This is not the type of message I would like to write as the outgoing President, but I believe that the situation is so serious it demands first page coverage.

On October 3, 1982, and in subsequent meetings on October 6 and 8, the NCSL Board of Directors was informed by NBS management of a change in policy to be implemented in the 1984 Department of Commerce budget that would, in my judgement, have a serious effect on Measurement Assurance Program (MAP) users. The net result of this policy change is that effective October 1, 1983 nearly two million dollars of research and development funds for MAPS & RMAPS would have to be recovered annually from users of this service. According to Ray Kammer, Deputy Director of the National Bureau of Standards, this policy reflects the Administration's position that all costs incurred by the Federal Government to provide a service must be fully recoverable if there is an identifiable beneficiary of the service. This is interpreted as meaning that the users of MAP service must pay fees which recover not only the operational costs (as at present) but also the research and development costs which support the service. The details of this and possible alternatives are contained in a letter from Mr. Kammer which has been reprinted on page 11 of this Newsletter. This policy seems to contradict the original intent of setting up the Bureau of Standards as an institution providing research and services to a broad range of users.

If Alternative 1 in Mr. Kammer's letter is selected (costs to be fully recovered from present MAP/RMAP users) this would destroy the MAP program. This means the present MAP/RMAP users would have to return to individual use of calibration services, and sets back progress in improving the National Measurement System by at least ten years.

If the Alternative 2 is selected and the MAP/RMAP costs are recovered by increasing calibration fees to all users, the fees would increase by a factor of between two to three. Therefore, this would discourage many laboratories from using NBS and would be destructive to the U.S. Measurement System Infrastructure.

The NCSL Board of Directors view this situation as extremely serious and believe that NBS is, and should remain, the preeminent technical asset of the nation. Research and development, particularly within the NBS, must be viewed (as it has since the Bureau was created) as a national investment in the future. It is irrelevant that there are few (comparatively) users of calibration and MAP services. These users are at the forefront of measurement technology and near the apex of the National Measurement System pyramid.

Research assures at least two important results. First, it leads to improved knowledge of measurement phenomena; to the capability to make consistent measurements which are required today and in the future, and (because of that knowledge and capability) to increased knowledge in science, technology, and commerce. Second, it provides the challenge to scientific inquiry which attracts the exceptionally high caliber of scientific, engineering, technical and management personnel which have characterized the staff of the NBS for over eighty years.

In my last President's message I stated my opinion that improved measurements have been the basis for most of our technological growth, and that measurements are the key to predicting and controlling the quality of our products. Therefore, if we are to improve quality, we should do everything we can to improve our measurements and our National Measurement System. Recently General Monroe T. Smith, the Air Force's Deputy Chief In-Staff/Maintenance at Wright Patterson AFB, stated that "Quality is the key to survival for a company and our country". Japan, France, and other nations realize this and their national laboratories are supporting industry in their countries by measurement research and providing support services at little or no cost because they know that the ultimate beneficiary is their country. If the U.S. is to maintain our technological position in the world and regain our reputation for quality products, we cannot let our measurement system infrastructure be destroyed.

Therefore, I have appointed George Rice of Rockwell International to chair an ad hoc committee to study all aspects of the problem and to recommend a course of action for the NCSL by the January 17, 1983 Board meeting. The options available are few and time is of the essence. In the interim, you can alert your management and, as individuals or companies, inform NBS of your concerns relative to this potentially disastrous situation.

In spite of the above, I think we have had a good year and we have made progress. I thank all of you for the privilege of being your President.

Dean A. Brungart, President
EDITOR'S MESSAGE

Strategic Plan

Some of you member delegates may not be aware that each year the NCSL Executive VP reviews, updates or sometimes totally revises the 5 year long range plan. The board approves or changes as appropriate and then uses the 5 year plan in its work. Thus it gets limited circulation.

If any member delegate would like to look at a copy of the latest plan they could request a copy from their regional coordinator or write to Ken Armstrong at the Secretariat for an individual copy.

