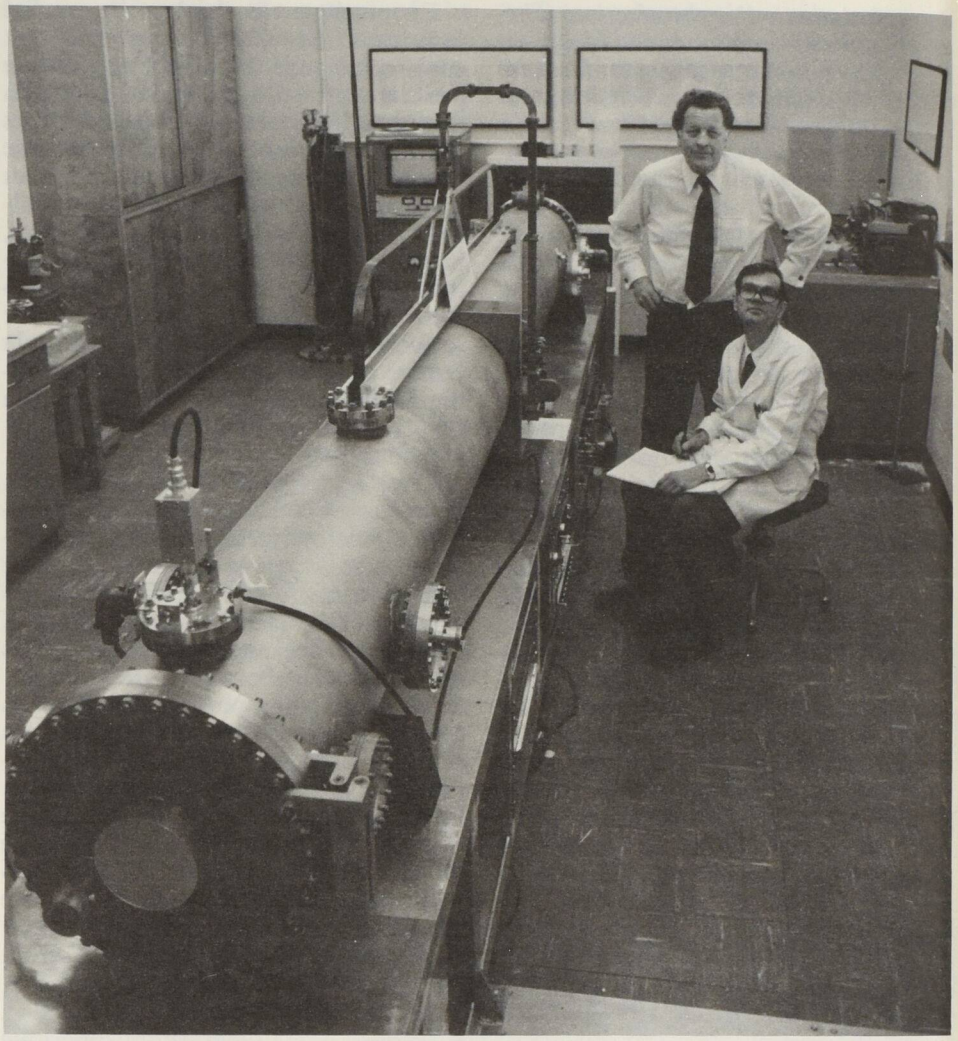
Canada's time standard

Cesium seconds

Physicists measure it as frequency from a primary cesium beam standard. We know it as minutes and seconds ticking by on the hands of a clock. Either way, time is the rhythm of society.



Dr. Allan Mungall (seated) and laboratory head, Dr. Cecil Costain make adjustments to CsV, the most accurate atomic clock in the world. *(Photo: Bruce Kane, NRC)*

Le Dr Allan Mungall (assis) et le Dr Cecil Costain, chef du laboratoire, ajustent l'horloge atomique la plus précise du monde: le CsV. *(Photo: Bruce Kane, CNRC)*

"Pardon me, do you have the correct time?" Ask that question at NRC's Division of Physics and you might hear more than you bargained for . . . an answer that's accurate to thousandths of a second.

Of course, that's too fine to set our clocks and watches by . . . minutes are usually good enough. But for NRC's atomic clocks, errors of even a millionth of a second are considered much too great.

The time and frequency laboratory in Ottawa is Canada's official timekeeper. Today, our time scale is derived from a large master instrument, a so-called primary or reference standard. This atomic clock generates a precise frequency corresponding to special properties of cesium atoms. That frequency actually defines the basic unit of time, the second.

Years ago, physicists used early models of cesium beam generators as primary frequency standards. These instruments were run only at intervals to adjust a group of smaller secondary clocks which ran continuously and were used to generate the nation's time scale. In 1975, the system was improved by combining the continuous operation of a clock with the accuracy of a primary standard. The result was CsV, the world's most accurate and stable atomic clock, off by no more than three seconds in a million years.

The construction of CsV marked a departure from conventional timekeeping practices . . . it was the first primary frequency standard designed and built to operate as a clock. The approach has proven so successful that other national time laboratories, in Germany and the U.S.A., have recently adapted their existing primary standards to clock operation.

Having thus improved the NRC time service on a primary standard level, physicists decided to go a step further. They turned their attention to their group of three commercial secondary clocks used routinely for calibration or for international time comparisons with other standards laboratories. "What we were aiming for," recalls Dr. Allan Mungall, "was a new set of secondary clocks having the performance qualities of primary standards. Of course, our experience with designing CsV gave us much of the necessary background to draw on."

After more than two years' work, a set of three new instruments, CsVI, was recently completed. Early tests indicate that the clocks are more stable than commercial models over a period of several hours and should be substantially more accurate. At present, physicists are evaluating the longer term stability (of the order of days or weeks).

"If things work out the way we hope," notes Mungall, "the CsVI ensemble will become our secondary standards, freeing our commercial clocks for other uses. For example, much of the calibration work we do involves transporting clocks from one location to another. Also, CsVI would certainly add another dimension to our ongoing research activities."

In recent months, Dr. Cecil Costain and co-workers at the laboratory have explored the use of satellites to compare time with French laboratories, the National Bureau of Standards in Colorado and the U.S. Naval Observatory (USNO) in Washington. In these experiments, the Symphonie and Hermes geostationary satellites have served as relay stations to transmit coded time signals back and forth between Ottawa and a distant partner laboratory. The NTS satellite on the other hand, carrying a cesium clock on board along with its own transmitter, has been used in a different way. Time signals have been sent from orbit to ground receivers at the Ottawa laboratory and at the USNO. Knowing the satellite's trajectory, the drift of its clock and the time taken for it to pass over the two centers, scientists have then been able to