NBS Low-Frequency Station WWVB to Broadcast International Unit of Time

Following the adoption by the 12th General Conference of Weights and Measures of a supplementary definition of the second based on the invariant transition of the cesium atom, the Bureau has begun broadcasting the new international unit of time from its Fort Collins, Colo., low-frequency station WWVB, effective January 1, 1965.

This action follows the request by the U.S. Study Group VII, of the International Radio Consultative Committee (CCIR), for a study to determine the most useful systems for broadcasting the various kinds of time signals which find use in civil and scientific affairs.

A recent users' survey conducted by the National Bureau of Standards reveals that at least a third of the Nation's electronics establishments not only use the NBS frequency and time broadcasts as the basis for precise measurements in their operations, but that they expressed a wish for exact atomic time and frequency by direct broadcast. These users include the largest governmental and industrial laboratories, precision instrument manufacturers, space hardware manufacturers, satellite launch facilities, and missile-tracking facilities.

The standard carrier broadcasts from WWVB will be maintained without offset with respect to the United States Frequency Standard (USFS) within a tolerance limit of $\pm 2 \times 10^{-11}$.

Time pulses are produced by amplitude modulation of the carrier. Each pulse, initiated at the same relative phase of a cycle of the carrier, is repeated at intervals of 60 kilocycles of the 60 kHz carrier—or once each second (the international or atomic second). Thus the new international unit of time is directly available to listeners for the first time.

The phase of these periodic time pulses relative to the carrier phase will be shifted by a step adjustment of 200 msec, or exactly 12,000 whole cycles of the carrier, about once every 3 months or so in order to remain within approximately 100 msec of the UT2 scale which is broadcast by the other NBS stations. Adjustments will always be carried out at 0000 UT on the first of each month. The first such adjustment was made on January 1.

Keyed Morse Code announcements, which provide the time difference, UT2 minus time of pulse, will be broadcast in the same manner as for WWV and WWVH. The difference in milliseconds will be broadcast during the identification period on the hour and every 20 min thereafter in International Morse Code. The code, UT2 AD (for add) or UT2 SU (for subtract) is followed by a three-digit number. Added to or subtracted from the time indicated by the time pulse, the correction will give the UT2 scale. The corrections will be revised daily, the new value appearing for the first time during the day after 0000 UT, and will be repeated for the ensuing 24-hr period. NBS obtains its UT2 information weekly from the U.S. Naval Observatory in accordance with the close cooperation maintained by the two agencies.

Advance announcements of step adjustments will be made in the *Federal Register* so that listeners may be adequately prepared.

Aluminum Carbide, cont.

In the NBS experiments, it was found that the completeness of combustion of the aluminum carbide sample was related to the heat capacity of the sample container in the combustion bomb. By use of small alumina disks as supports for the sample on the platinum-iridium loop, combustion of more than 99.5 percent of the aluminum carbide was achieved. The value for the heat of formation of aluminum carbide was determined to be −208 kJ/mole (−49.7 kcal/mole) with an overall uncertainty of ±5 kJ/mole (±1.2 kcal/mole).

An interesting result of the study was the finding that 45 to 75 percent of the solid combustion product was the delta crystalline form of aluminum oxide (alumina) which condensed on the walls of the bomb as a fine powder. The rest of the solid product, a massive lump remaining in the combustion zone, was the alpha crystalline form of alumina. The conditions under which delta alumina has been reported to be formed readily (presence of carbon and nitrogen, and rapid condensation and cooling from the gas phase) all were present in these experiments and may explain the formation of such a large amount of this less well-known form of alumina.

crystalline forms

In previous investigations, little if any mention was made of the crystalline forms of alumina in the combustion product. The present work shows that for accurate heat-of-formation data from calorimetric studies of refractory compounds, giving solid combustion products, it is important to identify the various crystalline forms in the combustion product and to correct the heat measurements for their formation. Information gained in these experiments, regarding delta-alumina formation, may be of value in describing aluminum reactions in the environment of a rocket motor, which is chemically similar to the environment in which delta alumina is formed in bomb calorimetric experiments.

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[1] The heat of combustion and heat of formation of aluminum carbide, *by R. C. King and G. T. Armstrong, J. Res. NBS* **68A** *(Phys. and Chem.), 661 (1964).*

[2] Precise measurement of heat of combustion with a bomb calorimeter, *by R. S. Jessup, NBS Mono. 7 (1960).*

[3] *The aluminum carbide sample for this study was supplied by the Aluminum Company of America Research Laboratories. Quantitative chemical analysis showed in weight percent:* Al_4C_3, 94.8; Free Al, 1.0; Free C, 1.0; AlN, 1.3; Al_2O_3, 2.2; Fe, 0.06.