Bascom Birmingham — an Extraordinary Volunteer

Years ago when we asked NBS for a sponsor's delegate with plenty of horserpower, we were delighted to have the Boulder Lab Director himself volunteer. Over the intervening years Bascom has attended MOST board meetings, brought NBS operations and strategy to NCSL and vice versa in a very professional manner. And at the same time ran Boulder Labs!

Bascom, it's been great working with you. You have been of immeasurable help to NCSL. Thank you for your fine personal effort and good luck in your future work.

John Minck

1983 NCSL MANAGEMENT ROSTER

The election returns are in and here are the results:

President: Hartwell Keith
Exec. Vice-President: *George Rice
Treasurer: Gary Davidson
Secretary: *Chet Crane

*1983 election

TRW OSG
Rockwell International
General Dynamics
Westinghouse Electric
Lockheed California Co.
Guideline Instr. Co.
Sanders Associates
Rockwell-Collins
Lockheed Georgia Co.
General Electric Co.
Lockheed Missile Co.

1983 NCSL MANAGEMENT ROSTER & REGIONAL MAP

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BOARD OF REVIEWERS

Brian Belanger
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Douglas Doi
Pete England
Hartwell Keith
George Rice
H. Bryan Werner

**Articles and other items appearing in the NEWSLETTER express the views of authors and contributors and are not necessarily those of the Editor or the National Conference Standards Laboratories.
Dr. Churchill Eisenhart, a Senior Research Fellow at NBS, Gaithersburg, has received the 1982 Wildhack Award from the National Conference of Standards Laboratories (NCSL). The award is presented annually by NCSL to recognize outstanding contributions to the field of metrology and measurement science consistent with the goals and programs of NCSL.

The award is named for William Wildhack, who was instrumental in founding NCSL, Wildhack was a staff member of the National Bureau of Standards (NBS), the sponsor of NCSL since its beginning in 1961. The Wildhack Award, consisting of an inscribed plaque and a $1000 honorarium, was awarded at the 1982 Annual NCSL Conference Delegates Meeting, October, 1982, by Dean Brungart. John Lee was Chairman of the Wildhack Award Committee.

Eisenhart, who joined NBS in 1946, is a well-known authority in the field of mathematical statistics and their application to the science of measurement. At NBS he conducts research in mathematical and statistical theory and methodology related to measurement, with particular attention to problems connected with the establishment, maintenance, and dissemination of national standards for physical measurement.

Eisenhart was cited "for his pioneering recognition of measurement as a process; for his fundamental papers on the identification of sources of measurement variability and their statistical treatment, for unique applications of methods of statistical quality control to metrology and physical measurement processes; for his masterly exposition regarding the proper statements of precision and accuracy of measurement; and for his inspiring leadership."

The impact of Eisenhart's statistical accomplishments is being felt around the world as leading measurement organizations strive to improve the basis for measurements and calibrations by application of his statistical methods.

Eisenhart received his A.B. in mathematical physics from Princeton University in 1934 and his Ph.D. from the University of London in 1937. He spent 1958-59 at the London School of Economics and Political Science as recipient of the Rockefeller Public Service Award. His other awards include the Department of Commerce Exceptional Service Award and the American Statistical Association's Samuel S. Wilks Memorial Award.

Eisenhart has authored more than 110 papers in his field, one of which, "Realistic Evaluation of the Precision and Accuracy of Instrument Calibration Systems" (1963), has become recognized as the most comprehensive and definitive treatise of this subject. He is a fellow of the American Association for the Advancement of Science, the American Statistical Association, and the Institute of Mathematical Statistics, and is a member of several other U.S. and international organizations.

