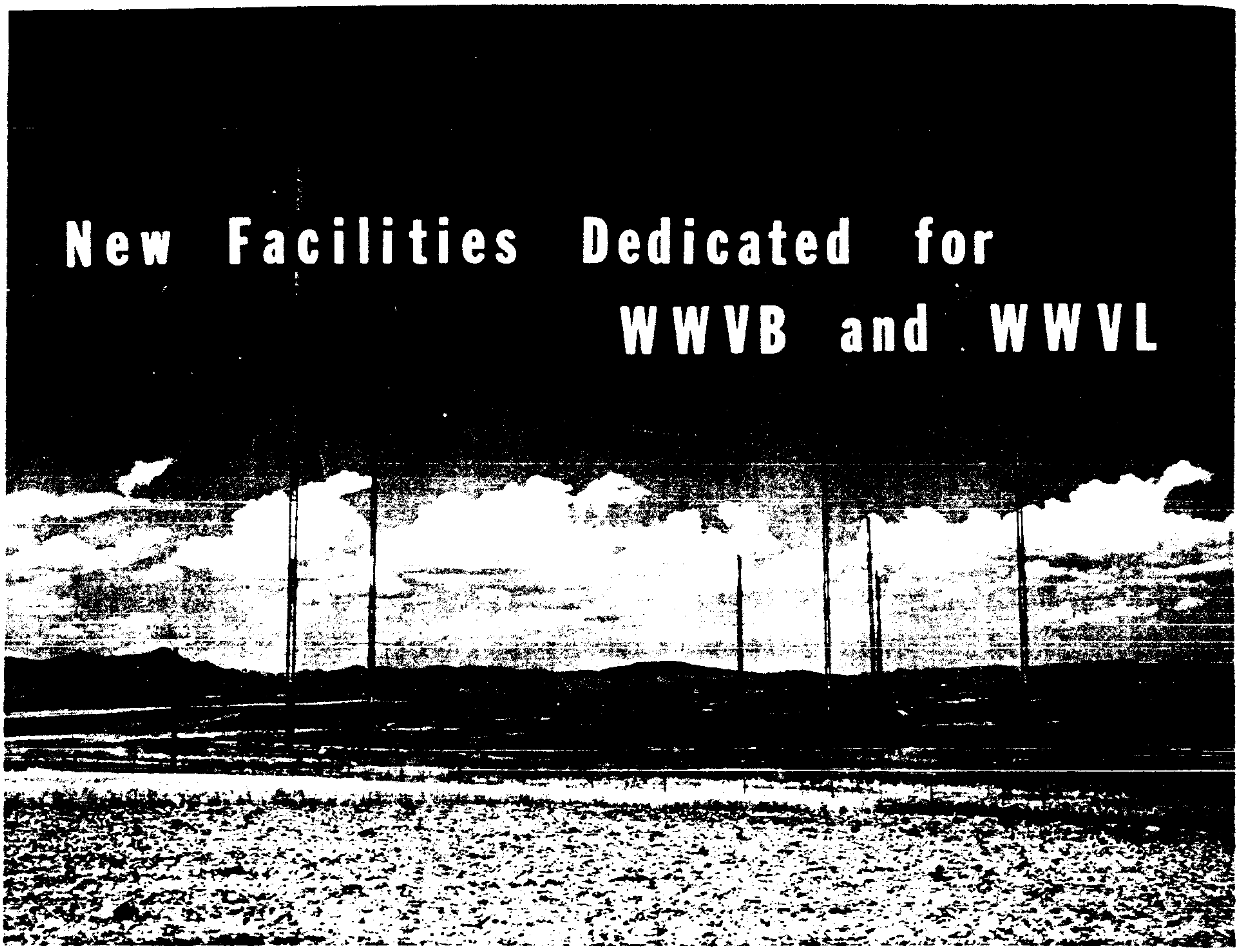
New Facilities Dedicated for WWVB and WWVL



NEW facilities, providing greatly increased power and range, were dedicated for standard broadcast stations WWVB and WWVL on August 13, 1963. Operated by the NBS Boulder Laboratories at a site near Fort Collins, Colo., these stations transmit standard frequencies which are received at greater accuracy than those of NBS high-frequency stations WWV and WWVH. This higher accuracy is required in many satellite and missile programs and for basic research on atmospheric and ionospheric phenomena.

