# Changes in WWV/WWVH Standard Broadcasts

On January 1, 1961, at 0000 UT, the Bureau retarded the time signals broadcast from radio stations WWV and WWVH by 5 msec,[1] and at the same time resumed broadcasting a special timing code[2] which gives the day, hour, minute, and second (UT) coded in binary form. The 5-msec retardation brought the time signals of WWV/WWVH into closer agreement with other standardized frequency broadcasting stations throughout the world. The pulse timing code, tried out on an experimental basis for several months during 1960, has now been returned to the air on a permanent basis.

## *Time Signal Adjustment*

The United Kingdom and the United States began coordinating their time and frequency transmissions early in 1960. This coordination is the result of an agreement announced by Dr. James H. Wakelin, Jr., Assistant Secretary of the Navy (Research and Development), Dr. Allen V. Astin, Director of the U.S. National Bureau of Standards, and in the United Kingdom by the Astronomer Royal, Royal Greenwich Observatory, and the Director of the National Physical Laboratory.

Coordination was begun to help provide a more uniform system of time and frequency transmissions throughout the world, needed in the solution of many scientific and technical problems in such fields as radio communications, geodesy, and the tracking of artificial satellites.

Participating in the project are the Royal Greenwich Observatory, the National Physical Laboratory, and the Post Office Engineering Department in the United Kingdom, and, in the United States, the U.S. Naval Observatory, the Naval Research Laboratory, and the National Bureau of Standards. This program follows previous cooperative efforts of these agencies to achieve uniformity and simplification in procedures.

The transmitting stations which are included in the coordination plan are GBR and MSF at Rugby, England; NBA, Canal Zone; WWV, Beltsville, Maryland; and WWVH, Hawaii.

Although the signals emitted by all these stations are kept on as uniform a basis as is feasible, occasional corrections are necessary. The last previous time adjustment for WWV/WWVH, a retardation of 20 msec, was made on December 16, 1959. It is expected that adjustments in the time signals will be made as infrequently as possible and preferably at the beginning of each calendar year when necessary. The time signals are locked to the broadcast frequency.

In 1961 it is planned to maintain the frequency stable to 1 part in $10^{10}$ and at the same offset value as before, i.e., $-150$ parts in $10^{10}$ with reference to the United States Frequency Standard.[3]

## *Timing Code*

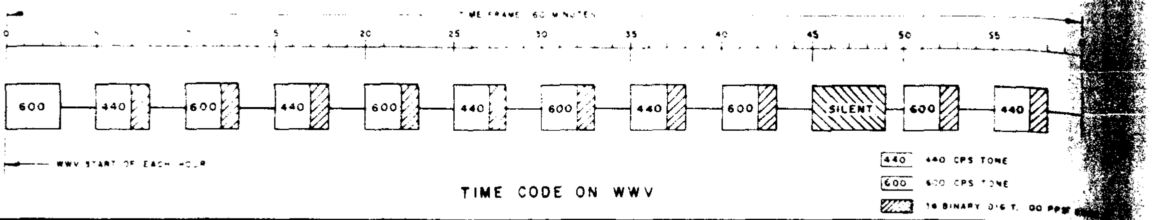
The timing code provides a standardized timing basis for use when scientific observations are made simultaneously at widely separated locations. It can be used for example, where signals telemetered from a satellite are recorded along with these pulse-coded time signals; subsequent analysis of the data is then aided by having unambiguous time markers accurate to a thousandth of a second. Astronomical observations may also benefit by the increased timing potential provided by the pulse-coded signals.

