



Electromechanical time-code generator, showing (right to left) the graduated seconds, minutes, and hours disks in which patterns of holes are drilled to permit the passage of light.

intervals. The disks rotate on the same shaft at different speeds. The "seconds" disk turns at 1 rpm, the "minutes" disk is stepped 6° per step by a cam-solenoid arrangement, and the "hours" disk is similarly stepped 15° per step. Each of these disks is paired with a readout disk rotating at 4 rpm.

The photodiodes are located to look at light

emanating from two linear-filament bulbs, one illuminating the seconds and minutes sensors and the other the hours sensors. The disks are placed between the light bulbs and the photodiodes so that light reaches the sensors only when the holes of the paired disks line up with each other.

The resultant current pulsations are interpreted and shaped electronically. Logic circuitry is used to convert the information from the photo circuitry to the desired serial code output. This logic circuitry is transistorized and compactly arranged on standard, commercial, plug-in cards.

The AMR design provides a visual display of time in addition to the coded signal output. This is accomplished by seconds, minutes, and hours numbers engraved on the edges of the rotating disks that can be seen through a transparent section of the front panel.

The electromechanical time-code generator can be compactly packaged and is producible at the relatively low cost of a few hundred dollars as compared to thousands of dollars for commercial equipment. Its use in many nonmilitary applications is clearly evident, as, for example, in fire departments, police stations, airports, telephone companies, and in the headquarters of civil defense units.

ALBEDO NEUTRON CONFERENCE REPORT

The Applied Physics Laboratory was host, on Oct. 15-16, 1963, to a "Conference on the Earth's Albedo Neutron Flux," its purpose being to gather together all the principal researchers in the field of albedo neutron measurements for a critical look at experimental and theoretical results to date.

The earth's albedo neutron flux is made up of neutrons that emerge from the top of the atmosphere and travel away from the earth. These represent leakage from the general atmospheric equilibrium neutron flux that results from the interactions of cosmic rays incident on the earth's atmosphere.

Scientific interest in the albedo neutron flux derives from the fact that it is one of the most discussed sources for the inner Van Allen radiation zone. Since a free neutron decays into a proton and an electron, it provides a very suitable mechanism for directly injecting these particles into the trapping region.

Over the last few years several experimental measurements and theoretical calculations of the neutron albedo have been conducted. An APL review of these measurements provided the impetus for this conference by revealing the existence of a number of discrepancies and areas of disagreement between the various experiments. It was also found that from the experimental results it was not possible to decide which of the theoretical predictions were valid. It was clear, therefore, that a gathering of all interested workers in the field should be of value to clarify or at least to recognize the extent of many of these discrepancies.

The following summary is broken down into the main parameters that are of interest in a measurement of the neutron albedo. They are: absolute flux or intensity of the albedo neutrons; variation of this intensity with geomagnetic latitude; time variations; the energy spectrum; diurnal and sunset effects; and observed bursts of neutrons.

ABSOLUTE FLUX—In the low-latitude range available experimental measurements of the albedo neutron flux disagree by as much as a factor of 5; in the middle-to-high-latitude range this factor is 10 or more. Conferees discussed the various experiments rather critically to obtain a solution for the disagreements, and several possibilities were suggested: background correction and charged-particle discrimination techniques; methods of calibration; directional properties and spectral response of the detector.

The problem of local neutron production is the most difficult to assess analytically. The obvious and best method of overcoming it is to position the detector well away from any material that will yield serious local production. However, the uncertainty in the measured results due to a local neutron correction factor will *not* eliminate the discrepancies observed, although it does play an important role.

It was also noted that, in some cases, anticoincidence shields that did not completely surround the neutron-sensitive element were used for charged-particle discrimination. Total shielding is necessary to gate out charged particles effectively and reduce discrepancies between experiments.

It was felt that the diffusion calculations of Lingenfelter and the S_n calculations of Newkirk, both published in 1963 in the *Journal of Geophysical Research*, are the more appropriate theoretical works with which to compare experimental results. It was pointed out, however, that as yet there is no preferred theoretical calculation as far as the experimental results are concerned.

Direct experimental information concerning the high-energy neutron albedo (> 50 Mev) is nonexistent. The theoretical work concerning the spectrum and absolute flux of protons in the inner radiation zone, as obtained from a high-energy albedo neutron source, shows that such a source is indeed sufficient if one allows a proton lifetime of several hundred years. However, a direct measurement of the high-energy neutron albedo remains desirable.