Previous winners of the NCSL Wildhack Award have included Dr. Ernest Ambler, Director of NBS; Doug Strain, President of ESI, Inc.; Frank McGlinnis, Director of Product Assurance at Sperry Rand Corporation; Jerry Hayes, Technical Director of the Navy's Metrology Engineering Center; J. D. Mitchell, Rockwell International; and Dr. Forrest K. Harris, NBS.
BASCOM BIRMINGHAM

As most of you know, the National Bureau of Standards sponsors NCSL and furnishes our secretariat services at considerable expense. In return, NBS gets one seat on the NCSL Board of Directors, the Sponsor's Delegate.

Since early 1976, our Sponsor's Delegate has been Bascom Birmingham, who was also Director of the NBS Boulder Labs. In the long period of service as Sponsor's Delegate, Bascom has shown a fine dedication and given great effort to further the success of NCSL. It was a period over which NCSL membership rose from about 200 to over 500 companies.

Perhaps more importantly, Bascom gave our NCSL Board top management access to the long range planning process at NBS to allow NCSL company needs to be considered. In turn, we were able to hear of NBS plans and operations affecting NCSL at the earliest times.

In October, Bascom, at his own request, because he thought NBS needed new blood, and because he wanted to re-enter his technical field, was stepping down from his NBS Director post. He'll become a senior engineer in the Bureau's Center for Chemical Engineering. He'll be working for the center's director, Jesse Hord, who worked for Bascom when Bascom headed the Cryogenic Division.

"You might deduce there's some kind of message in this. "Be nice to everyone. You never know who is going to be your boss next year or even tomorrow."

Educated at Massachusetts Institute of Technology (BSME-1948, MSME-1951), Bascom joined the Bureau's Cryogenic Division in 1951 after several years as a consulting power engineer. In 1953 he received a Commerce Department Exceptional Service Award for his contributions to the design and installation of Boulder Laboratories' hydrogen liquefier, largest in existence at the time. He was named chief of the Cryogenics Division in 1962, and in 1966-67 spent a year as a Commerce Department Science and Technology Fellow assigned to the Atomic Energy Commission. In 1971 he was awarded the Department of Commerce Gold Medal for exceptional management of the Boulder Laboratories. He is a member of the Scientific Research Society of America and Tau Beta Pi. He is an Associate Fellow of the American Institute of Aeronautics and Astronautics.

NCSL Sincerely appreciates and recognizes Bascom's dedicated efforts on its behalf.

* * * * * * * *

ROBERT KAMPER

Dr. Robert A. Kamper has been appointed Director of the National Bureau of Standards Boulder, Colorado Laboratories. The announcement was made recently by Dr. Ernest Ambler, Director of the Bureau, which is an agency of the U.S. Department of Commerce.

A physicist on the staff of the NBS Boulder Laboratories since 1963, Kamper is only the third person to hold the title of Director since the Boulder Laboratories were inaugurated in 1954. He succeeds Bascom W. Birmingham, who has been Director since 1968. Birmingham will remain on the NBS staff as a senior engineer in the Center for Chemical Engineering. Kamper will also assume the job of NCSL Sponsor's Delegate to the NCSL Board of Directors. He will be the sixth NCSL Sponsor's Delegate. The first Sponsor's Delegate and a prime mover in establishment of NCSL was Mr. Wildhack who served from 1961 to 1967; Dr. Wallenstein then served from 1967 to 1968; Dr. Ambler from 1968 to 1969; Joe Cameron from 1969 to 1976; and Bascom Birmingham from 1976 to 1982.

Kamper, who has been Chief of the NBS Electromagnetic Technology Division since 1978, will continue as chief of that division while serving in his new position. He joined the staff of NBS' Cryogenics Division in August 1963 and was made chief of the division's Cryoelectronics Section in July 1969.

Kamper's principal fields of research are cryoelectronics, super-conductivity, solid state physics that deals with extremely cold temperatures; cryoelectronics and superconductivity are applications of cryogenics to electronics and electricity.
Article VI, Paragraph A-1 requires the President to prepare an annual report for all Member Delegates. Since all Member Delegates receive the NCSL Newsletter, I have elected to incorporate this report in the Newsletter rather than have a special mailing.

