

Thus, the top row of this column represents the number 31 in the binary system. Likewise, the remaining rows represent the numbers 18, 3, and 0 in turn.

Although any signal quantized in time and amplitude can be regenerated, one involving two position or On-Off pulses is almost ideally suited to this process. Thus, it is seen that binary PCM is likely to become a very practical example of a system of transmission that overcomes the distance limitation in the transmission of wide-band high-fidelity material over radio relay systems.

In addition to the regenerative feature of PCM, another important property involved in the digital coding process is brought out by the following discussion. In microwave systems, where relatively wide bands are available, it is desirable at times to trade band width in the medium for signal-to-noise advantage. Wide-band frequency modulation is a well-known example of this method of operation. Here if the band width is doubled, the signal-to-noise power ratio is increased by a factor of 4. For a PCM system, however, a much greater factor is obtained. If we double the band width, we can send twice as many digits. Thus, if we start

with a 5-digit system and double the band width, a 10-digit system results. Since a 5-digit system has 32 levels and a 10-digit system has 1024 levels, the signal-to-noise power ratio has increased by $(1024/32)^2 = 1024$ times. From this discussion, it appears that the digital coding principle allows the trading of band width (necessary for the increased number digits) for noise on a much more favorable basis than that realized in ordinary frequency modulation.

Summarizing: We have seen that for continuous modulation systems the accumulation of noise in a repeater system results in a definite limitation to the length of the system. By using quantized modulation where both time and amplitude are quantized, it is possible to use regenerative repeaters and avoid the accumulation of noise in a long system. In addition, PCM, which is an example of a signal that can be regenerated, also has the property of trading band width for noise on a very favorable basis.

The curves shown in Figs. 2 and 3 of this article are taken from a paper by the author, "Telephony by Pulse Code Modulation," BELL SYSTEM TECHNICAL JOURNAL, July, 1947.

ROBERT A. MILLIKAN CELEBRATES 80TH BIRTHDAY

ON MARCH 22, Dr. Robert A. Millikan celebrated his 80th birthday. In honor of this occasion, the Associates gave a dinner on March 15, at the California Club, Los Angeles, and the faculty, under the chairmanship of Professor William Fowler, are planning a dinner early in April at which Dr. Millikan will be presented with a special issue of "Review of Modern Physics", published in his honor. This volume of the "Review", combining both the

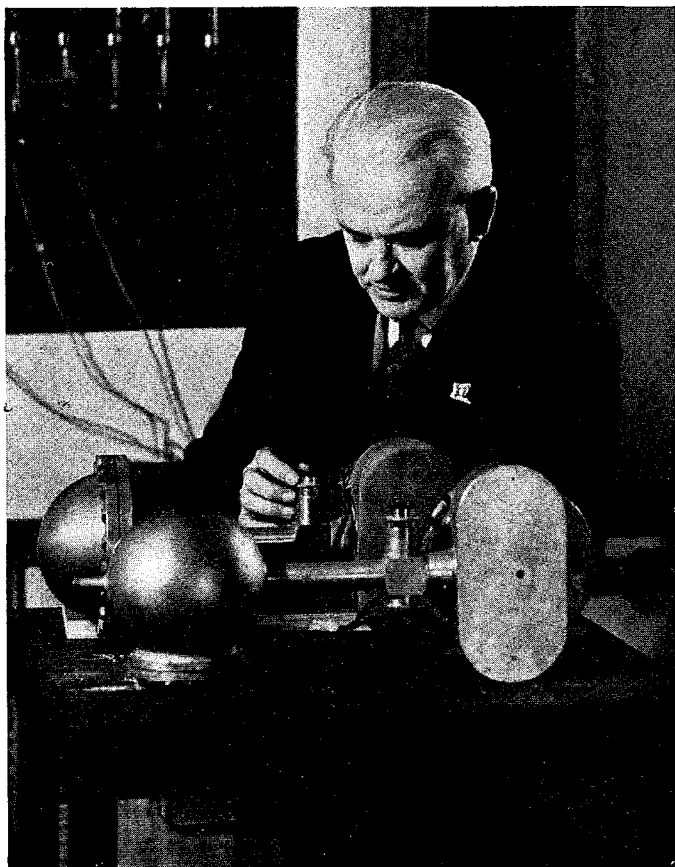
January and April issues, is comprised of articles on Millikan's scientific interests written by his former students and associates.

Dr. Millikan, having retired in 1946 from his administrative positions as director of the Norman Bridge Laboratory of Physics and chairman of the Executive Council at the Institute, is now acting in an advisory capacity as vice-chairman of the Board of Trustees and continuing his research work and writing. Prior to his retirement, Millikan had been with the Institute since 1921 when he left his position as professor of physics at the University of Chicago, where he had been in the Physics Department for 25 years.

A native of Iowa, Dr. Millikan received his A.B. degree from Oberlin College in 1891, his Ph.D. from Columbia University in 1895, and took advanced study in 1895 and 1896 at the Universities of Berlin and Göttingen. Although he took only one semester of work in physics during his undergraduate course, Millikan acquired a lifetime interest in this field when he helped work his way through college by teaching elementary physics during his junior year, and upon graduation, when he accepted a position as a physics tutor at the Oberlin Academy.

A recipient of many medals of honor, among them, the Nobel Prize in Physics from the Royal Swedish Academy in 1923, the Faraday Medal from the Chemical Society of London in 1924, and in 1937 the Franklin Medal from the Franklin Institute of the State of Pennsylvania, Millikan is best known for his work on the isolation and measurement of the electron; the direct photo-electric determination of the fundamental radiation constant known as Planck's h ; his study of Brownian movement in gases; his more recent study of the nature and properties of cosmic rays, and the 18 books of which he is either the author or joint author.

A former president of the American Physical Society, and the AAAS, Dr. Millikan is an honorary member of many other scientific societies, among them, the National Academy of Science, the American Philosophic Society, and several foreign groups, and has received honorary degrees from 20 colleges and universities in this country and abroad.



Dr. Robert A. Millikan