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Report of the 60th National Conference on Weights and Measures 1975

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[1] Headquarters and Laboratories at Gaithersburg, Maryland, unless otherwise noted; mailing address Washington, D.C. 20234.

[2] Located at Boulder, Colorado 80302.

Report of the

60th National Conference on Weights and Measures 1975

Sponsored by the National Bureau of Standards
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Representatives from U.S. Government,
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Abstract

This is a report of the proceedings (edited) of the Sixtieth National Conference on Weights and Measures, sponsored by the National Bureau of Standards, held in San Diego, California, July 13–18, 1975, and attended by state, county, and city weights and measures officials, the Federal Government, business, industry, and consumer organizations.

Key words: Calibration; communication; consumers; grain moisture measurement; laws and regulations; measurement; metric; packaging and labeling; police radar equipment; standards; supermarket automation; weights and measures.

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(Note: The reports of the standing, special, and annual committees and the treasurer's report, which were presented on Wednesday and Thursday, have been arranged together, beginning on page 165 for easier reference.)

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gives you $4.40 in change in the form of a ticket. This is a point of sale. We still don't have legislation on the control. I am sure it is done right, but how long will this equipment that is working right give you integrity in the proper change? These things have to be worked out.

The second trend is a greater movement towards surveillance. Mr. Everett Black, in Ventura County, California, has worked in that area, where the pressure is on the person who uses the device —he needs to service and maintain his own accuracy and be responsible. This action results in greater control and makes better use of county personnel and resources.

Third, I think one of the things we are working for in the State of California is the assurance that when you pick up a pound of bacon, regardless of where it comes from, there will be one pound in that package even if quite a bit of it is water.

CALIBRATION OF POLICE RADAR INSTRUMENTS

by DAVID W. ALLAN, Frequency and Time Standards Section, Time and Frequency Division, Institute for Basic Standards, National Bureau of Standards, Boulder, Colorado *

and

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State of Colorado

In common use for traffic speed control is a Doppler radar gun. The basic principle of operation of these guns is that the radar signal reflected from a moving vehicle is shifted in frequency by an amount directly proportional to the speed of the vehicle relative to the radar gun. Intrinsically one sees that such a radar gun is a frequency measuring device. The typical way of calibrating these radar guns is to place in front of the gun a vibrating tuning fork which produces a reflected signal to which the radar responds as though it were a moving vehicle. There exists a well-known relationship between this signal and the speed of the vehicle provided the radar frequency is known.

A question raised by the judiciary system is how does one know that a tuning fork used to calibrate a radar gun is at that certain

* Presentation was made by Mr. Allan.

specified frequency. Because of this question, several of these tuning forks have been brought to the Frequency & Time Standards Section of the National Bureau of Standards (NBS) in Boulder, Colorado for calibration. For example, the radar guns now operating, using the Federal Communication Commission (FCC) allocated frequency of 10 525 MHz (a "Hz" historically was designated cycle per second), have a 50 miles per hour calibration point using a tuning fork with a vibration frequency of 1569.54 Hz.

The demand for this calibration has increased to the point where it has become quite clear that it should be set up as an ongoing service. It seemed out of the context of the NBS mission and logistically difficult to provide this service nationwide. However, a reasonable alternative seemed to be to have the states' standards laboratories provide this service. A pilot program was set up with the Colorado State Standards Laboratory to demonstrate feasibility of a measurement system which would have traceability to NBS.

However, the possession of even an NBS calibrated tuning fork is not enough. Some of the available FCC allocated frequencies for law enforcement radar include 10 525 MHz and 24 150 MHz; the vast majority of current radar guns use the 10 525 MHz allocation. Suppose, for example, that a radar instrument which was designed for 10 525 MHz had a microwave oscillator which was detuned (outside the FCC allocation) to 12 000 MHz; then that radar instrument would measure a vehicle which was actually traveling 50 mph as traveling 57 mph even though a 50 mph tuning fork made for that gun would cause it to read 50 mph. Similarly, if a 50 mph tuning fork made for a 24 150 MHz type radar gun were used to calibrate a properly functioning 10 525 MHz type radar gun it would cause the latter to read 115 mph! For the protection of all parties, it is essential that both the frequency of the radar signal as well as that of the radar instrument's accompanying tuning fork be certified as correct within accepted accuracies. To directly measure the frequency of the radar signal is a nontrivial problem requiring sophisticated equipment; however, an indirect measurement of the radar frequency which can be easily implemented in the field is outlined below.