1982 is the first year that our fiscal year corresponds to the calendar year, and because of this, our Bylaws and many of our previous time schedules have had to be changed. While we were reviewing the Bylaws for changes necessitated by the fiscal year change, we also updated them to incorporate revisions not previously published. In the October Board of Directors meeting we further reviewed the Bylaws to maintain consistency of terminology between Articles and Sections, and to conform to the generally accepted practice of using gender in documents such as organizational bylaws. Originally we planned on publishing the Bylaws as updated and revised immediately following the Conference, however, a new revision was proposed in the October meeting which, I felt, needed to have further study. Therefore, we have delayed the publication of the revised Bylaws until February 1983 to allow the Board to study the new proposed revision and vote on it in the January 1983 meeting.

One of the highlights of 1982 was the very successful Conference and Workshop held at the National Bureau of Standards in Gaithersburg, Maryland, on October 4-7, 1982. This year the theme was "Metrology Management and Technology--A Scientific Approach," and we had 297 registered attendees. There were some outstanding papers and presentations, and our Co-Chairmen, Dr. Brian Belanger of NBS, and Maurice Corrigan, Jr., of Lockheed Electronics Co., are to be commended for their excellent work. I was pleased to present the Wildhack Award, and the accompanying check for $1,000 to Dr. Churchill Eisenhart of the National Bureau of Standards during the Delegates Meeting, and also special awards to John Lee and Bascom Birmingham for their past services to NCSL. The social highlight was the Cook-out at Smokey Glen Farm, during which the SOUTH won the annual volleyball championship game.

1982 has been an active and interesting one for NCSL in areas of broad national interest. Of particular importance to our membership were the hearings by the House of Representatives with respect to the Organic Act, the Charter which founded and provides direction for the National Bureau of Standards. Through a series of meetings and correspondence, an NCSL Ad Hoc Committee was given the responsibility to study proposals before the House of Subcommittee and performed an analysis of proposed changes. The Ad Hoc Committee was composed of representatives from the private and governmental sections: members were Hartwell Faitl, John Hinck, Co-Chairman George Rice, Jerry Hayes, Joe Rothleder, and Ed Nemeroff. Based on a rather voluminous report and a bill draft, the NCSL Committee provided our membership with both an abstract and analysis of the segments of the proposed changes which were considered to be of major importance to our membership and future directions of NBS. With the analysis was sent suggested points of contact in the government to which individual membership could direct their organizations' concerns. In concert with this activity, the NCSL membership was surveyed as to their opinions and suggested NCSL actions relative to proposed Organic Act changes. Results of this survey appeared in a previous issue of the Newsletter.

Another area of national interest and involvement by NCSL has been proposed changes to MIL-STD-45662 and Handbook 52. Along with the Aerospace Industrial Association (AIA), the National Security Industrial Association (NSIA) and Electronic Industrial Association (EIA), NCSL was invited to participate in the meetings at DARCOM Headquarters on MIL-STD-45662 and proposed Handbook 52. Since only the United States industrial sector of NCSL responded with comments on these documents, it was made clear that our representatives, President Dean Brungart and Vice President George Rice, were only representing that sector of NCSL in the meeting. As a result of these meetings, Change Notice 1 to MIL-STD-45662 was initiated and sent for concurrence to all affected governmental agencies and the industrial organizations represented at the meeting. Two of the services objected to the wording in Change Notice 1, and a second meeting of representatives from government and industry was organized and sponsored by OSD. It was held on November 29, 1982, in Crystal City, Virginia. The meeting resulted in a minor revision to MIL-STD-45662, paragraph 5.6, and concurrence by all attendees. The wording of the revised paragraph is contained in the announcement on page 10 of this Newsletter.

