minutes, but did not return to the original level. Three to four hours after detonation, the signal appeared strong. Six to seven hours after detonation, the signal appeared weaker than normal and faded 45-minutes earlier than normal (fig. 5A). Thirty to thirty-one hours after detonation, the signal appeared weaker than normal and faded 30-minutes earlier than normal (fig. 5B). Two days after detonation, the signal appeared normal (fig. 5C). Figure 5D is the normal control for the signal on this frequency.

The 11810 kc signal of Radio Australia remained very weak after detonation, with increases in the signal level occurring 25 to 45-minutes and 1.5 to 2-hours after detonation, the latter increase probably the effect of local sunrise. Figures 6 and 7 show the test and normal control chart recordings for this frequency.

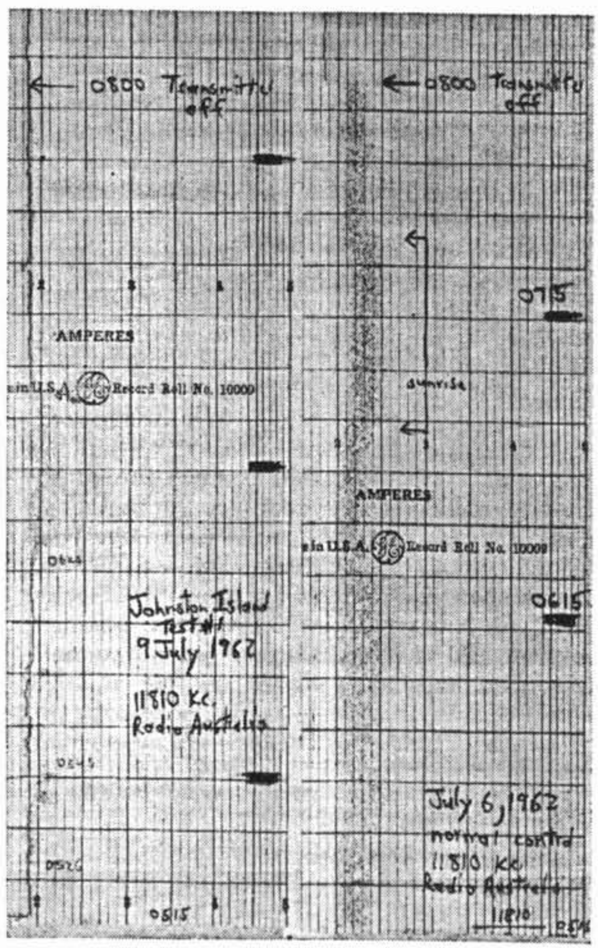


Fig. 6—(Left) Strip chart showing reception of Radio Australia on 11810 kc on morning of the test.

Fig. 7—(Right) Strip chart showing normal control on 11810 kc on July 6, 1962.

Radio Japan on 11725 kc was observed well above the noise level when checked 14 minutes after detonation. The Philippines station on 12736.5 kc was heard when checked 10 minutes after detonation, but was not identified. WWVH in Hawaii on 5000 kc was very strong 45 to 50 and 105 to 110-minutes after detonation. This station could not be heard at other times because of the presence of local station WWV on the same frequency.

The operation countdown was monitored on 15515 kc. The location of the station broadcasting the countdown is not known, although it was observed that the countdown station could not be heard at the instant of detonation or after the detonation.

According to sunspot count and geomagnetic data released by the National Bureau of Standards Propagation Warning Service, solar conditions appeared normal during the days of the July 9 Johnston Island nuclear experiment. This indicates that the effects observed during the nuclear experiment were not produced by abnormal solar activity.

Lower Altitude, Lower Yield Nuclear Detonations

Further tests in the high-altitude nuclear test series consisted of low-yield detonations in the mornings (EDT) of Oct. 20, 26 and Nov. 1 and 4. These explosions occurred at *D* and *E*-layer altitudes. Instrumentation for these tests consisted of a single Collins 51J-4 receiver and G. E. Strip-Chart Recorder which recorded the a.g.c. voltage of Radio Australia on 9570 kc. Details on the tests are as follows:

TEST No. 2, October 20, 1962, 0330 EST, under 20,000 tons yield, 20-30 miles altitude. RESULTS: no effects observed.

TEST No. 3, October 26, 1962, 0600 EDT, under one megaton yield tens of kilometers altitude. RESULTS: drop in signal level (Fig. 8), recovering gradually during the following two hours. Sunrise effects appeared more pronounced.

TEST No. 4, November 1, 1962, 0710 EST, under one megaton yield, 20-30 miles altitude. RESULTS: no effects observed.

TEST No. 5, November 4, 1962, under 20,000 tons yield, 20-30 miles altitude. RESULTS: no effects observed.

Summary of Observations

The observations made during the 1962 Johnston Island nuclear test series can be summarized as follows:

1. Signal drop-out effects were immediate in some detonations but were negligible in others.
2. Signal drop-outs were not total; *i.e.*, residual signals could be heard above the noise level after each detonation.
3. Long-term effects were most pronounced at 11710 kc, less pronounced at 9570 kc, and negligible at 7190 kc; lasting as long as two days.

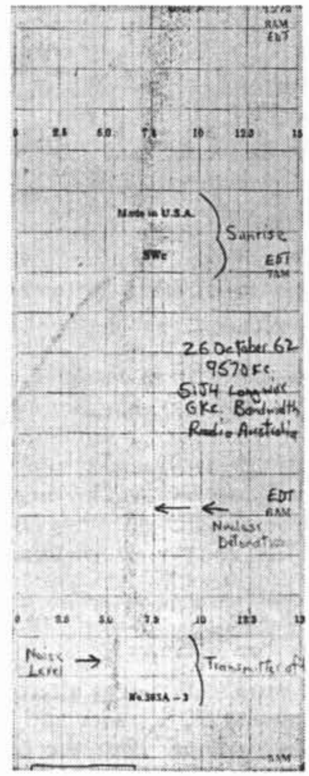


Fig. 8—Strip chart showing the results from the low altitude (D and E-layer) low yield explosions. Signal recorded is Radio Australia on 9570 kc on Oct. 26, 1962.

4. Sunrise effects appeared more pronounced than normal.
5. The extent of effects appeared greatest for a large detonation at high altitude (*F*-layer) than for small detonation at lower altitudes (*D* and *E*-layers).
6. Signals of stations not heard before detonation could be received immediately after detonation.

Conclusions

The extent of propagation effects, including long-term effects, appears to be a function of the altitude and yield of the nuclear detonation, and the frequency of the station affected. Signal drop-outs were not as prolonged as anticipated, lasting only a few hundred seconds, although less serious after-effects were observed for as long as two days. It is possible that the propagation path was altered, causing enhancement of other signals from different geographic locations. The effects from lower altitude (*D* and *E*-layer), low yield explosions were not detectable, with the exception of the sub-megaton detonation of October 26. Further data is needed, however, before any positive conclusions can be reached.

Acknowledgements

The author is indebted to Dr. Hunt Curtis, W1OKL/3 and George Selz of IBM for support and encouragement of this work; to Professor Schwartz of the Moore School, project advisor, and to Jan Carman, W3JXS of the Moore School for obtaining data from the receiving station in Yeadon, Pennsylvania. ■