of the proceedings were undiscernible or inaudible due to inadequate sound pickup or extraneous sound masking pickup. Stringent control over courtroom demeanor was required to insure good recording.

The guide is aimed at the non-scientist and includes a glossary of technical jargon. With the guide, the reader can evaluate costs, prepare the courtroom for recording, choose effective tape recording systems and techniques and plan maintenance and training programs. The guide also provides information on how to monitor events and performance, establish courtroom procedures for optimum recording, transcribe and store tapes and recognize system capabilities and pitfalls.

Specific recommendations are made on how to handle such problems as unintelligibles due to language difficulties, nonverbal acts, indistinct or inaudible sounds and malfunctioning recording equipment.

The user guide recommends that each part of the system be considered for its effect upon the whole. Air conditioning and acoustics should receive attention because indoor and outdoor noise, sound reverberation or room deadness lower recording quality and increase transcribing time and cost. Microphone type, pickup pattern and output mixing must be carefully considered for optimum courtroom recording quality. For verbatim courtroom recording, events should be recorded directly through strategically placed open microphones. Event logging methods given in the user guide were chosen for effective documentation of playbacks and transcriptions. Procedures are also given for cases of equipment failure or inadequate recording.

After a critical review by NBS and the sponsor, the guide will be printed by the Government Printing Office. It should be available late in the year. □

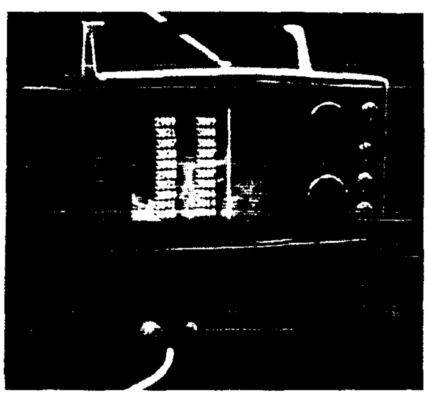
Color TV Used to Calibrate Oscillators

RESEARCHERS at the Boulder laboratories of the National Bureau of Standards have developed a series of techniques which use network television signals to calibrate oscillators with accuracies approaching a part in 10^{11}, in 15 minutes or less of measurement time.

This combination of speed and accuracy exceeds that of any other system of frequency calibration available today and accomplishes it at relatively low cost. For example, short wave radio broadcasts can achieve only 1×10^{-7} accuracy (a part in 10^{7}) if propagation conditions are favorable, and low frequency broadcasts can provide 1×10^{-10} only after one day of averaging or 1×10^{-11} in a week of averaging. Such long averaging times for high accuracy are obviously inconvenient and, when the oscillator under test has a drift rate exceeding a part in 10^{10} per day, they become useless.

The new techniques permit anyone with a color TV set to "borrow" the networks' atomic frequency standards for his test. All four major networks (ABC, CBS, NBC and PBS) use rubidium-controlled oscillators to create the 3.58-MHz frequency that forms the color burst signal. This stable signal is present in all network-originated color programs, and when a TV set is tuned to a live network program (not delayed on tape by the local station), the TV set's circuit is locked to this frequency.

The digital offset computer displays the current 10 samples of frequency difference in the left column and the averages of 10 groups of 10 samples each in the right.



NBS measures the networks' frequencies regularly and publishes their relationship to the NBS standard frequency.[1] Thus, a user can calibrate his own oscillator in terms of the NBS standard by using TV.

There are several ways to extract this frequency from the TV receiver and use it to calibrate another oscillator. In order of increasing complexity, four techniques developed at NBS are: the "RF Color Bar Comparator," "Video Color Bar Comparator," "Digital Subcarrier Comparator" and "Digital Offset Computer."

The "RF Color Bar" technique requires no modification to the TV set and achieves 1×10^{-9} accuracy in less than 5 minutes of measurement. For a parts cost of less than $50, a small electronic circuit can be built which creates a vertical rainbow colored bar on the TV screen when attached to the antenna terminals. When the oscillator under test is plugged into the circuit, the bar moves across the screen at a rate proportional to the difference between the tested frequency and the network frequency. When the difference is small, the motion is very slow, and the bar changes colors at a rate proportional to the difference.

