The final session of formal presentations consisted of papers by R. R. Sakaida (Linde Research Laboratories), P. Mazur (Oak Ridge National Laboratory), M. Persidsky (Presbyterian Medical Center, San Francisco), P. J. Melnick (VA Hospital, Oakland), and M. J. Gonder (VA Hospital, Buffalo). This session was devoted primarily to the preservation of living systems at very low temperatures. Several concepts were presented concerning the protection of substances to be preserved by the addition of extracellular polymers such as polyvinylpyrrolidone and the optimization of procedures for bulk preservation of living materials such as blood. Interesting observations were also revealed concerning the damage inflicted upon cells subjected to sub-zero temperatures. Damage appears to be ascribable to the concentration of solutes accompanying ice formation and the formation of large intracellular ice crystals. Systematic studies of growth of ice crystals in water and in the presence of various solutes show that the rate of growth in pure water does not increase uniformly with a decrease in temperature. In aqueous solutions the rates of ice growth rise and fall considerably at certain temperatures. Enzyme activity in slowly frozen tumor tissue was either greatly diminished or stopped entirely. The activity was intense, however, when tissues were rapidly frozen to −160°C. Hydrolases and dehydrogenases behaved in this way, whereas opposite activity was noted for cytochrome-C-oxidase. Lastly, histochemical evidence was presented to show that freezing of the prostate *in situ* causes beneficial necrosis and cellular breakdown with minimal inflammatory reaction in surrounding tissue.

A masterful integration by H. Fernandez-Moran (University of Chicago) and H. S. Frank (University of Pittsburgh) of the biologic and physicochemical points of view highlighted this stimulating and provocative meeting. Following excellent summations, supported by their own laboratory data, the cochairmen were joined by the session chairman to constitute a panel for the open interdisciplinary discussion. The chemists and physicists urged the adoption of a systematic study of the water problem through the physical model system. The biologists, on the other hand, contended that the biologic system is so complex that it is not amenable to the model system and extrapolation of data therefrom. What began as discord soon took on the appearance of an attempt to understand each other's problems and an agreement for more interdisciplinary exchanges of hypotheses, avenues of approach, and aims toward multidisciplinary application. A summary can best be written by quoting an eminent participant: "Without a doubt, this meeting was one of the most fruitful and stimulating that I have ever attended. The published proceedings will rank among the classics in the field."

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Communications in Unusual Media

Recent advances in unusual communications techniques were brought to the attention of the scientific community at the session on Communications in Unusual Media of the Northeast Electronics Research Meeting (NEREM), held in Boston on 4 November 1964.

In the opening paper K. Powers of R.C.A. Laboratories discussed the possibilities for long-range seismic communications. A convincing presentation was made describing seismic modes which appear to permit communications over thousands of kilometers. Powers based his arguments on data recorded during United States underground nuclear detonations. Because the gradient of velocity increases with depth in the earth, seismic wave fronts of nearly vertical incidence into the ground bend upwards to arrive back at the surface at some distance from the source. Work of the seismologist B. Gutenberg has shown the existence of a "low-velocity layer" or negative gradient layer about 80 km below the continental crust. As a ray hits the low-velocity layer with near grazing incidence, the negative gradient tends to bend the wave downward until the layer of positive gradient reverses the direction of the ray. This layer thus produces a shadow zone but, more importantly, provides a wavelength in which seismic waves can be trapped and can travel with low attenuation to great distances.

Although the propagation characteristics of the lower layer have not been completely established, seismological data from underground nuclear explosions lend support to the hypothesis advanced by Gutenberg. During 1958, a network of seismic recording stations was set up to observe seismic waves resulting from the Blanca underground explosion. The network provided observations from ground zero out to a range of 4000 km. At close range and out to a distance (d) of about 500 km, straight spreading in which the amplitude is proportional to $1/d^3$ was noted. However, the magnitude in the vicinity of 1000 km is seen to be somewhat below the level that would be expected for the normal compressional-wave mode. It is suspected that these seismic stations were in the "shadow zone." At distances beyond 1000 km, the amplitude was found to be considerably higher than one would expect from normal ray theory and could be explained only in terms of channelized or waveguide mode propagation. In addition, there appeared to be no significant loss due to attenuation between 1500 and 4000 km. The predominant period of the waves observed at the greater distances was about 1 second or slightly less.

For communication purposes, the explosions must be replaced by coherent waveform generators—for example, the hydraulic shakers that are used in oil exploration. Although only 5 percent of the seismic energy produced by such a shaker results in compressional waves, the compressional-wave content can be increased by the use of a phased array.

Since most of the high-attenuation mode conversion and multipath phenomenon characteristic of seismic propagation actually takes place in the 30-km deep crustal layers of the continents, it would be advantageous to place both transmitter and receiver as deep as possible in the ground—for example, in abandoned mine shafts. Such placement would not only have the advantage of obtaining a more direct coupling to the earth's mantle and reducing the generation of surface waves, but the microseism noise at the receiving site would also be low. Under these conditions, a means of communication between deep holes in the ground on the east and west coasts of the United States, which would transmit data at a rate of approximately 1 bit per second, may be possible.

