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A SYSTEM FOR DETECTING ATOMIC TESTS AT LONG RANGE

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MAR 1 1966
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Jack W. Reed - 5111

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ABSTRACT

Radio "whistler" signals as observed from lightning discharges may also be observed from atomic blasts. If this is true a test event may be detected at the geomagnetic conjugate of the test shot location.

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Case No. 407.09

October 17, 1956

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A SYSTEM FOR DETECTING ATOMIC TESTS AT LONG RANGE

Introduction

An article in Scientific American by P. A. Humphrey[1] referred to observations of atmospheric radio "whistlers" made during the Atka voyage to Antarctica in preparation for the International Geophysical Year. These signals have been attricuted to lightning flashes, either near the observation point, or at the other end of the geomagnetic line of force, in the other hemisphere. Since atomic test blasts are often a source of a similar low-frequency electromagnetic transient, a long-range detection mechanism is suggested.

Whistler Observations

Whistlers have been observed by many investigators, but the most definitive study of these phenomena has been conducted in England by Storey.[2] These noises are heard on low-frequency radio, 400 c/s to 10 kc/s, as audio-tones beginning in the ultrasonic and descending through sonic tones in one or two seconds. In general there are so-called short and long whistlers, the long requiring roughly twice as long as the short for a tone drop. By comparing long whistler observations with Sferics radio storm detections Storey has shown the long whistlers follow lightning discharges. Their audio frequency, f, follows the relation with time, t, after lightning,

$$f^{1/2} = D/t \quad ,$$

where D is the dispersion. Observations occasionally show trains of whistlers, and if the trains follow a lightning discharge the dispersions

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of successive long whistlers increases in the ratios 1:2:3:4, etc. However, trains of short whistlers give dispersions proportional to the sequence 1:3:5:7, etc. Thus it is deduced that long whistlers were transmitted from observed lightning, reflected by the southern hemisphere, and observed in England, with repeated cycles. The short whistlers originated from southern hemisphere lightning, not detected by the Sferics organization, and were observed in the north. Dispersion of tone is due to slightly different propagation speeds for the different frequency components in the initial discharge. Signal strength for such tremendous distances is maintained because wave packets are propagated along magnetic force lines without divergence and because there is little scattering outside the ionosphere. In summary, then, an extraordinarily strong whistler-type radio signal may be observed near the geomagnetic conjugate of the location of an electromagnetic discharge.

In addition, strong long whistlers are observed within 300 to 500 miles of lightning and weak long whistlers out to 2000 miles from the discharge.

Atomic Test Signals

Strong electromagnetic transients are observed from tower bursts in Nevada, although it has not yet been determined if such transients occur on high altitude atomic shots. Also, lightning flashes are visible in photographs of thermonuclear bursts. Electromagnetic signals have been used by the Sandia Corporation microbarograph program[3/] to record shot-time zero for sound propagation analysis out to 300 miles, with very simple equipment. Further long-range detection over thousands of miles is possible, but

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signal strengths are generally inadequate for discrimination from ambient atmospheric noise, and the correlation is often obtained only after the fact of burst time is known. However, by proper location of the detector recording site where a consequent whistler from a nuclear detonation would occur, might well allow positive, nearly instantaneous indication of the event.

To test the whistler signal receipt from Nevada tests a recording would be necessary from within about 300 to 500 miles of the geomagnetic conjugate of the Nevada Test Site. This would be in the South Pacific, far from any land or island, as shown in Fig. 1, where geographic coordinates in the southwest United States have been transformed along geomagnetic force lines onto southern hemisphere geographic coordinates.[4/] Thus a monitor ship in this area would be necessary to make whistler recordings of Nevada tests. Results from a monitor could be used to study feasibility of this system as a detection device and also to learn if any differences exist between atomic signals and lightning. This latter information is necessary if positive discrimination is required.

Since the Pacific Proving Ground is very near the geomagnetic equator, electromagnetic signals following force lines would never travel to very high altitudes and would be attenuated by air scattering. Thus recording a few hundred miles from a Pacific test, although feasible, would not yield significant results.

