INTERNATIONAL COMPARISON OF ATOMIC FREQUENCY STANDARDS VIA VLF RADIO SIGNALS

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A study was made of data obtained over an 18 month period (July 1961 to December, 1962, inclusive) on the comparison of atomic standards located in six laboratories in the U.S., Europe and Canada, using the VLF signals of GBR (16 kc/s), Rugby, England and NBS (18 kc/s), Balboa, Canal Zone. Also included were data obtained by the U.S. Naval Observatory.

The statistical analysis was designed to separate the observations at each laboratory into three components: (a) long term mean differences among the atomic standards; (b) statistical estimates of the receiver uncertainties, $\hat{x}_i$, (c) statistical estimates of the transmitter uncertainties, $\hat{T}_i$. $\hat{x}_i$ includes receiver fluctuations, propagation effects peculiar to the path, and measurement uncertainties; $\hat{T}_i$ includes the transmitter fluctuations and propagation effects common to all paths.

The study shows that $\hat{x}_i$ at each receiver varied from $0.39 \times 10^{-10}$ (GBR data) at NEUT to $1.97 \times 10^{-10}$ (GBR data) at NRC with an average for all stations of $0.88 \times 10^{-10}$ measured against GBR and $0.99 \times 10^{-10}$ when measured against NBA.

Average $\hat{T}_i$ for GBR is $1.25 \times 10^{-10}$ and for NBA is $0.68 \times 10^{-10}$.

Finally, (1) all atomic standards agreed to within two parts in $10^{10}$ for the 18-month period, and (2) laboratory type standards agreed to within one part in $10^{10}$.

THE NBS TIME SCALE RELATION TO OTHERS

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An atomic time scale (NBS-A) using the United States Frequency Standard hyperfine structure separation in cesium 133 c/s. NBS atomic time was assigned to time on January 1, 1958. Since then, it has an average rate of about $1 \times 10^{-10}$ sec/sec.

More recently atomic clocks with more precise values have been placed in operation at Boulder, Colorado, and more recently the Naval Observatory and the Loran-C receivers in North Carolina, were determined to an accuracy of $10^{-10}$ second between these various stations.*

The Loran-C time pulses are now used to define the NBS-A time.

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* J. Newman, L. Fey, and W. R. Atkinson,
** J. A. Barnes, D. H. Andrews and D. W. A.
*** J. A. Barnes, and L. Fey, Proc. IEEE, 51