A major milestone for NCSL was the establishment of the Advocacy Position Guidelines. This document establishes guidelines and methodology for the NCSL Board of Directors to take advocacy positions when deemed in the best interest of the NCSL membership. Although the document may not be perfect, it is a start in providing guidelines for future NCSL officers in this very sensitive area.
One of the job functions of each Executive Vice President is to review and revise the five year strategic or long range plan. Hartwell Keith briefly presented his revised plan at the Member Delegates Meeting during the Conference. In it, new thrusts were identified for the coming years and complete re-writes were developed for a number of the positions within the NCSL. The plan was adopted at the October Board of Directors Meeting, and copies were then sent to each Board Member. Added to the document were the positions and responsibilities of the newly created Director in International Regions and two new committee chairships, Membership Promotion and Publicity. Both of the committees are under the Vice President of Communications and Marketing.

The International Director, Graham Cameron of the Canadian Department of Defense, has done an outstanding job in the first year for this position. Graham's primary contribution has been his contact and follow-up with existing and potential international members, but he also arranged an excellent International dinner meeting during the Conference, and arranged and International Canadian Sector meeting in December at Canadian Marconi Company in Montreal.

Another function of the Executive Vice President is liaison with other societies. Hartwell reports that the Liaison Delegates' activities were somewhat dynamic through both changes in delegates and the addition of new liaison positions. Karl Speitel of Eastman Kodak replaced Jim Valentino as liaison to ASQC and Rolf Schumacher of Rockwell International was appointed as liaison to ANSI. With the retirement of a good friend and long-term member Past President Don Greb, Brian Belanger assumed the liaison roll to OIML. Another new liaison position was created and Dr. Robert Kamper of NBS Boulder Laboratories assumed the responsibility as our liaison to the Conference on Precision Electromagnetic Measurement (CPEM).

Our Treasurer, Gary Davidson of TRW, will publish his final report after the books are closed and audited. This report will probably appear in the Spring issue of the Newsletter. It does appear that the dues increase has kept NCSL in a relatively healthy position. Estimates for 1982 year end are expenditures of $45,000 with an income of $50,000. This will leave reserves of $3,000. Most of the estimates do not include the 1982 Conference income and expenses, however, they are expected to be positive. Contrary to Past President John Lee's predictions, even your President stayed within his 1982 budget.

Secretary Selwyn Smith of RCA's Solid State Division experienced serious personal problems this fall with the death of his mother, and his wife Harriett's severe heart attack. These events kept him from attending the Conference and the October Board Meeting. However, Doug Doi, Vice President of Measurement Requirements, and Chet Crane of Teledyne Microelectronics, our newly elected Secretary for 1983, filled in for Smitty and are responsible for the minutes published elsewhere in this Newsletter. Prior to that time, Smitty was a very responsible secretary and did an outstanding job. Unfortunately, his work environment prevents him from continuing to serve in NCSL. We will miss him and Harriett at our meetings, and wish them both the best of luck in overcoming these adversities.

The membership status as of October 1, 1982, lists 545 members, of which 62 are unpaid, and ahead of the Long Range Plan forecast.

The following are Vice Presidents' reports on committee activities:

**COMMUNICATIONS AND MARKETING**

Vice President Pete England of General Dynamics, reports the accomplishments in this area include the printing of 2000 Membership Brochures which were available in early January. The brochure is in the process of revision and new brochures will be available at the start of 1983. Considerable effort has been expended in 1982 accumulating data and formatting the printing for the Bi-annual NCSL Laboratory Directory which will be printed in January 1983 for the years 1983-1984. Also in process are regional maps which will depict membership locations. These endeavors are under the Information & Directory Committee Chairman Ralph Bertermann of G.D. Searle & Company.

Newsletter. Another accomplishment which has to be recognized is the quarterly publication of our Newsletter. Editor John Minck, of Hewlett Packard Co., continues to do an outstanding job in producing a quality Newsletter for the NCSL, and we are pleased that he has agreed to continue in that capacity.