Fortunately, the microwave oscillators typically used in most radar guns have proven to be very stable, and being solid state devices they endure the rigors of field usage (e.g., shock, vibration, large temperature and car battery voltage variations) and still read accurately, i.e., ± .1 mph. The FCC allocation tolerance is comparable to an accuracy of ± 0.1 mph at 50 mph, and two of the major vendors in this country, which have sold about 20,000 radar guns, report that of the ones returned for repairs and maintenance almost none of them were outside the FCC allocation tolerance. It is still recommended, however, that the law enforcement officer using the radar gun occasionally check the radar frequency by transporting the gun in a vehicle with a calibrated speedometer, and while pointing the gun at a stationary object compare the radar gun's reading with that of the calibrated speedometer. The readings should agree within 2 percent (± 1 mph at 50 mph) if the radar frequency is correct within 1 percent, the angle of pointing of the radar gun is within about 8° of the direction of motion of the vehicle, and the speedometer is calibrated to within ± 1 mph.

The above procedure or one equivalent to it is mandatory for completeness because of the way the Doppler equation is used in most speed radar instruments. The Doppler equation may be written:

$$\frac{\Delta\nu}{\nu} = \frac{2\,v\cos\Theta}{c},$$

where ν is the radar microwave carrier frequency transmitted by the gun, $\Delta\nu$ is the radar signal received by the gun as reflected back from the moving vehicle minus ν, v is the approach velocity of the moving vehicle relative to the ground, Θ is the angle between the pointing direction of the gun and the direction of travel of the vehicle, and c is the propagation velocity of the radar signal. Most, if not all, radar guns are constructed to simply measure $\Delta\nu$ under the assumption that Θ is zero (0), and that ν is within the Federal Communication Commission (FCC) frequency allocation. Under these assumptions the gun can be made to directly calculate and display the value of v well within a 1 percent error. The tuning fork placed in front of a properly operating radar gun simply generates the signal $\Delta\nu$ commensurate for some velocity v under the same assumption that if the tuning fork's frequency is right the radar gun's reading will be right. However, if a gun's radar signal ν is off in frequency (outside the FCC allocation) then this radar gun's indicated velocity of a vehicle will be off by an amount directly proportional to the amount ν is off from the allocation assumed in the design of that gun, even though a tuning fork used to calibrate the gun gave the right gun velocity indication. The probability of being outside the FCC allocation seems quite remote and hence the assumption made above is very reasonable—making the tuning fork method a more convenient method in the field of checking the radar gun. All that remains is to determine a procedure which will assure that the tuning fork's frequency is right.

NBS recommended an equipment configuration for calibrating the radar gun's tuning fork that would be relatively easy to set up and operate, reasonably inexpensive, and yet with sufficient accuracy traceable to the primary frequency reference operated by NBS. The following is our first effort to achieve the above goals.

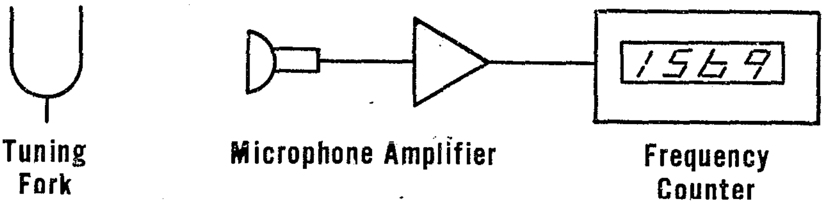

FIGURE 1

In figure 1 there remains the unresolved question of how does one know the reference frequency standard in the frequency counter is correct? Figure 2 shows a relatively inexpensive answer to this question:

