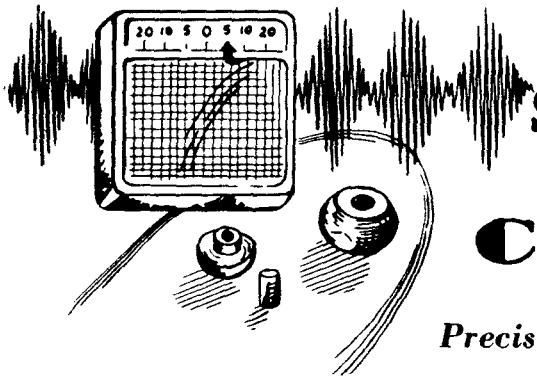


STANDARDS AND CALIBRATION

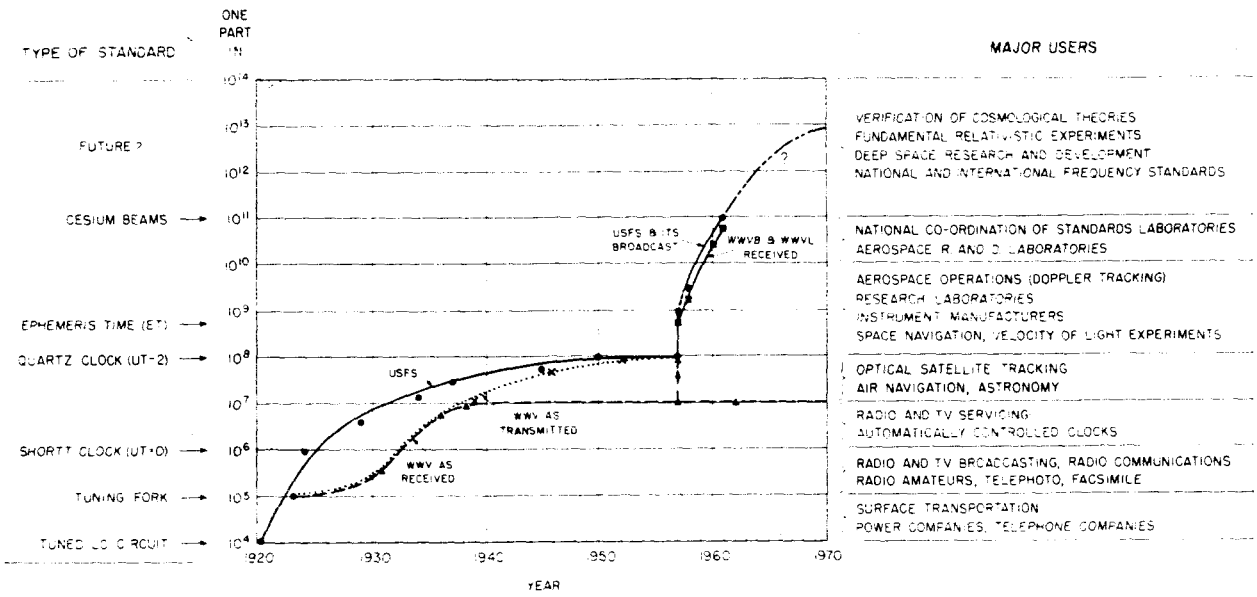
Precision of the U.S. Frequency Standard

THE BUREAU has maintained the United States Frequency Standard (USFS) since 1920, and since 1923 has made the standard available through the high-frequency broadcasts [1] of station WWV, now located at Beltsville, Md. A companion HF station (WWVH, Maui, Hawaii) was established in 1948 to provide wider coverage, and new facilities were recently put in operation for low-frequency stations WWVB and WWVL,[2] Ft. Collins, Colo., to assure reception on a global basis.

Research and development over the years have resulted in vast improvements in the precision of the USFS, and in the stability of the broadcast signals. In the figure below, the solid line represents the improvements in the precision of the USFS. The sharp upward turn in 1957 reflects the conversion to an atomic frequency standard. The present standard, a cesium beam maintained at the NBS Boulder (Colo.) Laboratories, is precise to 2 parts in 10^{12}, a precision much higher than that achieved in the measurement of any other quantity. One to two parts in 10^{13} are attainable for measurement times of about 10 hr. Work is in progress at Boulder on a cesium standard that should provide about twice the precision of the present standard: on a thallium beam that to date has provided the same precision as the standard and can perhaps improve on the accuracy of the cesium beam by a factor of 10; and on a hydrogen maser that represents a potential increase in precision by a factor of 10.

The dotted line in the figure represents the stability of WWV (and WWVH after 1948) as transmitted. Since 1957, the stability of all broadcast signals has been essentially that of the USFS. The dashed line shows the stability of the WWV and WWVH signals as received. The leveling off of the signals as received at about 10^{7}, despite great increases in the stability of the broadcast signals, results from inherent limitations imposed on the signals by ionospheric instabilities.

IMPROVEMENTS IN THE PRECISION OF THE U.S. FREQUENCY STANDARD (USFS) AND ITS DISSEMINATION



Improvements since 1920 in the precision of the U.S. Frequency Standard, and in the precision of the broadcast and received signals of NBS standard radio stations. From 1957 on, the precision of the broadcast signals matches that of the Frequency Standard. At the left are listed the various frequency standards used over the years, and at the right the level of precision required by different users.

Low-frequency stations WWVL and WWVB provide a much higher received accuracy than WWV and WWVH because of the difference in the modes of propagation. High-frequency signals are propagated by successive reflections between the earth and the ionosphere. Changes in the composition and height of the ionosphere create instabilities in the propagation of these signals, and degrade the received accuracy. Low-frequency signals, on the other hand, are propagated directly from source to receiver, ducted between earth and ionosphere, and are degraded very little during propagation.

[1] *NBS Misc. Publ. 236*, Standard frequencies and time signals from NBS stations WWV and WWVH, *available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C., 20402, price 10 cents.*

[2] *See* New facilities dedicated for WWVB and WWVL, *NBS Tech. News Bull.* **47**, *178 (Oct. 1963)*.

New NCSL Officers

The National Conference of Standards Laboratories recently held an election by mail ballot. Results of the election are as follows:

Chairman: A. J. WOODINGTON, General Dynamics/Astronautics.
Vice Chairman: W. G. AMEY, Leeds & Northrup.
Recording Sec./Treas.: H. W. LANCE, NBS Boulder (2-yr. term).
General Committee:
H. C. BIGGS, Lockheed Missiles and Space.
O. E. LINEBRINK, Battelle Memorial Institute.
S. C. RICHARDSON, General Electric.
C. E. WHITE, AVCO R.A.D.
L. B. WILSON, Sperry Gyroscope.

I. G. EASTON, General Radio, continues as Corresponding Secretary until September 30, 1964, at which time the terms of the above officers, with the exception of Mr. Lance, also expire.

Astin Receives Rockefeller Award

Dr. Robert F. Goheen (*right*), President of Princeton University, presents NBS Director Dr. Allen V. Astin with a 1963 Rockefeller Public Service Award. Dr. Astin was cited as a senior career government employee who has "made outstanding contributions to the nation" through his work. (See p. 23 in the January 1964 *Technical News Bulletin*.)