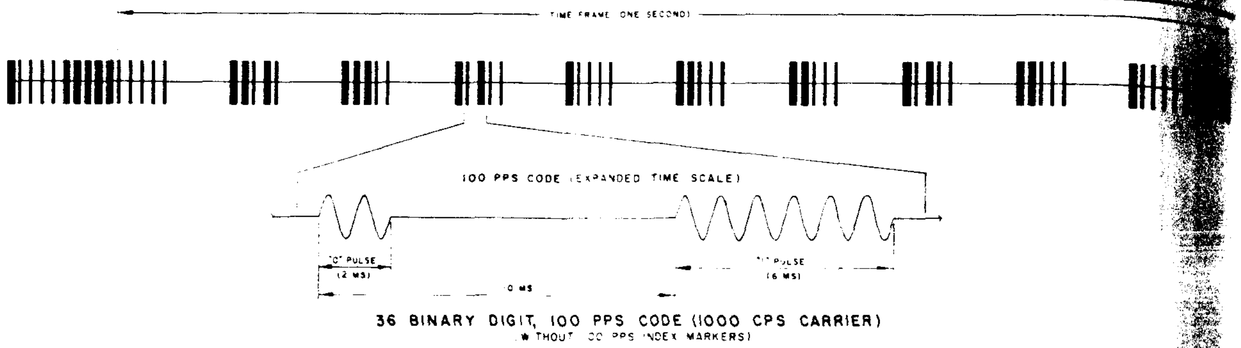
## *Description of Time Code on WWV*

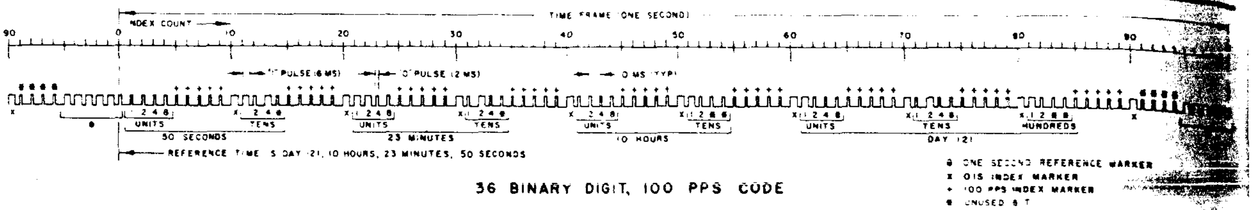
This 36-bit, 100-pulse/sec time code, carried on 1,000–c/s modulation, is being broadcast from radio station WWV (2.5, 5, 10, 15, 20, and 25 Mc/s). Starting date was January 1, 1961.

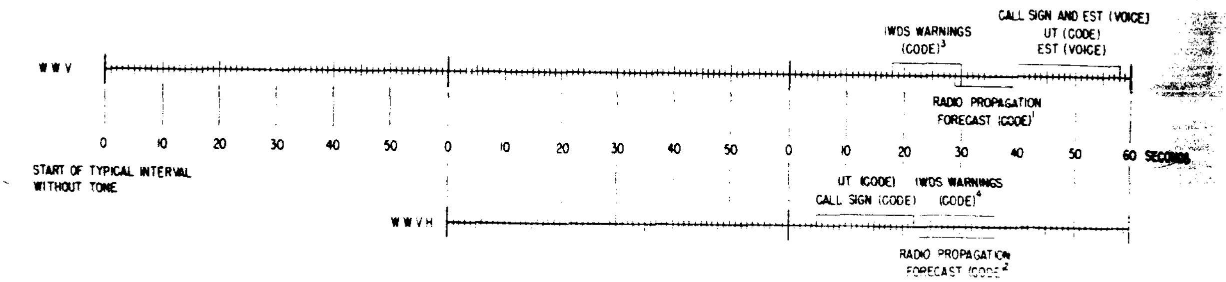
1. The code is broadcast for 1-min intervals and 10 times per hour. Except at the beginning of each hour, it immediately follows the standard audiofrequencies of 440 c/s and 600 c/s.
2. The code contains time-of-year information (Universal Time) in seconds, minutes, hours, and day of year. It is locked in phase with the frequency and time signals.
3. The code is binary coded decimal (BCD) consisting of 9 binary groups each second in the following order: 2 groups for seconds, 2 groups for minutes, 2 groups for hours, and 3 groups for day of year. Code digit weighting is 1–2–4–8 for each BCD group multiplied by 1, 10, or 100 as the case may be.
4. A complete time frame is 1 sec.
5. The least significant binary group and the least significant binary digit in each group occur first. The binary groups follow the 1-sec reference marker.
6. "On time" occurs at the leading edge of all pulses.
7. The code contains 100-per-second clocking rate, 10-per-second index markers, and 1-per-second reference marker. The 1,000 c/s is locked to the code pulses so that millisecond resolution is easily obtained.
8. The 10-per-second index markers consist of "1" pulses preceding each code group except at the beginning of the second where it is a "0" pulse.
9. The 1-sec reference marker is made up of five "1" pulses followed by a "0" pulse. The second begins at the leading edge of the "0" pulse.
10. The code is a spaced code format; that is, a binary group (BCD) follows each of the 10-per-second index markers. The last index marker is followed by