LATITUDE VARIATION—Latitude variations of ≈ 4 to 1 and ≈ 10 to 1 have been predicted and observed, and the differences remain to be resolved. However, the form of the equilibrium neutron flux at the top of the atmosphere plays an important role in the magnitude of the albedo neutron flux, and a study of this effect might be undertaken.

TIME VARIATIONS—Short-term variations (as distinct from the solar cycle variation) have been reported, but they have not yet been explained. Measurements made of them were questioned at the conference on the bases of both equipment malfunction

and statistics. If real, such time variations could very well explain some of the discrepancies encountered.

SPECTRUM—No direct spectral measurements exist above the atmosphere. In the atmosphere, a spectrum of the form $E^{-1.220.2}$ has been observed in several experiments.

DIURNAL AND SUNSET EFFECT—Experiments show generally that if any diurnal effect is present, it is less than 5%.

The sunset effect—an increase in the observed neutron intensity occurring just prior to local sunset—has not been observed in recent measurements. It was suggested that this effect is strongly correlated with solar activity and may be washed out effectively during solar minimum.

BURSTS—Observations have been reported where sudden large increases occur in the observed neutron intensity. These can be as large as a factor of ≈ 100 over ambient counting rates and persist for times of a few seconds to a few minutes. They have been interpreted as local dumping of charged particles and subsequent neutron production in the payload. Some observations correlate well with the response of charged-particle detectors aboard the same payload.

Only enough data exist to record

these bursts as an empirical phenomenon, however. More information is needed to correlate the bursts with other phenomena such as magnetic disturbances. This effect is not actually in the realm of albedo neutron measurements, but because it could cause discrepancies between experiments, it merits continued investigation.

The October conference at APL was successful in delineating several problem areas and in indicating the general direction that albedo neutron flux research must take if definitive measurements are to be obtained. From the discussions there emerged a clear need for further measurements of all the characteristics of the neutron albedo and a better understanding of the problems involved in obtaining such measurements. There was also a clearer recognition, and in some cases a partial explanation, of the discrepancies found between various experimental results. Finally, some new and interesting data, such as the observed neutron bursts and time variations, were presented. Such results should lead to a better understanding of the relative importance of the albedo neutron flux as a source for the Van Allen radiation zone.

—D. J. Williams

Conference Papers

What Determines the Lifetime of Trapped Protons?—S. F. Singer, National Weather Satellite Center
The Cosmic Ray Neutron Leakage Flux—R. E. Lingenfelter, Institute of Geophysics and Planetary Physics, University of California at Los Angeles
Neutron Albedo and Charged Particle Measurements on Polar Orbiting Satellites—J. H. Trainor and J. A. Lockwood, University of New Hampshire
Measurement of Albedo Neutron Latitude Variation from a Polar Orbiting Satellite—J. P. Martin, RIAS
Albedo Neutrons in Space—D. J. Williams and C. O. Bostrom, Applied Physics Laboratory
Neutrons from the Sun—W. N. Hess, Goddard Space Flight Center, NASA
Fast Neutrons in the Earth's Atmosphere—R. C. Haymes, Jet Propulsion Laboratory
Neutron Measurements of Aircraft Altitude During the Summer of 1962—J. Gauger, Boeing Scientific Research Laboratory
Latitude Survey of Cosmic-Ray Intensity by Explorer 7, October 1959 to February 1961—W. C. Lin, State University of Iowa
Panel Discussion on Neutron Detection—E. L. Chupp, Moderator, University of New Hampshire
Summary and Discussion—G. F. Pieper, NASA Headquarters and the Applied Physics Laboratory

APL COLLOQUIA

Oct. 4—"The Shape of the Earth," by Robert R. Newton, The Johns Hopkins University Applied Physics Laboratory.

Oct. 11—"Physics on the Moon," by A. C. Pearse, BellComm, Inc.

Oct. 18—"Optical Pumping and Atomic Clocks," by T. R. Carver, Princeton University.

Oct. 25—"High-Intensity Molecular Beams," by J. B. Fenn, Princeton University.

Oct. 30—"Memory and the Theory

of Schema," by R. C. Oldfield, Oxford University.

Nov. 1—"The Statistical Mechanics of Some One-Dimensional Systems," by M. Kac, Rockefeller Institute.

Nov. 15—"Latin America on the Verge of Revolution," by Milton S. Eisenhower, President of The Johns Hopkins University.