Recommended Practices. Chairman, Al Kohler of Varian Associates, reports that there was little activity for his committee since there were no new practices introduced this year. Pete also developed the charters for the two new committees previously mentioned, and has been working on the staffing of these committees.

**LABORATORY AND OPERATIONS**

Vice President George Rice of Rockwell International, reports that the Calibration System Management Committee Chairman,
Phil May of the Bionetics Corporation, was appointed late in the year and has been spending his time staffing the committee and establishing a framework to make an early contribution in 1983. Phil replaced Bob Guibord of TRW who had to resign because of increased job requirements in his company. Phil plans to have a workshop at the 1983 conference on calibration intervals, and is looking into other Laboratory Manager technical and administrative concerns such as productivity management, management techniques, and a series of cost studies.

Measurement Assurance Committee. Chairman Laurel Auxier of Beckman, reports that although the future of Measurement Assurance Programs (MAPs) has been clouded by the NBS announcement regarding increased fees to recover R&D costs, the committee activities continue and among accomplishments this year were:

- The 10K ohm Resistance Standard ordered in 1981 was received, paid for and deployed in the first Reverse Regional MAP experiment.
- The regional Gage Block MAP pilot program was completed, results reviewed and plans to continue in a Regional Round Robin (linking to NBS through two ten block sets) have been made.
- The first Reverse Regional Voltage MAP experiment was implemented.
- The MAP Handbook was broken into two sections, General and Statistics. The Statistics section is now in rewrite. General section is in the review cycle.
- The seminar on MAPs was postponed and rescheduled for the week of January 24, 1983.
- Phase II of the Reverse Regional Resistance MAP pilot program was completed.
- The three experimental regional MAPs have brought problem areas into sharper focus and committee efforts have been directed toward solving through contact with those parties directly involved (i.e. the MAPs identify shortcomings of participants' standards, lab documentation, measurement process and personnel; they also highlight problems related to inadequate procedures, data handling, transfer standards, etc.).

It is planned to reactivate this committee in 1983, to expand its current limited membership, and to address those key issues. High on the list of projects to be undertaken next year is a review of the effectiveness of the RP with (perhaps) introduction of updates.

Automatic Test and Calibration Systems Committee. Committee Chairman Don Tobey of Science Applications, Inc., reports that the principal focus of this committee during 1982 was the development and presentation of three workshops at the annual conference. The committee is structured and staffed in a way conducive to simultaneous working on more than one project. In 1983, the committee will begin to consider several new projects including draft RPs on topics relating to calibration of automatic test equipment and to automatic calibration of test equipment.

Other accomplishments by Lab Management and Operations this year include the development and publication of a "Laboratory Managers Handbook" which is intended to aid managers new to metrology and/or companies in the process of establishing a metrology laboratory.

Administration

The Administration Vice President, H. Bryan Werner of Westinghouse Electric Company, has three committee reporting to him: Education and Training, Meetings and Programs, and Honors and Awards.

The Education and Training Committee Chairman, John Martin of Westinghouse, has organized his committee into several subcommittees, and his report is submitted accordingly.

Jay Varvel of Rockwell Hartford, Chairman of the Training Aids Library, reports that his subcommittee is primarily organized to assist Secretariat Ken Armstrong in the operation of the Training Aid Library. Accomplishments this year include developing procedures for retrieving overdue training tapes and for making the tapes available to international members, expanding the quantity of tapes which are in heavy demand, and adding the following to the library:

- 19 new video tapes on microprocessor training.
- Video and audio tapes of the French Bureau of Nationale De Metrologie presentation.
- Video tape of Ed Nemeroff's presentation on "Building the Measurement Pyramid."
Dave Lorenzen of McDonnell Douglas, Chairman of the Training Information Subcommittee, reports that his committee mailed a supplement to the October 1981 Training Course Register in June and published a Training Information Directory in September. The latter has been expanded to include journals and publications along with training courses, has a table of contents, and is now bound. The Directory is planned as an annual publication with quarterly updates in the NCSSL Newsnotes.

