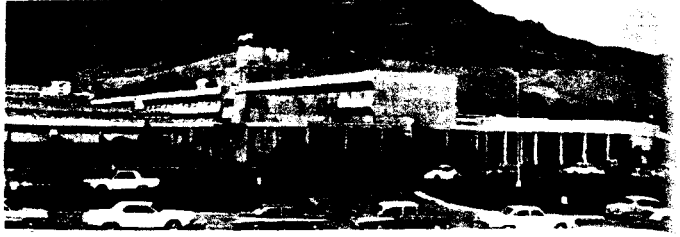

The Nation's two "time keepers"—the National Bureau of Standards, Boulder, Colo. (top) and the U.S. Naval Observatory, Washington, D.C.—recently synchronized their clocks to provide the country with a unified time system of unsurpassed accuracy.

NATION GETS Unified Time System

NBS and Naval Observatory Synchronize Time to About 1 Microsecond

A UNIFIED TIME SYSTEM of unsurpassed accuracy for the entire country was achieved recently when the Nation's two "time keepers"—the National Bureau of Standards and the U.S. Naval Observatory (USNO)—synchronized their clocks. On October 1, 1968, these agencies cooperated to effect a much more precisely coordinated time system than has ever before existed. The action taken by these agencies was the synchronization of their Coordinated Universal Time (UTC) clocks to within about 1 microsecond of each other. Synchronization was achieved when the NBS Time and Frequency Division (Boulder, Colo.) increased the rate of its UTC(NBS) clock by 4 parts in 10^{13}, while the Naval Observatory (Washington, D.C.) decreased the rate of its UTC(USNO) clock by 4 parts in 10^{13}.

The Bureau and the USNO have been cooperating under regulations of the International Radio Consultative Committee (CCIR), which for the past several years has required synchronization of standard time broadcasts to one thousandth of a second. This has been adequate for most users, but as technology has advanced, many precise timing needs have developed that cannot be met by this tolerance. More than a year ago, the desirability of synchronizing the USNO and NBS frequency and time standards to much finer tolerances than 1 millisecond was recognized.

In anticipation of a coordinated coordinate rate for USNO and NBS, on August 24, 1967, the Coordinated Universal Time clock of the Bureau, UTC(NBS), and all UTC transmissions of NBS were advanced by 200 microseconds. This left NBS about 35 microseconds early relative to USNO.

As the rate of the USNO clock has been high relative to the NBS clock by about 1 part in 10^{12}, the two clocks drifted toward each other. Their time lines converged on about October 1, 1968, and the time difference between the USNO clock, UTC(USNO), and the NBS clock, UTC (NBS), became zero. At that time USNO reduced the rate of its clock by 4 parts in 10^{13}, and NBS increased the rate of its clocks controlling NBS standard transmissions by 4 parts in 10^{13}. (A clock running fast by 4 parts in 10^{13} accumulates about 35 billionths of a second error per day. This rate of error would require about 80 000 years to accumulate one second in error.) The present specified absolute accuracy of the rate of the NBS clock is ± 5 parts in 10^{12}.

Measurements made after October 1 with portable clocks indicate that the time difference between the USNO and the NBS coordinated clocks is within one microsecond. By mutual agreements between USNO and NBS, small frequency adjustments ($<10^{-12}$) will be made infrequently to assure that this time difference remains less than about three microseconds.

Among scientists requiring more precise time measurements are geodesists, who, in attempting to measure the Earth very accurately, must sight on an artificial satellite from distant locations at very nearly the same instant of time. The sightings must be made within about 100 microseconds of each other, but the geodesists would prefer that the time error be within 10 microseconds. There are also military and NASA requirements that require synchronization accuracies in the microsecond range. It should be emphasized that this is synchronization accuracy and not absolute time-of-day accuracy.

Meanwhile, there is a general trend in technology toward tighter tolerances on synchronization. For example, the planned Aircraft Collision Avoidance System (ACAS) specifies worldwide synchronization accuracy of 0.5 microsecond, which is possibly beyond the current state-of-the-art.

To meet such needs, the National Bureau of Standards and U.S. Naval Observatory are engaged in a joint effort to provide a unified time service to all the United States. The new system is near the limit of the present state-of-the-art in its ability to provide accurate time and time synchronization to remote locations. This synchronization system is expected to provide a working model of a coordinate time system suitable for extension to worldwide coverage at some later date.