REPORT OF TRIP TO

NBS 1960 CONFERENCE ON
STANDARDS & ELECTRONIC MEASUREMENTS

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K. B. Mallory

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At the 1960 conference on Standards and Electronic Measurements there were many papers which stated that "The engineer who needs to measure absolute values of quantities has problems," or that "I have a scheme for making better measurements." It appeared to be accepted without question that absolute measurements are difficult and expensive. This, of course, is true; but there seemed to be little effort to reduce the cost or complexity of accurate instruments.

There is little point in trying to offer a precis of every paper since the abstracts stated as much as I could grasp in many cases and the papers will soon be published in full in the IRE Transactions on Instrumentation. I shall therefore report here only some highlights-I have a copy of the abstracts should more information be desired.

The first session was largely devoted to describing the magnitude and complexity of standardization of measurements in current industrial problems. For example, the Minitrack satellite tracking system requires that absolute time, accurate to 1 millisec/day, be defined at various locations around the earth. The DEW-line has some 80 types of test equipment which has to be transported to a main station for calibration. (Some of this equipment must be kept in continuous operation during transit.) H.W. Lance of NBS, pointed out that any place which needs standards should have a well-staffed standards laboratory, that equipment to be calibrated should be brought to the standards, that adequate records must be kept if calibrations are to have any meaning. He also suggested that some engineering goals are unattainable without adequate standards and that others are made overly expensive; the engineer should specify what standards are to be used as part of the overall specifications of a job.

In the next session, J.A. Barnes, also of NBS, discussed the purity of signals multiplied from crystal oscillators. A particular experimental result, of some possible interest to us, was that when an oscillator signal with some 60 cycle hum was multiplied by 9 the output spectrum had an RMS frequency deviation of 170 cycles and the carrier was zero!

Several papers discussed rf measurements. Bussey, of NBS, described some pretty work on measurement of skin depth of metals in a TE_{011} cylindrical cavity. He has reached 97% of theoretical Q in a copper cavity. The cavity consists of a cup and a demountable end plate. Transmission measurements repeat to a 1 part in 1000 in their system, so relative Q is quite well measured by the change in transmission. Allerton of Western Electric, measures volume resistivity of semiconductors by placing the sample over a small aperture in the side wall of a TE_{011} rectangular cavity. The method appears to give very consistent measurements of sensitivity of small positions of the sample. Kohane, of Raytheon, measures small beads of ferrites with resistivity less than 1 ohm-cm. (Extreme example: Magnetite; 6 x 10^{-3} ohm-cm.) For a saturated sample, $\mu = \mu_0$, he uses a formula direct from Smythe to take skin depth into account exactly, and can determine the resistivity from the change of Q of a cavity due to the perturbing bead. He claims that for such lossy material the tenser permeability cannot be measured.

Reflectometer measurements were discussed in several papers, but the notation and the concepts used were rather cumbersome. Indeed, one speaker spent his entire allotted time explaining that the observed reflected signal will vary as an imperfect sliding termination interacts with a fixed reflection. His announced subject was only touched upon in the questions following his paper.

Engen and Beatty, both of NBS, discussed some very good reflectometer work in connection with power measurements and with measurements of very low VSWR (1.0006). The latter was made with equipment which could easily observe directly the change of reflection coefficient of a sliding short caused by resistive loss in the waveguide.

Sorger, of Weinschel Engineering, presented a paper entitled "A Subtle Error in RF Power Measurements." The error is introduced in AC self-balancing bridges made by some of Weinschel's competitors when the bridge frequency is low compared to the bolometer time constant. In such cases, the DC and AC resistance of the bolometer are not equal; and if the amount of AC power required to produce DC balance is measured, the errors could be enormous. The AC power required to produce AC balance is in slight error, depending on the amount of DC bias used. The only subtlety is that a 10 KC bridge is indeed at a low frequency for most sensitive barreters which have time constants no greater than 100 microseconds.

I went to the 1960 NBS Conference on Standards and Electronic Measurements hoping to find at the conference or at the Bureau the solutions to two problems. First, what instruments would Project M need in its standards laboratory; second, what new microwave instruments could be adapted to reduce the cost of instrumentation for the accelerator. Neither problem was solved for me and I left feeling somewhat disappointed with the outcome.

Since returning, I have realized that the conference indeed opened my eyes to the standards problem, and, as a personal experience, my attendance was worthwhile. With this note, I hope to start realizing a benefit to Project M directly.

While precise measurements are of importance to linear accelerators, we have been in the habit of assuming that absolute measurements are unneccessary except for the physicists, who need to know absolute value of beam energy and current if they are to compare their results with the results obtained at other laboratories. It is, of course, this intercomparison of results which makes absolute measurements necessary. Hitherto, we have built accelerators and all essential components within the laboratory. Relative measurements were adequate to insure that the machine would perform satisfactorily.

The Project M accelerator will be built with many subcontracts, including some for essential parts of the machine such as klystrons and modulators. It is essential that we and our vendors agree on how to measure the characteristics of the equipment. (The efficiency of a klystron is a particularly nasty example of a quantity whose value appears to depend on who makes the measurement.)

It is clearly desirable that the standards required for the project be determined early and that vendors be required to use the same or equivalent standards for all their testing of equipment. Very soon, we must determine how accurately we wish to know DC, AC or pulsed voltage and current; microwave impedance and power; rf frequency; mechanical dimensions; attenuation constants, etc.

Once we know the quality of absolute standards required, we may then determine what transfer standards are required. For example, if we have a power meter which we trust to read microwave power to $\pm$ 1% absolute, we then need a stable source and procedure by which other power meters may be calibrated.

It has become clear that the accelerator will be built as if to operate at some particular frequency and temperature. Fortunately, frequency standards even better than our needs are readily available. The absolute temperature standard is probably adequately taken care of by reasonable glass thermometers. The major problem on the accelerator is again relative measurements - the temperature difference between various parts of the accelerator.

The only standards problem which appears serious at the moment is that involved in measuring gain and efficiency of klystrons. There may also be some problem defining modulator performance.

There must be other standards which will be required to insure that we will be satisfied by the equipment supplied by vendors. The measurement of high-vacuum might possibly be one of these. I would like to discuss any such problems as soon as possible.

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