Surveillance System

Geomagnetic conjugate surveillance of Soviet tests would also require monitoring over an uninhabited expanse of the South Indian Ocean. In Fig. 2

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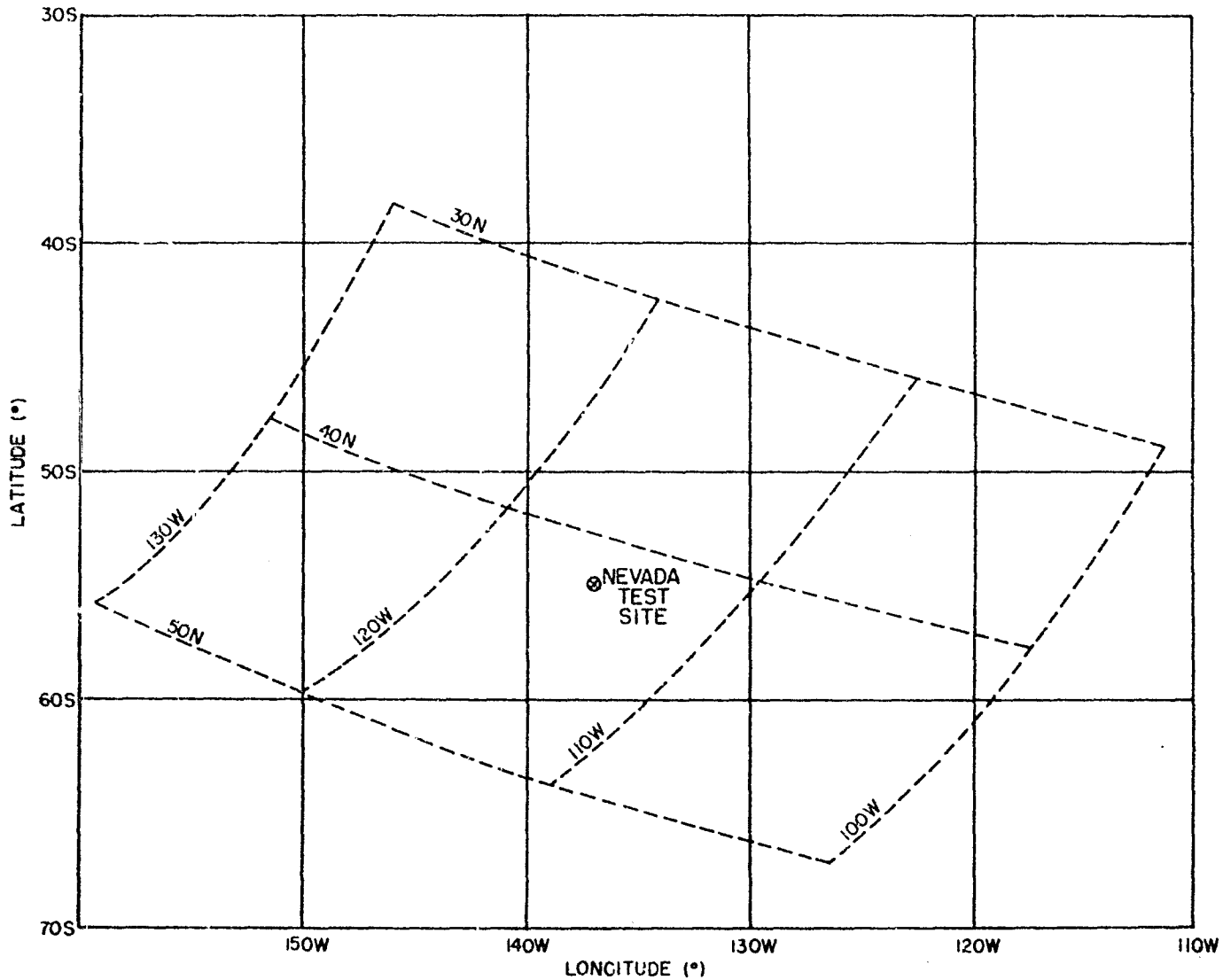

FIGURE 1 - NEVADA TEST SITE TRANSFERRED TO SOUTHERN HEMISPHERE ALONG GEOMAGNETIC LINES OF FORCE

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REF: "DESCRIPTION OF THE EARTH'S MAIN MAGNETIC FIELD AND ITS SECULAR CHANGE, 1905-1945", E.H. VESTINE, ET AL., DEPT. OF TERRESTRIAL MAGNETISM, CARNEGIE INSTITUTE OF WASHINGTON PUBLICATION 578, WASHINGTON, 1948.