## Chart of time code transmissions from NBS radio station WWV.

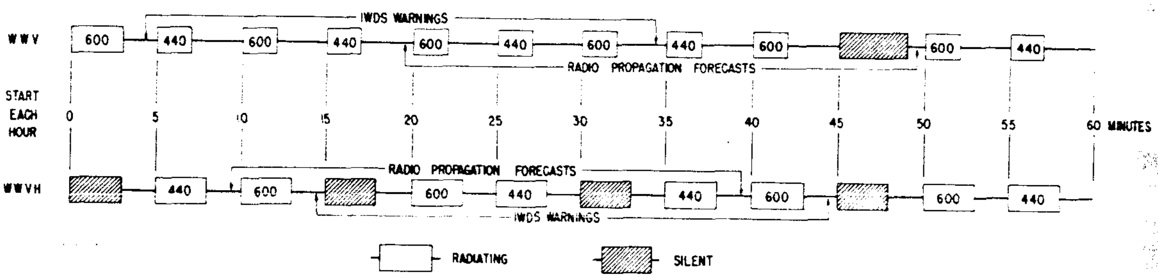


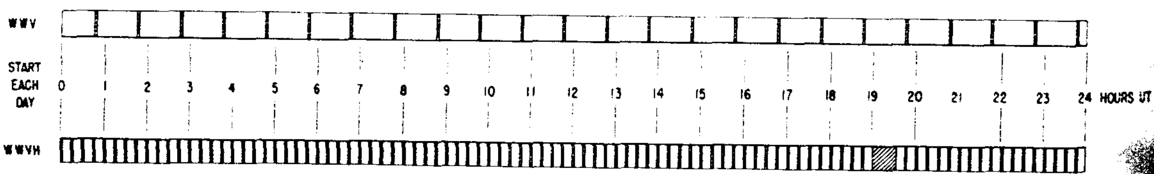




[1] 19.5 AND 49.5 MINUTES PAST EACH HOUR
[2] 9.4 AND 39.4 MINUTES PAST EACH HOUR
[3] 4.3 AND 34.3 MINUTES PAST EACH HOUR
[4] 14.4 AND 44.4 MINUTES PAST EACH HOUR



an unused 4-bit group of "0" pulses just preceding the 1-second reference marker.

11. The unused 4-bit group may be used in the future to transmit other types of coded information, such as the last digit of the year, station number, etc.

12. Width coding:

"0" pulse, 2 msec wide (2 cycles of 1,000 c/s)
"1" pulse, 6 msec wide (6 cycles of 1,000 c/s)

13. The time code is amplitude modulated on 1,000 c/s. The leading edges of the time code pulses coincide with a positive-going zero-axis-crossing of the 1,000 c/s.

[1] National standards of time and frequency in the United States, *Proc. IRE* **48**, *105–106* (*Jan. 1960*).

[2] Experimental timing code added to WWV broadcasts, *NBS Tech. News Bul.* **44**, *114* (*July 1960*).

[3] Atomic frequency standards, *NBS Tech. News Bul.* **45**, *8* (*Jan. 1961*).

*For additional technical information see* Standard frequencies and time signals from NBS stations WWV and WWVH. *NBS Misc. Publ. 236, available from the Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C. Price: 10 cents.*

# The AMOS IV Computer

## for a prototype automatic weather station

THE BUREAU, in cooperation with the U.S. Weather Bureau, has developed a specialized digital computer[1] for the Weather Bureau to use as a research tool in exploring the concept of the automatic weather station. The AMOS IV computer receives data from weather-sensing instruments and processes these data through such functions as sampling, comparing, selecting a maximum, and arithmetic operations. The results are transmitted via teletype to a central forecasting station and to other airport weather stations. Values of two quantities recently developed as aids to air safety—runway visual range and approach light contact height—are given by the machine through automatic table look-up.

For a number of years the Weather Bureau has been appraising the possibilities of an automatic weather station. Such stations could be widely distributed, and would be especially useful in relatively inaccessible locations that are important sources of early data on meteorological activity. The various developmental prototypes of this concept have been called AMOS (Automatic Meteorological Observation Station); the current version, containing transistorized packages, is AMOS IV. This model was designed and built by Paul Meissner and J. A. Cunningham of the NBS data processing systems laboratory and by C. A. Kettering of the U.S. Weather Bureau. It is an outgrowth of previous work done by NBS for the Weather Bureau that resulted in a special computer[2] for processing cloud-height signals from a ceilometer. The ceilometer was intended for use with the AMOS III.

Several of the input quantities to the AMOS computers, such as cloud height and precipitation, cannot be satisfactorily represented by instantaneous values but must be time-averaged. Varying amounts of data

**Overall view of the prototype AMOS IV computer. Inset: One of the drawers of transistorized plug-in package assemblies (at left in large picture).**