Adjunct Training Subcommittee Chairman, Jack Park of Heath Company, had to resign because of a job change, and Bill Loeffler has started his own company and resigned from the subcommittee. Therefore, the Basic Metrology Training Course packaging effort has progressed at a slow pace. However, Kate Webster of Bionetics Corporation has agreed to take over this subcommittee, and the partially completed "Basic Metrology" package and reference material will be transferred to her. John Martin and Kate will review the material and assess what has to be done to complete this project. They will present their report and the January Board meeting.

The Metrology Publicity Subcommittee Chairman, Milt Towne of Sanders Associates, reports the development of a Metrology Career Exhibit which was displayed at Butler Community College's Metrology Fair, Technomart '82 in Pittsburgh, and at the 1982 NCSSL Conference. They also developed a slide presentation with a text on Metrology Public Relations. The display and presentation material is available for NCSSL members to use in promoting Metrology. The Metrology Publicity Subcommittee is co-sponsored by the training directors, and is directed toward student recruitment with emphasis on career opportunities, professionalism, salary and work environment.

The Full Time Metrology Training Subcommittee is co-chaired by Jay Varvel of Rockwell International and Jack Baloq of Westinghouse. They report that a set of guidelines have been developed and approved by the NCSSL Board of Directors on delegate interaction and support for education institutions offering a metrology curriculum. Jack, who is liaison to Butler Community College, reports that six students have completed the first year of the program and are well into their second year. They are expected to graduate in September of 1983. Approximately 600 students attended the 1982 Measurement Science Fair in April, and they now have 14 students enrolled for the 1982/1983 Metrology Program. Butler also presented two short courses for government and industry during 1982, Non-Destructive Testing in July and Statistics in August.

J.M. Perry Institute of Yakima, Washington, announced in July of this year that they were offering a metrology curriculum as an adjunct to their primary course in electronic instrumentation, and would be optional to all students enrolled in the primary course. The school is in the process of developing additional courses and is setting up a metrology laboratory. Jay Varvel will be liaison with this school.

The Training Committee is also receiving information from Roberto Gonzales, DWSO, on ISA education and training activities, from Bill Fry on GIDEAP activities, and Karl Speitel of Eastman Kodak on ASQC training.

Meeting and Programs. Chairman M.J. Corrigan, Jr., of Lockheed Electronics, regularly provided the Board of Directors, Committee Chairmen, and Regional Coordinators with meeting and program announcements, regional meeting schedules, and topics for discussion. Progress has been made on two action items assigned during 1982. The Committee was changed from the historically one man effort to a true committee whose membership includes each Director and Regional Coordinator and the following individuals: John King of General Dynamics, and John Cox of Lockheed Missiles and Space Company. A committee meeting was held in October and the next will be published in January for implementation in 1983.

Honors and Awards. Chairman Hillary Taff of the Tennessee Valley Authority, performed his tasks very efficiently. He prepared and distributed new NCSSL letterheads at the beginning of the year, and kept the Board amply supplied throughout the year. He also designed and had plaques made for Regional Coordinators and the International Director, prepared certificates and purchased or arranged for awards which were, or will be, presented to the Board members, committee chairmen, regional coordinators, and outgoing and incoming presidents. Hillary also prepared the Wildhack Award and special awards for John Lee and Bascom Birmingham, and assimilated a comprehensive listing of who received what award over the past years.

MEASUREMENT REQUIREMENTS

Vice President Doug Doi of Lockheed California Company, presents the following report on his committees:

National Measurement Requirements Committee. Chairman Del Caldwell of the U.S. National Metrology Institute, reports that the Committee's goal to conduct the "NCSSL 1982 National Measurements Requirements Survey" has been completed. The objectives of the survey were to identify the requirements for new or improved NBS calibration services, and to identify new test, calibration, or measurement requirements which are required to establish or improve technical quality and/or productivity capabilities.
The survey was conducted in two parts: 1464 questionnaires were mailed in Part I and there were 411 responses. In Part II, 193 questionnaires were mailed to respondents indicating a need for new or improved services, and 49 responses were received. As a result, 259 technical requirements for new/improved technical services/capabilities were identified. Del presented this data at the 1982 NCSL Conference, and has committee goals to establish 9-10 technical working groups to review survey results in more detail, complete a technical summary report by January 1983, and the final survey report by March 1983.