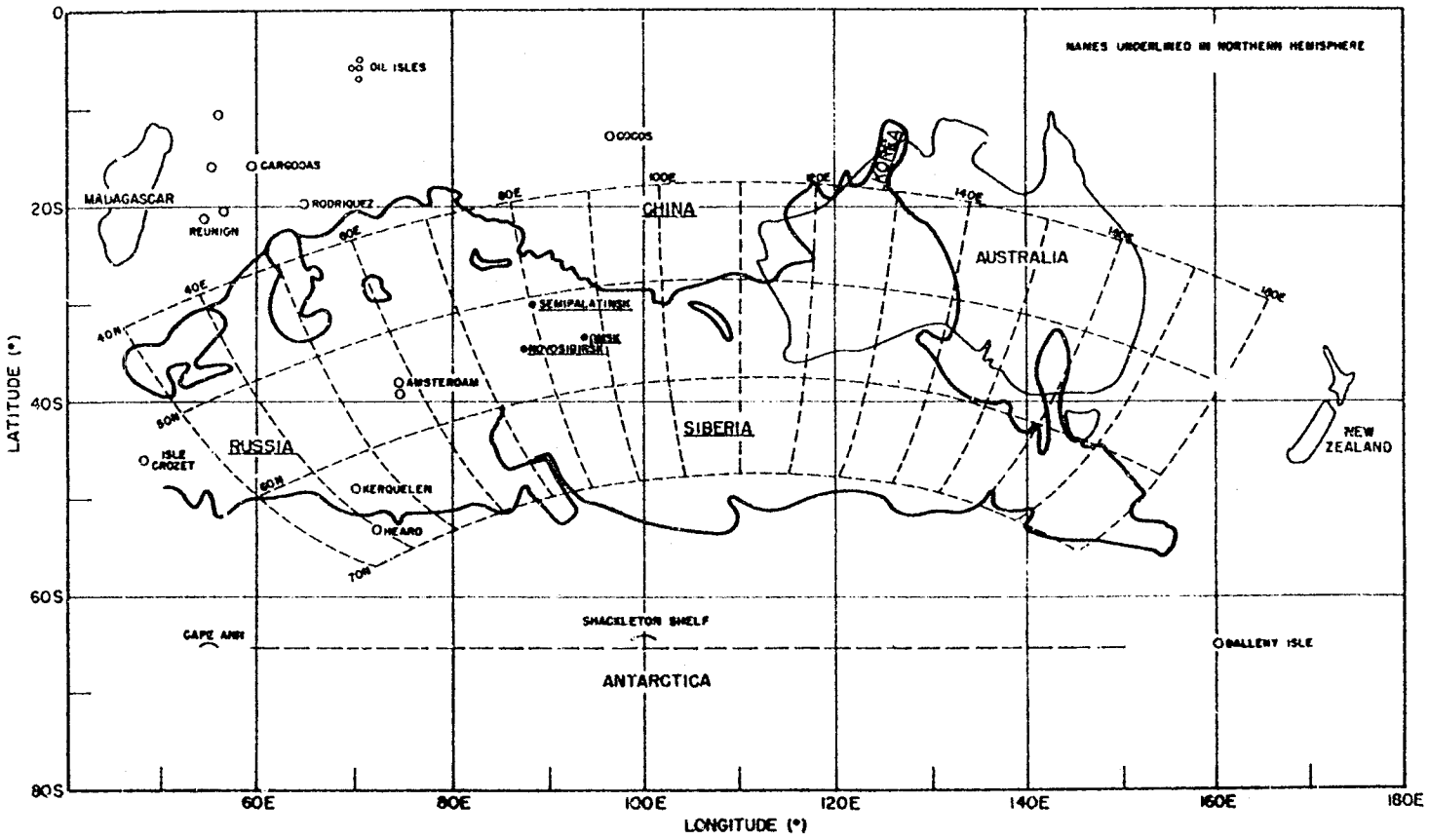

FIGURE 2 - U.S.S.R. TRANSFORMED ONTO SOUTHERN HEMISPHERE ALONG GEOMAGNETIC LINES OF FORCE

the USSR is mapped along geomagnetic force lines onto the Southern Hemisphere. With no intelligence on shot points, a grid of recorders spaced about 700 miles apart over the area would be required for full surveillance. With stations established on the available land areas and islands, another twelve or fifteen ocean stations would be necessary. However, simplicity of the receiver suggests that a buoy station which could relay the signal over communication channels to a recording site on land might be used.

Compared with many places in the world, likely Soviet test areas are in regions of low thunderstorm frequency, which reduces the possibility of signal confusion. The per cent of days of the year with thunderstorms occurring in Europe and Asia is shown in Fig. 3, reproduced from work by Brooks.[5/]

Conclusions and Recommendations

Electromagnetic signals discharged by atomic tests may be detected as audible whistlers on a 0.4-10.0 kilocycles, broad-band radio receiver placed within 500 miles of the geomagnetic conjugate of the shot point. Recordings should be made during Nevada tests to find whether atomic signals may be discriminated from lightning discharges and whether a high-altitude burst eliminates the radio-frequency transient so that it could not cause a whistler. If it is found that this method provides a feasible system for long-range, immediate detection, a monitor network over the South Indian Ocean would indicate Soviet nuclear tests.

