Chapter 17

HOLOGRAPHY OF INFRASOUND AS OBSERVED FROM NATURAL AND ARTIFICIAL SOURCES

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Atmospheric geoacoustics has developed in the last four years to such an extent that many long-range signals have been identified and related to different sources. Also, several propagation characteristics have been determined. However, in view of the numerous sources, the background noise, and the propagation paths, with the complexity of two temperature channels and three wind currents, it is still far from being a field of applied science under present techniques. In order to be able to utilize the observations presently obtained by the geoacoustics stations, it is necessary to analyze the data by methods such as have been developed for holography. The phasing of a dynamic generator signal with respect to a monitored signal can give an interference pattern which is recognizable. It is of interest to apply these techniques in order to support and advance the present status of the infrasonic art.

INTRODUCTION

Geoacoustics, the study of ultra-low-frequency waves propagated in the earth, the ocean, or in the atmosphere, has become a field of interest because of its association with large-scale geophysical phenomena. Moreover, this field is a useful tool of research for studying the dynamics and disturbances associated with the lower atmosphere and upper atmosphere. Experimenters generally recognize the extent of the field of geoacoustics when using infrasonic waves for probing the atmosphere. However, a closer look at the field reveals potentialities for the development of sensors, new techniques of analysis, and related large systems, as well as the basic problem of defining the physics involved. The scientist must delve into the field of geoacoustics and study it from all aspects.

Geoacoustics can be utilized not only for probes, but also for detection of all types of phenomena for use as warnings, such as with regard to volcano
eruptions, storms, nuclear explosions, and other natural and man-made phenomena. These waves propagate long distances—thousands of kilometers. Their travel is mostly at the slow speed of sound. However, there have been many observations of supersonic infrasonic signals that had group velocities of two to about five times the speed of sound.2

Signals observed from several arrays of sensors will have to be transmitted to a central analyzer which will have to identify the signals, locate them, and give all information of interest to the observer, thus giving immediate warning of hazards. The identifying patterns will require the utilization of holographic techniques.

**ATMOSPHERIC ACOUSTICS**

Seismic waves are acoustic waves that propagate long distances through the earth's crust and indicate the dynamics of the latter. Earthquakes are regularly monitored by seismic stations dispersed throughout the globe. Similarly, any dynamic phenomenon in the atmosphere is accompanied by acoustic noise. It is important to be able to listen to natural sounds and through them learn about the sources of these sounds. However, the usual audio sounds do not travel large distances. Furthermore, most large-scale natural sounds cannot be heard by the human ear or by regular microphones. These sounds are emitted at frequencies called infrasound, which are below audio frequencies. They travel thousands of kilometers, and indicate the existence of winds all the way up to 120 km altitude, of storms, of ocean waves, of volcanoes, of magnetic storms, aurorae, tornadoes, and other dynamic phenomena. They can also be artificially formed by explosions (nuclear or chemical rockets, planes, and so forth). Every source has its own infrasonic print, and it intermixes with others. The resolution of the signals, and the understanding of their propagation, characteristics, and generation mechanism characterize the field of geoacoustics today.

**COUPLING WITH THE IONOSPHERE**

Energy from outer space affects our ionosphere before hitting the atmosphere or earth. Many of its effects are known to man as cosmic rays, as aurorae, or as radio interference. In order to estimate the energies involved, we generally look at the byproducts which reach us. Similarly, some disturbances propagate in the ionosphere in a wave form, such as magnetohydrodynamic waves. When they reach the atmosphere their energy is transferred into two other wave forms: electromagnetic waves and infrasonic waves. The coupling, or interaction, of these waves through their respective media is of extreme interest for determining energy transfer, which indicates the nature of the source of disturbance and explains something about the