Until recently, stations WWVB and WWVL have been used only for experimental low-frequency transmissions—WWVB broadcasting at 60 kc/s from Boulder, Colo., and WWVL at 20 kc/s from Sunset, Colo. The success of the experimental broadcasts provided technical justification for the construction of new facilities at Fort Collins and establishment of the two stations on a permanent basis. The new stations complement but do not replace WWV and WWVH, which are sufficiently accurate for many important applications.

Special dedication ceremonies for the low-frequency facilities were held at the NBS Boulder Laboratories during the Symposium on Ionospheric Propagation of Very Low Frequency Waves (August 12–14). Dr. J. M. Richardson, Chief of the NBS Radio Standards Laboratory, was chairman of the dedication session, at which Dr. A. V. Astin, NBS Director, and Dr. R. D. Huntoon, Deputy Director for Basic Standards and Services, spoke. The dedication was followed by a technical session devoted to the new stations and their use, after which the Symposium delegates had an opportunity to visit the Fort Collins site.

The Bureau has for many years provided standard frequency and time broadcasts over high-frequency stations WWV and WWVH. These high-frequency signals are propagated over long distances by alternate reflections between the earth and the ionosphere. As the height and density of the ionosphere change constantly, resulting in changes in the path of the radio waves, there is a loss of accuracy in the signals at the point of reception. To overcome this inherent limitation of high-frequency transmissions, WWVB and WWVL are operated in the low- and very-low-frequency regions, respectively. Their radio waves follow the curvature of the earth, with the ground and the ionosphere acting as the lower and upper limits of a gigantic duct to guide the signals over the globe. As the iono-

Opposite page: **The new facilities for WWVL and WWVB will provide frequency standard broadcasts at 20 kc/s (WWVL) and 60 kc/s (WWVB) with greater received accuracy than was previously available. The antenna for each station consists of four steel towers arranged in a diamond 1900 ft long and 750 ft wide.**

sphere acts as a boundary and not as a reflector, its variations have almost no effect on the travel of the waves; thus the stability of the received signals is increased. The stability of the signals of all Bureau stations is 2 parts in 100 billion at the transmitter.

Station WWVB broadcasts at 60 kc/s, with a radiated power of 5 (later to be increased to 7) kilowatts. The signal as received is some 100 times more stable than those available from WWV and WWVH. This station is designed to serve the continental United States, as it provides more stable coverage at distances up to 2,000 miles than does its sister station WWVL. WWVB will be of service to the Air Force, U.S. Geological Survey, geophysical and seismic laboratories, missile ranges, and laboratories concerned with high-precision frequency research and calibration.

