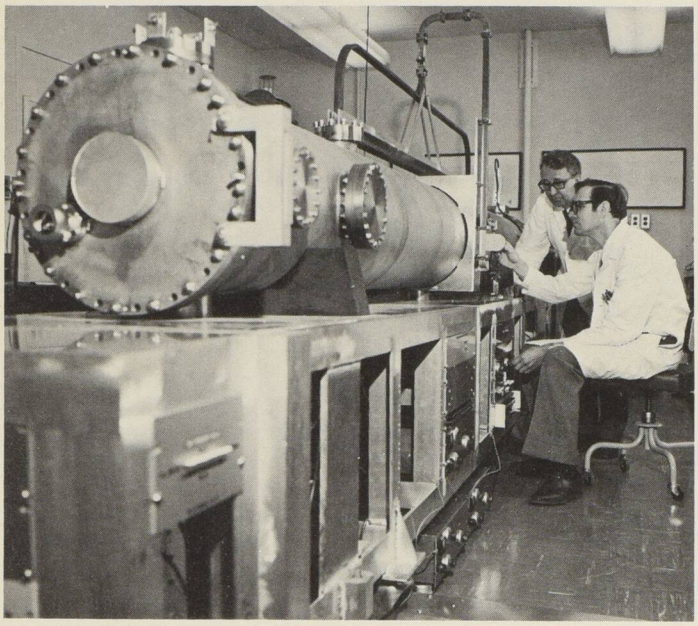

Cs V will begin operation shortly as the world's most accurate clock in the Time and Frequency Section of NRC's Division of Physics and will form the basis for Canada's official time scale. Dr. Allan Mungall (right) was responsible for the overall design and was assisted by Mr. Herman Daams (left) and Mr. Ralph Bailey.

L'horloge atomique Cs V sera bientôt en service à la section Temps et fréquence de la Division de physique du CNRC. Elle sera la base de l'échelle du temps officiel canadien. Le Dr Allan Mungall (à droite) a été responsable de sa conception globale et il a été aidé dans ses travaux par M. Herman Daams (à gauche) et M. Ralph Bailey.

remains stable, the output frequency from Cs V can be counted down by a series of electronic dividers and used to generate regular pulses at one second intervals which appear as numbers on a digital clock — precise atomic time.

Although the design of Cs V is similar to its predecessor, Cs III, certain modifications lead to a tenfold improvement in accuracy and stability.

For example, cesium oven and detector units are mounted at each end of the instrument making bi-directional beam operation possible. By averaging the results from operation in both directions, scientists can compensate for any differences in phase between the two microwave fields used to excite the atomic transitions.

"We want to realize the primary standard definition as accurately as possible," notes Dr. Cecil Costain, head of the Time and Frequency Section, "so that measurements have meaning not only today but in 50 or 100 years."

Scientists expect Cs V to maintain an accuracy of one part in 10^{13}. In other words, the atomic clock would be off by no more than three seconds in one million years.

The only other instrument of comparable accuracy is the hydrogen maser, a frequency standard based on the hydrogen atom as a microwave oscillator. Because of a greater short-term (up to 1000 seconds) frequency stability, two NRC-built masers can be used periodically to evaluate Cs V. However, these instruments are currently less suitable as clocks since their performance gradually deteriorates, showing a frequency shift over a longer time.

With Cs V, NRC will bring substantially improved accuracy to its dissemination of time and frequency to outside users in Canada and to its participation in international time comparisons with other countries through the Bureau International de l'Heure (BIH).

The NRC time scale is also compared regularly with those of other countries through reception at the main time laboratory of the 100 kHz (100 kc/s) pulsed radio signals of the Loran-C navigation system. The Loran chain, a series of stations which extends across the United States, spans the north Atlantic and reaches into Norway and Europe, is operated by the United States Coast Guard and is closely related to the time scale of the U.S. Naval Observatory (USNO). It provides the most convenient regular communication network between various national time laboratories.

In addition to the use of Loran-C, time comparisons using television signals provide links between NRC, the USNO and the National Bureau of Standards in Boulder, Colorado, and also between the NRC time laboratory and the independently operating clocks which provide the standard frequency and time signals transmitted by station CHU in Ottawa.

Although CHU generates its own signal via a secondary cesium standard (installed in 1963), daily cross-comparisons are made with the main time laboratory to ensure that the station's frequency and time conform to the standards agreed upon internationally. Continuous English and French voice announcements are transmitted over three short wave operating frequencies, 3 330, 7 335 and 14 670 kHz (kc/s).

Mr. Sidney Sheard, who is responsible for CHU's operation, notes: "Our time service via radio is available to anyone possessing even the most inexpensive short wave receiving set. Present-day users range all the way from interested listeners to government, scientific and industrial organizations for whose operation precise time is essential."

Time is also disseminated by telephone line from the main laboratory to other government departments. The telephone signal provided to the Canadian Broadcasting Corporation is retransmitted daily at 13:00 EST over the trans-Canada English network and at 12:00 daily on the French-language system.

In addition, many new methods of distribution are currently being investigated. These include dissemination of time by satellite through television broadcasts, and by high speed digital data transmission lines for aircraft collision-avoidance systems.

Another service planned for the near future is serial digital time code transmission over standard telephone lines. By this system, a user anywhere in Canada who owns a commercial digital clock can dial a given telephone number to place his unit in contact with a code generator clock at NRC's time and frequency laboratory. An electronic time code provided by NRC then acts by a data link through the telephone receiver to correct the commercial clock's time automatically to within one millisecond.

Dr. Costain foresees many applications for this service, particularly in the area of control voice-communication networks such as used by many police forces. In this system, audio tapes can be legally indexed with a time readout which would be displayed digitally on a suitable receiver to accompany a playback of the voice.

Another possible use is a digital display of time on home television receivers.

"I believe this is the best way to distribute time accurately and conveniently to the public," Dr. Costain says.

Modern timekeeping seems undoubtedly more efficient than timekeeping in Shakespeare's day:

"It shall be what o'clock I say it is." (Petruchio, Act IV, Scene III, The Taming of the Shrew).

For Petruchio, determining the hour of day was usually a matter of guesswork. However, with the advent of precise modern atomic clocks such as Cs V, these words now describe the certainty of NRC's role in providing official time for Canada □

W.J. Cherwinski