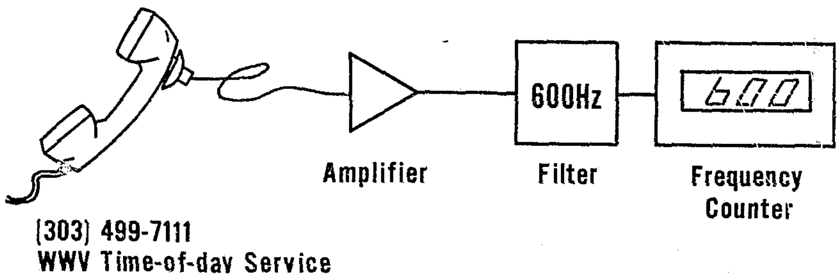

FIGURE 2

The format for the Standard Time and Frequncy broadcasts of NBS radio station WWV provides a continuous 600 Hz tone during every odd minute from 0 seconds to 45 seconds except for a 0.04 second hole where the second's tick occurs, and except for minutes 9, 45, 47, 49, and 51 of every hour. Using this method with the frequency counter set at a sample time of 1 second or a multiple of one second, one can calibrate the frequency counter to better than 0.4 percent as limited by current telephone frequency fidelity specifications. Only 1 percent accuracy is required for the tuning forks.

The equipment configurations in figures 1 and 2 have been tested for ease of use and for cross country telephone signal-to-noise problems on the telephone and were very satisfactory. The equipment cost of the components we used was about $500.00. A number of other, different equipment configurations are possible and acceptable if they guarantee traceability to NBS; e.g., by use of the

NBS Time Services either via telephone (figure 2) or via the radio station WWV.

The pilot program began in September 1974. Since that time over 200 forks have been tested for more than 40 law enforcement agencies in Colorado and from Wyoming. All of the tuning forks tested were found to oscillate within 5 Hz of the calculated (correct) frequency (less than 0.2 mph error).

The acceptance by the enforcement agencies is enthusiastic, particularly for those police departments having court difficulties. About 40 percent of all agencies contacted quickly responded and have had their tuning forks calibrated. About 10 percent of the departments have indicated interest and their forks are slowly coming in. Forty-eight percent either did not have radar units or did not have tuning forks for the radar units. Two percent did not find it important to have the forks calibrated.

Tolerances have not been developed for tuning forks as of this writing. A tolerance of about ± 1 mph seems acceptable which corresponds to ± 31 Hz for a 10 525 MHz radar gun. Most of the tuning forks tested had a frequency averaging 2/10 of 1 percent in excess of the calculated frequency for that particular speed. Note: this slightly higher frequency is shaded to be a slight advantage to the violator.

Reports have been received from several police officers that attorneys in court are starting to question the accuracy of tuning forks that appear to be damaged, referring to the scars appearing on the forks from striking the unit to make it "ring." Nearly all the forks tested by the Colorado laboratory bear these marks.

The frequencies of the Colorado tuning forks were within 5 Hz of the calculated frequencies (same as new forks).

Two forks were tested that appeared to have been run over or possibly dropped from a moving vehicle. Yet when testing the forks, the output of each was within 5 Hz of the correct frequency!

Several forks, when presented for test, did not bear serial numbers or identification. The units were tested and the frequencies recorded. Next, each fork was stenciled with appropriate identification. Markings were placed below the tines and just above the handle. The forks were retested under the same test conditions. The frequencies did not change even though this may be interpreted as a scarring of the forks.

Temperature tests were conducted on five different forks with temperatures ranging from 0° F to 110° F. The average change in miles per hour was only 0.69 mph for the 110° F span. The data for four of these is plotted in figure 3.

Overall, the tuning fork appears to be a very stable standard and suitable for the use intended.