The second paper, concerning radio propagation through the earth's crust, was presented by J. deBettencourt and C. Tsao of the Raytheon Company. In the light of recent interest in hardened communications modes the audience welcomed this summary of the theoretical aspects of underground radio propagation and short report of recent experimental results.

DeBettencourt's theoretical discussion began with a review of the complications introduced into the transmission equation by the presence of a lossy medium. The importance of the exponential attenuation due to the conductive rock was stressed. Several slides were shown which illustrated the dependence of path loss on the electrical conductivity of the medium. The performance of linear antennas immersed in the medium was also discussed with emphasis on the inefficient nature of the electrically short dipoles required by the low frequencies of operation. Slides showing curves of the input impedance of buried antennas were shown and their interpretation reviewed.

In his presentation Tsao reviewed a large number of experiments concerning propagation through rock. Results obtained over a mile path on Cape Cod, Massachusetts, and two paths, respectively one and three miles long, in upper New York State were discussed. Local conductivities found were about 10^{-3} mho/meter for Cape Cod and about 10^{-4} mho/meter for New York. Propagation at low frequencies (below 10 kc/sec) was principally through the rock, while at higher frequencies propagation was by the "up-over-and-down" or surface wave mode. The transmission path was determined by calculating from experimental data the amplitude and phase of the mutual impedance between separated antennas.

For a known transmitter current, the magnitude of the induced voltage at the receiver as a function of frequency yields the magnitude of the complex phase constant of the rock medium. The phase constant was determined from a measurement of the phase angle of the mutual impedance between the antennas. The amplitude and phase results were plotted and compared with theoretical calculations to arrive at a best estimate for the electrical characteristics of the path.

Tsao concluded by reminding the audience that the mode is feasible, subject to the limitations of very short ranges and low data rates necessitated by the low frequencies of operation.

The final paper, presented by A. Orange of the Air Force Cambridge Research Laboratories, was a review of another mode of communications in the earth. For the system he described, current at extremely low frequencies (less than 30 cy/sec) is injected into the earth at the transmitter terminal and the induced conduction and induction fields are detected at a distance R as a potential difference between two electrodes.

This technique has been used for some time by geophysicists as a means for determining the electrical resistivity of the upper crust. The work by geophysicists has provided experimental transmission data that approximate use of the technique for communications purposes and has provided data on earth resistivity, one of the controlling factors in predicting performance as a communications mode.

The received voltage was shown by Orange to be a function of the applied current, the geometry of the transmitter-receiver layout, the frequency of operation, and the apparent resistivity of the earth between the two terminals. The apparent resistivity may be considered as an average resistivity to a depth which is related to the terminal separation, frequency of operation, and actual resistivity profile of the earth. For a uniform earth the apparent resistivity will not vary with separation. For a nonuniform earth the apparent resistivity will vary with separation, depending on the dimensions and resistivities of the layers. A slide was shown which illustrated the apparent resistivity trends for various earth models, and experimental data giving values obtained at several locations in the United States were presented.

A typical earth model was chosen, and the variation of received voltage with distance and frequency was shown. From the curves presented it appeared that practical communications via this mode would be limited to distances of the order of 25 to 50 km at frequencies less than 10 cy/sec.

Of some interest is the natural background noise at these frequencies, well below those normally considered by communicators. Below 1 cy/sec the noise is geomagnetic in origin, "micropulsations" of the earth's magnetic field inducing a voltage on the receiving electrodes. At about 1 cy/sec the noise is atmospheric in origin. From a standpoint of noise it would be desirable to operate in the "hole" around 1 cy/sec.

Combination of the field strength curves with the noise data appeared to constrain communications via this mode to a relatively narrow range of frequencies around 1 cy/sec. At these frequencies the rate of transmission of data even over a distance of only a few kilometers will be severely limited. While through use of large electrode spacings and sophisticated detection techniques contact between terminals may be effected over distances in excess of 165 kilometers, communications at a data rate lower than one bit per second will be limited to ranges of the order of tens of kilometers.

Because of the great variations in apparent resistivity from place to place and varying noise levels, each location must be considered a separate case. In all cases this system will provide only low data rates and have a limited range. To offset these disadvantages, the system has the features of security and possibility of extreme hardness, reliability, and survivability of the propagation medium.

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Radiochemical Methods of Analysis

Improvements in nuclear radiation detectors, development of a variety of sources of neutrons, and, particularly, the ready availability of multichannel pulse-height analyzers have accelerated progress in the use of radiochemical methods of analysis. The rapid changes in this field were emphasized by H. Seligman in his opening talk at a symposium held by the International Atomic Energy Agency in Salzburg, Austria, 19–23 October.

In a special lecture at the symposium, W. W. Meinke of the National Bureau of Standards discussed the place of radiochemical methods in analysis today and their anticipated role in the future. Radiochemical analysis has been a mature and well-developed technique for almost a decade, presenting the analyst with methods which are comparable in usefulness with other procedures and often offer unique advantages. In the future these methods can be expected to offer special help in problems of sensitivity, speed, cost, low matrix effects, and preservation of samples.

At the session on reactor activation analysis, papers representative of anal-