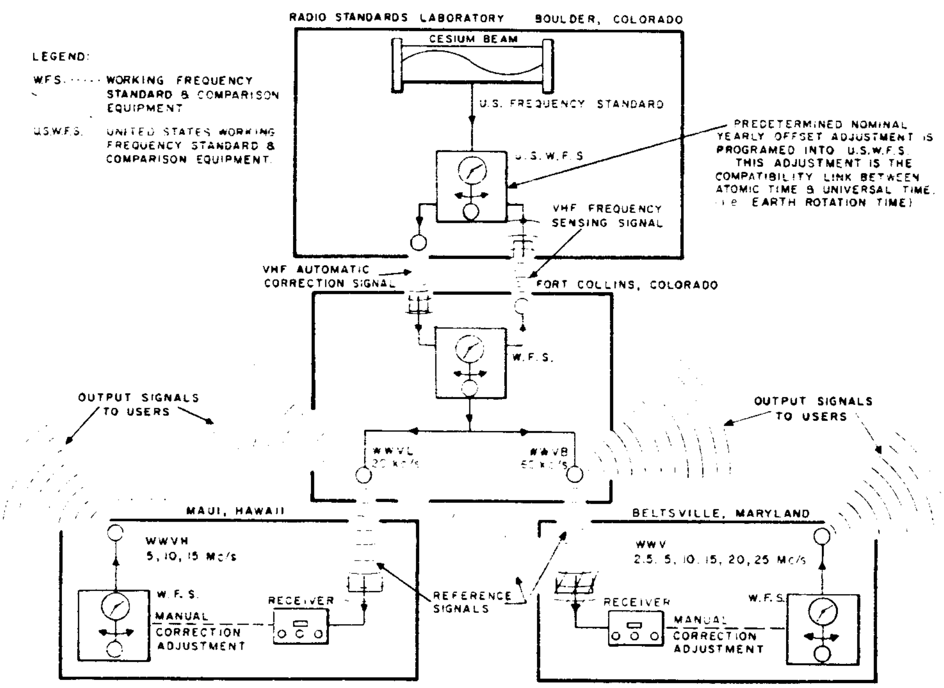
WWVL operates at 20 kc/s, with a radiated power of 1 kw. Frequency signals only are now being broadcast; time signals will be added later. The 20-kc/s signal of station WWVL provides intercontinental reception with a precision of 1 part in 10 billion in an observing period of about 1 day. Very-long-distance reception is important to international standardization activities, military bases, and the National Aeronautics and Space Administration. NASA, in fact, partially supported the construction of WWVL.

The Fort Collins site, covering 380 acres, was chosen because of the following advantages: High electrical conductivity of the soil; availability of the necessary electrical power; relative freedom from violent weather; ease of access to the site and nearness to NBS Boulder (not so near, however, as to interfere excessively with Boulder experiments); and a location away from major air routes.

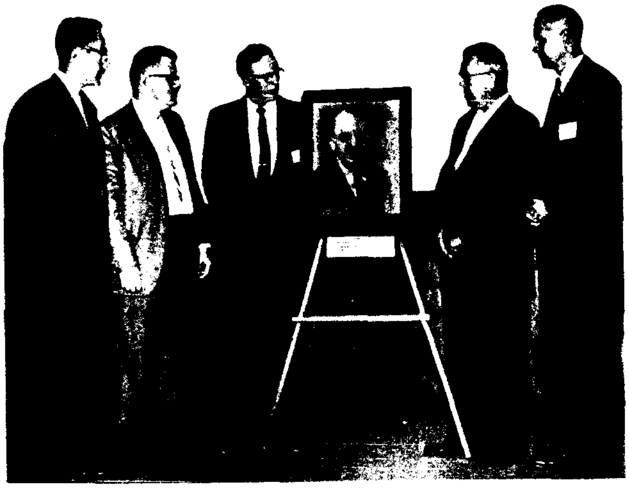
The antenna array for each station consists of four guyed steel towers, arranged in a diamond 1,900 ft long and 750 ft wide. Counterbalances are arranged at the inside and base of each tower to maintain proper tension at the top of the tower and to compensate evenly for winds which may sweep down from the nearby Rocky Mountains. A transmitter building is located between the two antennas; a helix house, used for resonance tuning, terminates each antenna.

A high-quality quartz crystal oscillator at the site provides stable carrier frequencies for the transmitters. To insure that the phase of these frequencies agree with that of the United States Working Frequency Standard maintained at NBS Boulder, a servo loop has been established between the site and the Boulder Laboratories. The carrier phases as received at Boulder are compared with the standard by means of phase detectors, any phase difference resulting in error signals. These error signals, along with a servo motor reference phase, modulate a 50 Mc/s FM telemetering transmitter at Boulder. The FM signals received at Fort Collins are applied to servo motors to correct phase errors that have occurred.

NATIONAL BUREAU OF STANDARDS
FREQUENCY & TIME FACILITIES



Drawing depicting the relationships between the cesium beam frequency standard and the U.S. Working Frequency Standard at NBS Boulder, and the standard frequency and time broadcasts from stations WWVL, WWVB, WWVH, and WWV.