Case No. 407.09
October 17, 1956

Jack W. Reed, 5111

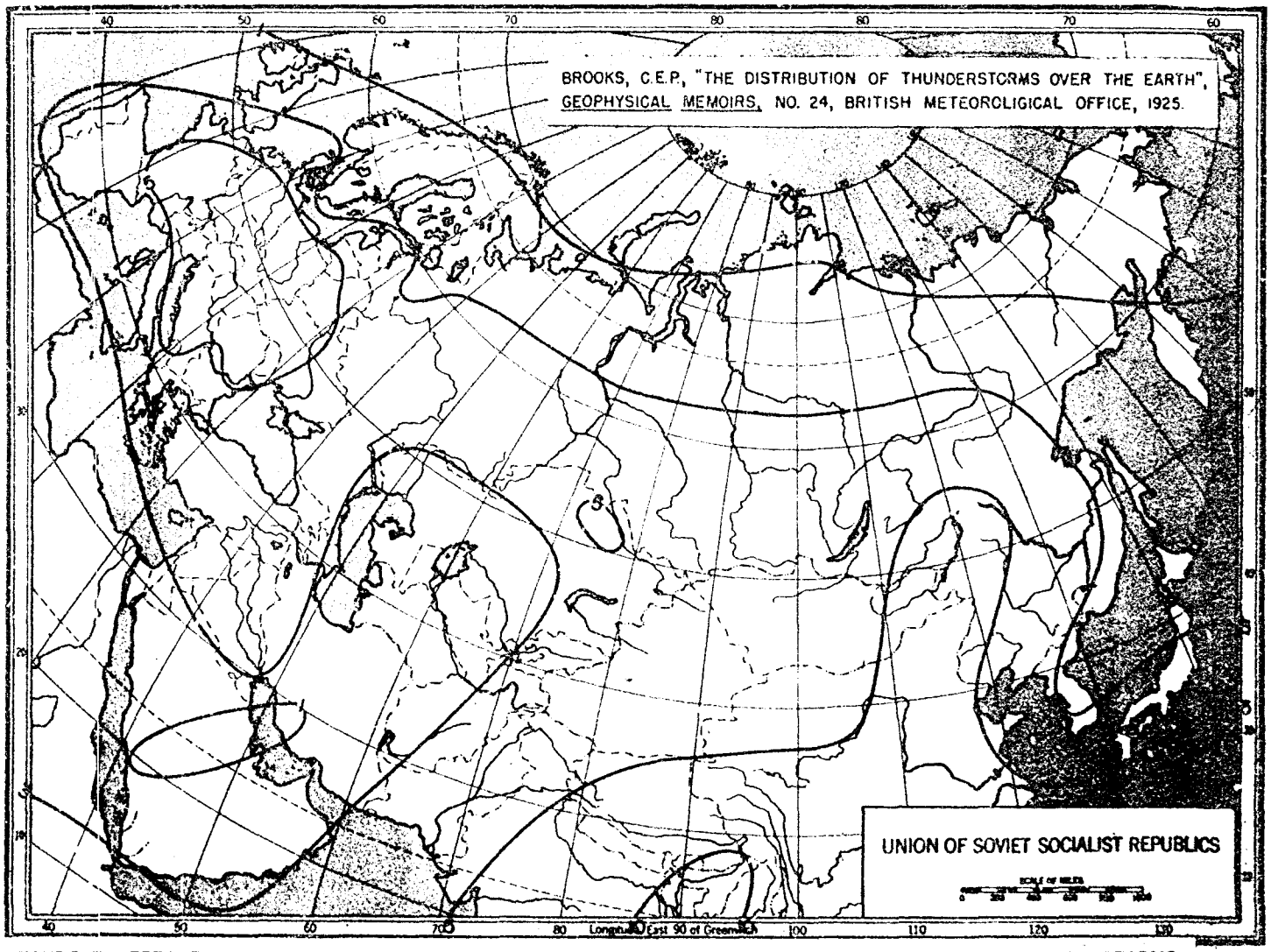

FIGURE 3 - FREQUENCY OF THUNDERSTORMS EXPRESSED IN PERCENTAGE OF DAYS IN A YEAR HAVING SUCH STORMS

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