The test oscillator must have a frequency of 5/N MHz when N = 1,2, 3,. . . . By timing the number of seconds required for the colors to change from red through blue, green and back to red, the difference between frequencies can be calculated.

The "Video Color Bar" technique is very similar, except that the color calibration signal is injected into the chroma circuit instead of the antenna terminal. This requires the addition of a resistor and two capacitors to the TV circuit, but does not interfere at all with normal program reception. The advantage is an improvement in the appearance of the color bar, which improves the resolution of the measurement. This version permits 1 x 10^{-10} accuracy in 5 minutes.

The third version requires more elaborate circuitry and provides greater accuracy. Called the "Digital Subcarrier Comparator," it generates a narrow vertical line that proceeds slowly across the screen and then snaps back rapidly, acting as an analog indicator of the phase difference between the frequency being tested (or adjusted) and the reference signal from the network. At the same time, the period of one cycle of this phase difference is indicated by a 4-digit counter. Accuracy to one part in 10^{10} is possible in 1½ minutes of measurement time, or 2 parts in 10^{11} in about 15 minutes.

The most accurate and easiest-to-run is the fourth technique which is almost completely automatic. The circuits developed by NBS take a series of averaged readings, automatically compute the difference between test oscillator and reference signal and display the difference in 10 four-digit numbers on the TV screen. The numbers are averaged by the operator to obtain an accuracy approaching one part in 10^{11} in 15 minutes. □

NBS Time Services Bulletin, published monthly. Subscriptions may be obtained by writing to NBS Time and Frequency Services Bulletin, Frequency-Time Broadcast Services Section, Time and Frequency Division, National Bureau of Standards, Boulder, Colo. 80302.

Frequency Standard Systems Compare Atomic Time Scales

THE National Bureau of Standards laboratories in Boulder, Colo., currently maintain two of the world's most accurate primary frequency and time standards. Designated NBS-4 and NBS-5, these devices form a system capable of mutually supporting each other or operating independently. Each device is recognized as a primary standard for frequency and the unit of time.

NBS-4, became operational in August 1973; NBS-5 was first operational in January 1973. NBS-4 has been used on a continuous basis for six calibrations of the NBS atomic time scale and is currently available on a monthly or bi-monthly basis for this purpose. Modifications are being made on NBS-5 to improve stability and to make possible an operational capability on a continuous service basis.

Measurement Evaluations

During recent evaluations the stabilities of NBS-4 and NBS-5 were checked against each other and against other high performance crystal and cesium oscillators. NBS-4 can be characterized by a frequency stability of 1.5 x 10^{-12} $t^{-½}$ and NBS-5 can be described by 9 x 10^{-13} $t^{-½}$, where t is in seconds. In a comparison between these two primary standards a flicker "floor" (best stability) of 9 x 10^{-15} was reached.

Accuracy evaluations of both devices were conducted separately and independently. Souces of uncertainty included measurement of the magnetic field, magnetic field inhomogeneities, microwave excitation spectrum, servo system shifts and others. The most significant accuracy limitation, the cavity phase shift, was checked and measured using three different methods. NBS-5 was subjected to three methods:

- Reversal of the beam direction.
- A frequency shift experiment using different atomic velocities, which were selected by pulsed operation of the microwave excitation.
- Measurement of the velocity distribution followed by a frequency shift experiment where the power of the microwave excitation was changed in a controlled way.

NBS-4 was checked only by the third method.

The second order Doppler effect correction was obtained for both devices from the velocity distribution of the atomic beam, which was determined from pulsed excitation and analysis of the microwave spectrum. All of the different mentioned methods led to a satisfying agreement within the independently assigned uncertainties. Individual and independent full accuracy evaluations of one sigma uncertainties of 2 x 10^{-13} (NBS-5) and 3 x 10^{-13} (NBS-4) were achieved. By the use of a series of the evaluations (the memory of each resting with the continuous NBS atomic time scale) an accuracy of close to 1 x 10^{-13} was achieved. At present, the reproducibility of either NBS-4 or NBS-5 is estimated at better than 1 x 10^{-13}.

Measurements of TAI

Since January 1973, NBS-4 and NBS-5 have together provided 13 individual calibrations of the NBS atomic time scale. The relationship

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