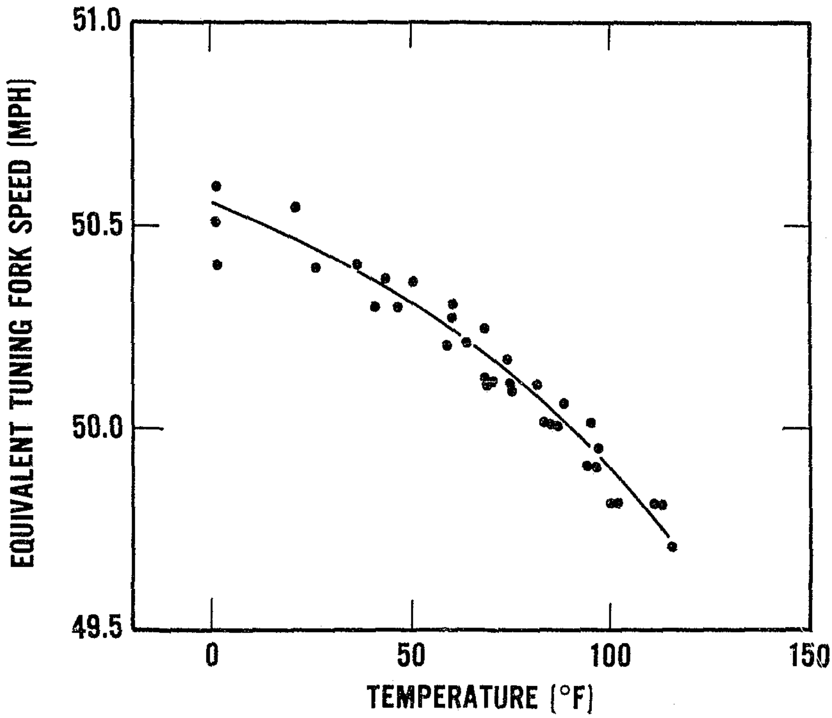

FIGURE 3. *Equivalent radar gun speed versus temperature for 4 different 50 mph tuning forks. These were typical tuning forks which are used to check a radar gun.*

Calibration of the frequency counter using the 600 Hz tone derived from the NBS, WWV telephone line has proven itself totally adequate. The largest errors encountered have been ± 2 Hz (less than ± 0.1 mph). Note: the telephone signal automatically "hangs up" after 3 minutes, so one should carefully note the WWV format given in the text under figure 2 before calling (303) 499–7111.

We have received informal reports that significant litigation cost savings are realized when the law enforcement officer produces an official calibration certificate which has ultimate traceability to NBS.

DISCUSSION

MR. R. L. THOMPSON (Maryland): Are you familiar with what they are calling Vascar?

MR. D. W. ALLAN (NBS): Yes, some.

MR. THOMPSON: Is this appropriate for that type of system?

MR. ALLAN: It is not. It is a totally different system.

MR. THOMPSON. Thank you.

MR. C. WOOTEN (Florida): You mentioned giving a certificate on this.

MR. ALLAN: Pardon me?

MR. WOOTEN: A certificate, a certification. Did I misunderstand you that you certify these?

MR. ALLAN: That is right. We give written certificates.

MR. WOOTEN: What we receive on weights is a report of test. Is that the same as a certificate?

MR. ALLAN: Basically.

MR. WOOTEN: I have no further question on that, then. Now, if you calibrate one of these turning forks, what is the life of that calibration?

MR. ALLAN: That is a good question. It seems that these tuning forks are very rugged. In fact, we have measured some that apparently were run over and bent, and it seems that they have a very high fidelity in maintaining their frequency. Within the 1 percent tolerance, they are quite acceptable; and from year to year you will see essentially no change.

MR. WOOTEN: Will this particular gun stand up in court?

MR. ALLAN: Will the gun?

MR. WOOTEN: Yes.

