N, was varied from 1 to 3000. The signal-to-noise ratio was varied over a sufficient range to define a graph for a range of P_N between approximately 0.001 and 0.999.

The significant figures, which can be read from graphs of the data, are sufficient for most purposes. All of the data are graphed in Ref. 6, and if greater accuracy is required for any particular problem, the tabulated data are on file. These data were computed exactly to six significant decimal digits. The new data indicate that the accuracy of Marcum's data for non-fluctuating targets is at least as good as the accuracy of reading his graphs, which is poor for some ranges of the arguments. Swerling's data for all four cases, however, are quite approximate, especially when the number of pulses integrated is large. The exact data indicate lower probabilities of detection for the same signal-to-noise ratio.

[6] L. F. Fehlner, *Marcum's and Swerling's Data on Target Detection by a Pulsed Radar,* The Johns Hopkins University, Applied Physics Laboratory, TG-451, July 2, 1962.

An Electromechanical Time-Code Generator

A persistent problem in data recording, reduction, and analysis is that of linking significant events to their precise time of occurrence. To meet the problem, some data-handling specialists at APL time-code their records by means of commercial, electronic time-code generators—expensive devices well suited as fixed-installation equipment for use by highly skilled technicians. In actual use, a time-code generator records an analog reference time on tape simultaneously with a taped record of a particular sequence of events. The two taken as a unit constitute an accurate, time-referenced record, as, for example, of a missile firing.

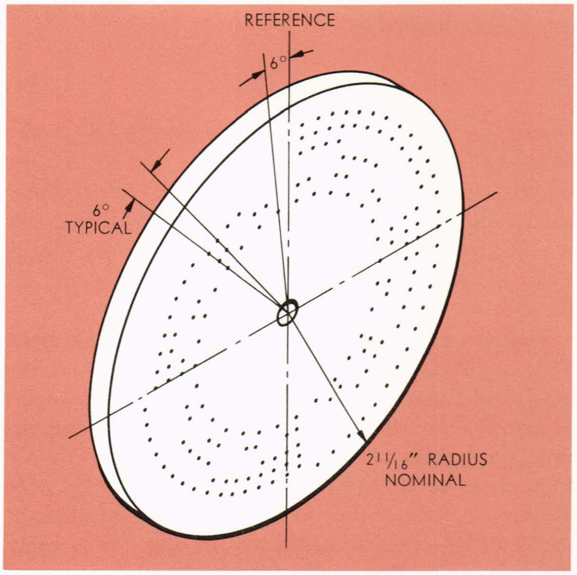
For mobile installations requiring simplicity of operation and minimum maintenance, however, the available commercial equipment is often too complex. To meet the demand for mobile equipment, W. E. Hanson* proposed that a photoelectric sensor could be used in an electromechanical device to provide a simple, inexpensive, chronometric generation of a code-pulse train. He then constructed a model that used a series of disks to interrupt light beams at regular intervals. By means of this well-known technique, timing pulse signals were produced by photodiodes that detected the interruptions of the light beam. A refinement of the model, suggested by E. H. Fischer,* was to use additional disks and to place them in pairs to strobe through a pattern of holes drilled in the disks. Stationary light beams would thereby be interrupted in a predetermined sequence to produce a timing code.

Just such a simple, rugged, and inexpensive device to provide a timing code for shipboard records of missile firings was needed at APL. Therefore, the time-code generator developed at APL was adapted to generate the Atlantic Missile Range (AMR), 13-bit, 1-pulse/sec code (it is equally adaptable to many other codes, including 100-pulse/sec codes).

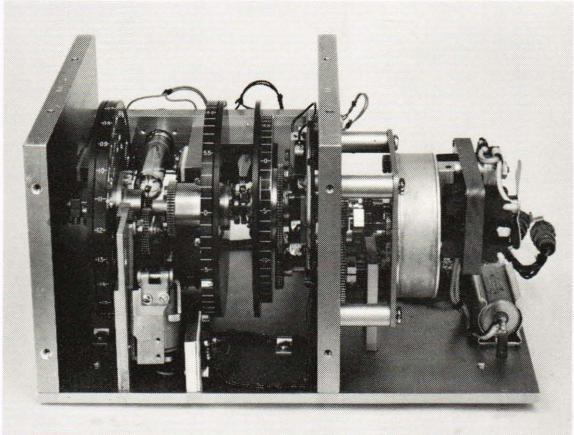
The accuracy of the generator depends on a synchronous motor, which may be driven by 60-cycle AC power as in the AMR design. Increased accuracy may be obtained by using a tuning fork and power amplifier, or a piezoelectric crystal and power amplifier.

The coded photo readout is accomplished by using three disks, seconds, minutes, and hours respectively, in which holes are drilled at appropriate

*W. E. Hanson is a member of the Analog Playback Section, and E. H. Fischer is a member of the Electronic Development Project, Bumblebee Instrumentation Group.



The face of a representative disk, showing the pattern of holes drilled for minutes.



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.