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.

A. ORANGE
Air Force Cambridge Research Laboratories, Bedford, Massachusetts

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-

ysis in many fields were presented, and many of the technical problems of this method were also explored. Analyses of trace elements in matrices as varied as industrial metals, reactor materials (including uranium and graphite), ancient Grecian marbles, Flemish paintings, human hair, snake venoms, and meteorites were discussed. Among the major problems brought out were those of sampling in connection with archeological and art samples, preparation of samples (including washing) for meaningful analysis for the forensic samples, matrix effects for trace elements in manganese, the general problems of neutron absorption, inhomogeneity of samples, radiochemical separations required for many trace methods, determination of special tracers such as O^{18}, and nondestructive analysis of precious samples such as meteorites (or, eventually, samples from the moon).

Possibilities of using radioisotope neutron sources for activation analysis were well summarized in several papers. Mention was also made of the use of captured gamma radiation from such sources for analysis. Although such methods will not have the high sensitivity of reactor activation, they are readily adaptable to rapid routine analysis at the 0.1- to 1-percent levels. Of particular interest was a new type of portable neutron source described by S. Amiel (Israel) which utilizes the reaction O^{18} (α,n) Ne^{21}. The source consists of two tubes, one with an interior of Po^{210} plated onto nickel, the other containing CO_2 labeled with O^{18}. In use, these tubes are connected so that the CO_2 can come in contact with the Po^{210} alpha particles. For "shut-off" and storage, the CO_2 is frozen in its own storage tube. Such a source is portable and presents no shielding problem. It should become commercially available next year at a cost of a few hundred dollars.

Recently the use of accelerators in activation analysis has enjoyed a major revival. Albert and Engelmann in France have systematically studied the application of (γ,n) reactions from a linear accelerator, as well as charged particles from cyclotrons, for determinations which are very difficult or impossible by reactor irradiation. Examples are the determination of part-per-million amounts of oxygen, carbon, nitrogen, and silicon in high-purity metals such as beryllium, aluminum, and germanium. Albert presented an interesting summary of (γ,n) activation throughout the periodic table.

The session on experimental techniques of activation analysis was highlighted by a very interesting report on progress toward a versatile automated radiochemical separation system by F. Girardi of the Euratom Center, Ispra, Italy. Girardi's system is based on ion-exchange separations and should be particularly applicable where analysis of a large number of repetitive samples is required. D. Comar of Orsay complemented this work by a description of the system he already has in operation to determine the element iodine in biological fluids, while W. Lyon presented an excellent summary of errors and artifacts which the Oak Ridge group have found after long experience in activation analysis. Several other papers described certain specialized nondestructive techniques for use in activation analysis, while a second group of papers considered the application of computers to activation analysis.

The two sessions on analytical applications of radioactive tracers, though hardly representative of the potential of the subject, did nevertheless show some bright spots. Several papers described radiometric methods which use radioactive reagents in both organic and inorganic systems. Similarly, there was discussion of the present state of radiometric titrations. Excellent examples of the powerful radio-release methods were described by D. Chleck (kryptonates) and W. Lyon (sulfur dioxide in air polution), while various modifications of the isotope dilution principle illustrated the experimental simplicity of these methods.

In particular, the papers by J. Ruzicka of Prague and J. DeVoe of the National Bureau of Standards on substoichiometry in isotopic dilution and radiometric methods evoked very interested comment. This principle shows great potential for submicrogram trace analysis involving minimal expense for facilities and equipment.

W. Blaedel (University of Wisconsin) completed the session with an intriguing discussion of his current progress toward a continuous isotope derivative procedure with direct readout for amino acids. Here again, the automation of laborious chemical procedures is a very important step in overcoming the "potential barriers" many people feel toward the use of radioisotopes in analysis.

The final session of the symposium was on the analytical application of radioactive sources and included application of backscattered radiation as well as secondary emission such as x-ray fluorescence excited by radioisotope sources. An interesting new development mentioned was the analytical program in Mössbauer spectrometry being carried out by DeVoe at the National Bureau of Standards.

The proceedings of this symposium will be available from the IAEA and from its sales agents throughout the world within about 6 months.

W. W. MEINKE
National Bureau of Standards
Washington, D.C.

Oceanography of the Western South Atlantic

The Brazilian scientific community has become increasingly concerned by the neglect of oceanography in that country, even as it applies to the immediately adjacent seas. As a start in rectifying this situation, the First International Symposium on the Oceanography of the Western South Atlantic was held 14–18 September 1964 at the Brazilian Academy of Sciences in Rio de Janeiro. The large attendance clearly attested to the widespread interest in this theme. There were 157 participants present: 132 from Brazil, eight from Argentina, three from Uruguay, two from Great Britain, eight from the United States, three representing UNESCO, and one from the FAO. On relatively short notice the sponsors arranged for the presentation of 67 papers, including seven invited lectures, a feat of considerable consequence for a region of the world where the study of oceanography is thought to be still in its infancy.

The composite nature of the topic made it necessary to divide the symposium into four sessions: Water Masses and Oceanic Circulation; Ecology of Marine Animals; Topography, Sediments, and Benthos; and the Estuaries and the Littoral Zone. A variety of subjects were covered, including: the activities of the Instituto Antartico Argentino; special aspects of the problem of determination of characteristics of oceanic waves; results of some littoral drift measurements in a basic coastal model; the distribution and displacement of water masses in the Argentinian Sea; new references, based on the study of planktonic foraminifera, on the location of the convergence of