MR. ALLAN: We have seen several instances where certificates have been taken to court for verification of the calibration of the tuning forks and it has helped quite a bit. As far as the gun itself, we are not certifying the gun. If people will raise questions about the inward parts of the gun and electronics, then they must raise those with the manufacturer.

MR. WOOTEN: So, there is always a question, then, of accuracy?

MR. ALLAN: There is, to some degree. This question also has been asked and when you look at it in detail, if the tuning fork gives you the correct reading, the chances of having an erroneous reading from a moving vehicle are essentially zero. It is either working or it is not.

MR. WOOTEN: Thank you.

MR. J. R. BIRD (New Jersey): We are trying to get into this, as Harry Johnson is aware of. We are trying to get the funds through the Highway Safety Act to get this equipment. I am waiting on a response from them now to get this. In response to Mr. Wooten and to Dick Thompson, I am quite happy to announce that within the past month we were sustained in the Superior Court in New Jersey for our certificates. They now become prima facie evidence in court; and we do not have to go and testify to the accuracy of the equipment that we have calibrated or explain the circumstances. This particular substantiation was involved in a Vascar case where we had laid out and certified the base half-mile/mile courses for the State police and certified the stopwatches they used in calibrating those devices.

MR. ALLAN: Very good.

Mr. G. H. Fishman (J. B. Dee & Co.): The point I am trying to bring out is if you are fined on the basis of this gun, money changes hands. Consequently, I am asking you if this makes the gun a commercial device and if it requires that it be certified?

Mr. Allan: The gun itself?

Mr. Fishman: Yes, sir.

Mr. Allan: I really cannot give you the legal implications of that. All I know from the history is that tuning fork calibration has been adequate. The tuning fork is a part of the radar gun system. When you buy a gun, the companies supply the forks in the same kit as a part of the calibration procedure. That is a part of the industrial certification that they give you, that the gun is working if you get this number with this fork; and I suspect that that is probably part of a commercial instrument, but I really cannot answer your question in full detail.

Mr. Fishman: Okay, sir. Thank you.

Mr. J. H. Akey (Wausau, Wisconsin): Our local police force is using a radar type device which does not need a tuning fork for calibration. It has a built-in checking factor. By just pressing a button, you get a particular readout. Are you familiar with this type of radar device; and, if so, how are these calibrated?

Mr. Allan: I have not seen that particular unit. There is a check position on many counters, and there must be a reference standard there. Probably what happens when you put it in this check position is that you cause some oscillator to vibrate to give you a particular frequency. It has to be that way. That is how it works. I mean, those are fundamentals, and at some point that unit has to be calibrated. You cannot get something for nothing.

Mr. L. D. Draghetti (Agawam, Massachusetts): When you calibrate a radar gun at 50 miles an hour, the tuning fork is set for 50 miles an hour. What is the possibility of the gun being inaccurate at, say, 40 miles an hour?

Mr. Allan: In other words, is it linear?

Mr. Draghetti: Yes.

Mr. Allan: The physics involved say it has got to be linear, unless there is something which is extremely pathological in the gun, which would probably indicate other problems as well. It has to be linear. It has to be right at 40 if it is right at 50.

Mr. Draghetti: I see.

Mr. Allan: The equation itself is a linear equation; and if it works, it has got to be linear.

Mr. S. Darsey (Florida): Are any variables involved with the type of metal and the size of the vehicle; for instance, a Corvette that has a plastic body versus a motorcycle or a big truck or an aluminum vehicle, against a ferrous-type of metal? Are these variables in this thing?

Mr. Allan: Yes, they are. I personally do not have experience with the radar guns doing this; but having a background of physics, knowing that it is a microwave signal and that it bounces off a reflecting surface, it is those surfaces and the size of the surface that determines how much signal you get back. It is a signal to noise problem at microwave. So, the larger the surface, the better the signal to noise, and it has also got to be the right kind of surface. Essentially what it boils down to, at 10.525 GHz, is that most of your metals are excellent reflectors. Plastic is lousy. In other words, if you have a big truck alongside a Corvette with a plastic body and he is really racing along, you probably will not see him.