A plaque and portrait photograph were placed at the Fort Collins site of WWVB and WWVL in tribute to W. D. George. Mr. George, killed in an automobile accident while attending an international meeting in Switzerland early this year, devoted his 33-year career at NBS to radio standards and measurement. Here *(left to right)* Dr. J. M. Richardson, Chief of the NBS Radio Standards Laboratory; Dr. R. D. Huntoon, NBS Deputy Director; Dr. A. V. Astin, NBS Director; Dr. R. B. Scott, Manager, Boulder Laboratories; and Dr. Y. Beers, Chief of the NBS Radio Standards Physics Division, are shown with the portrait.

Special Tribute to W. D. George

During the dedication ceremonies a bronze plaque, together with a large framed photograph, was placed at the Fort Collins site in memory of William Donovan George. Mr. George, a Consultant to the Chief of the Radio Standards Physics Division, was killed February 12, 1963, in an automobile accident in Switzerland. Mr. George was in Geneva as a U.S. Delegate to the International Radio Consultative Committee (CCIR).

Mr. George, a veteran of 33 years' service with NBS, had a distinguished career in the field of radio and electronics. Joining the Bureau after his graduation from the Georgia Institute of Technology, he devoted himself to the development of radio standards and measurements. In 1946 he was appointed Chief of the High Frequency Standards Section, and later served as Acting Chief of the Radio Standards Division at Boulder. Mr. George, author of 20 technical papers, served at both national and international conferences on radio propagation, and served as Chairman of U.S. Study Group VII—Standard Frequency Transmissions and Time Signals of the CCIR.

Stress-Corrosion Studies of Stainless Steel

data obtained with new type of specimen

A SPECIALLY designed specimen was recently used at the Bureau to investigate the stress-corrosion cracking of metals at elevated temperatures. This specimen, hollowed out so that the corrodent may be sealed into the cavity before stressing begins, was developed by H. L. Logan of the metal reactions laboratory in a study sponsored by the Atomic Energy Commission.[1] Data recently obtained with austenitic stainless-steel specimens of this type may be used to determine the conditions under which the alloy can be utilized safely for reactor components.[2]

In the method generally employed to evaluate the resistance of metals to stress-corrosion at elevated temperatures, both the specimen and the corrodent are placed in an autoclave in which they may be held at the desired temperature until cracking occurs. To apply stress, the specimen is bent into an arc or a U-shape and restrained from returning to an equilibrium position. However, with this technique no determinations can be made of the threshold value of stress necessary to start cracking nor of the changes that occur in strain with time-at-temperature.

To obtain such data, a specimen was designed that would itself serve as an autoclave which could be heated in a conventional creep furnace and simultaneously subjected to a known tensile stress. Specimens produced according to this design were machined from 1-in.-diam rods into 6 in. lengths. To make the cavity for holding the corrodent, a hole 0.50 in. in diameter was bored to a depth of approximately 4 in. along the longitudinal axis of each specimen. A reduced section about 2 in. in length was machined symmetrically on the outer surface about the longitudinal and transverse axes to achieve wall thicknesses of 0.034 or of 0.060 in. in this section. An austenitic stainless-steel plug was used to close the open end of the cavity, with a tube extending through the plug so that oxygen could be forced into the specimen cavity.

Concentrated Solution Experiments

In one series of experiments, the resistance of type 304 austenitic stainless steel to stress-corrosion cracking was investigated with a corrodent consisting of distilled water containing 20,000 ppm of chloride ion as sodium chloride. After the specimens were sealed and before they were heated, oxygen was forced into the cavities at a pressure of 100 psi. In a number of the specimens, the air above the corrodent in the cavity was also carefully displaced with oxygen at atmospheric pressure before the plug was inserted and the oxygen forced in under pressure.

Of 17 specimens exposed in this way under a stress of 30,000 lb/in.^{2} at preselected temperatures in the range of from 455 to 615 °F, 13 failed completely as a consequence of stress-corrosion cracking, with the