Mr. Darsey: You do not calibrate these, then, based on the type of vehicle you have? In other words, a truck makes no more difference than a car?

Mr. Allan: No. The police officer in court is going to have to say that he, in fact, was pointing the gun and he was discriminating between one vehicle and another. He knows the gun itself has about an eight degree angle of acceptance.

Mr. Akey: Approximately how many tuning forks were checked, how many were certified, and how many were found to be in error?

Mr. Allan: In this pilot program, the Colorado State metrologists sent out to all of the police departments in the State of Colorado invitations to send in their tuning forks. Let me give you the numbers from his report. He has a paragraph here that indicates the results. It says the acceptance by the enforcement agencies is enthusiastic particularly for those police departments having court difficulties. About 40 percent of all agencies contacted quickly responded and have had their tuning forks calibrated. This number is in the vicinity of 100 total, some of which are from Wyoming. About 10 percent of the departments have indicated interest and their forks are slowly coming in. Forty-eight percent either did not have radar units or did not have tuning forks for radar units. Two percent did not find it important to have the forks calibrated. So, that is basically our response in the pilot program.

Mr. Akey: The question was how many of the tuning forks that were calibrated were. . .

Mr. Allan: You said that and I did not finish the question. As I recall, and again I wish Frank were here—if Earl can remember? Six tuning forks were outside. Was that 1 percent or what?

Mr. E. Prideaux (Colorado): I think it was about 1 percent or 2 percent.

Mr. Allan: If you are off 15 Hz, it can read one way or the other. If you are off 15 Hz, it can read, for example, 51 miles an hour as well as 50 miles an hour.

Mr. W. I. Thompson (Monmouth County, New Jersey): I wonder if you could explain the principle of these so-called antiradar outfits that are being sold in some of the motor magazine ads.

Mr. Allan: Well, there are various kinds of devices. One is an alarm so that you know there is radar in the vicinity. All it is is a good receiver. It receives a 10.525 GHz signal. A light comes on or a buzzer flashes or something that could tell you to look out. Another thing that people do that is effective is to have a lot of moving metal. I have heard the story of people putting aluminum foil in plastic hubcaps so that it flips around inside. Again, it is a signal to noise problem. You have got to have enough moving metal to overcome all of the other solid moving metal that is moving at the same velocity. But there are various kinds of these tricks that people, I suppose, have tried. I am not aware of all of their tactics, but these are examples.

Mr. J. Douglas (Douglas Equipment Company, Inc.): I would like to know if it is truly possible for the Highway Patrol, with radar coming in your direction and you going in the other direction, to actually measure the speed that you are traveling when you are going toward him?

Mr. Allan: You are both moving? Both the vehicles are moving?

Mr. Douglas: Right, right.

Mr. Allan: You measure the relative speed.

Mr. Douglas: How can he do it?

Mr. Allan: Well, again, the principle involved is a matter of a reflected microwave signal between the two vehicles.

Mr. Douglas: Well, I have talked to people in our State on the Highway Patrol and they say it is not possible. Yet, they use those machines to do it, and they will nail you for it.

Mr. Allan: The thing that I would worry about in that situation is that they are made to be stationary. They do make a moving vehicle radar system, but it is a much more complicated system and this is not what we are talking about. The radar gun that we are talking about is made to be stationary for the following reason: The radar signal goes out and is reflected from the moving vehicle. A moving vehicle is the only thing that will give you a frequency different from that you send out. Now, in the environment there are many other cars that are stationary and he (operator of the gun) is stationary. Those cars will also reflect signals, but they are on the same frequency that he sent out.

The radar gun has the capacity to discriminate between those frequencies that are different and those that are on the frequency that are sent out; so it can tell a moving vehicle relative to itself, but it cannot see vehicles that are stationary with respect to itself. So, if you are driving along the road and there are other cars along the side of the road that are also moving, this would foul up the system because I do not think it would work well. I do not know. I have not conducted that experiment.

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