Laboratory Evaluation Committee. Chairman Ron Kidd of Microwave Associates, reports that the Committee continues to achieve its goal in an effective manner by keeping NCSL members abreast of recognized and emerging evaluation programs. Highlights of 1982 activities were:

- NVLAP has been reorganized under the Office of Product Standard Policy (OPSP) with Dr. Stanley Warshaw as Director. This means that NVLAP is under NBS responsibility.
- NVLAP now also has the mechanism to accredit foreign laboratories.
- Ron Kidd attended and reported on an Electromagnetic LAP on July 1 & 2, 1982, in Boulder, Colorado, and Ron also conducted a Laboratory Accreditation Workshop at the 1982 NCSL Conference.
- Activity on the NVLAP Electromagnetic program for accrediting power and attenuation continues. The Advisory Committee for this LAP is in the process of being selected. Ron Kidd has been nominated to serve on the committee.

Biomedical and Pharmaceutical Metrology Committee. Chairman William Fitzgerald of Travenol Laboratories, Inc., reports that his committee's 1982 goal was to develop a voluntary guideline to be used by the medical products industry to develop internal metrology and calibration programs that meet the intent of the Food and Drug Administration's GMP and GLP Rules and Regulations. The third draft of the "Medical Products Industry Calibration Control Systems Guideline" has been completed and submitted to the Recommended Practices Committee for review and comment.

The Committee is concerned about the lack of participation by the medical products industry in NCSL activities. A goal for 1983 is to establish liaison between the Association for the Advancement of Medical Instrumentation (AAMI), Health Industry Manufacturers Association (HIMA), Pharmaceutical Manufacturers Association (PMA) and others in the area of metrology and calibration issues.
President Dean Brungart announces that there has been 100% concurrence by government and industry representatives on the proposed Change Notice 1 to MIL-STD-45662. This concurrence was reached on November 29, 1982, in a meeting organized and sponsored by the Office of Secretary of Defense (OSD) in Crystal City, Virginia. Thomas Wolf, from DARCOM Headquarters, predicted that the long awaited Change Notice 1 will be issued prior to December 31, 1982, and that the revision to Handbook 52 will be issued in the first quarter of 1983. The following changes are to paragraphs 5.5 and 5.6 of MIL-STD-45662:

The underlined portion has been added to the next to the last sentence of paragraph 5.5, which has been revised to read:

"As a minimum, the procedures shall specify either the measurement standard to be used or the required accuracy of the standard."

Paragraph 5.6 has been rewritten to read:

5.6 OUT OF TOLERANCE

5.6.1 Calibration Systems Accuracy. The contractor shall establish a procedure to evaluate the adequacy of the calibration system based on out of tolerance data generated from calibrating test and measurement equipment. The procedure shall include, but not be limited to, adjustment of calibration frequency, adequacy of the measuring or test equipment, calibration procedures and measuring or test procedures. The procedures shall specifically provide for the identification and prevention of use of any equipment which does not perform satisfactorily.

5.6.2 Notification of Out of Tolerance Conditions. The contractor’s procedure shall include the requirement for the calibration activity to notify the measurement and test equipment user or appropriate contractor element of significant out of tolerance conditions so that appropriate action can be taken by the contractor or T&M user to correct possible non-conforming products. The procedure shall define what constitutes a significant out of tolerance condition.

It is believed that these changes will make MIL-STD-45662 acceptable, and eliminate the current practice of requesting a waiver or taking exception to the MIL-STD-45662 when it is specified in a contract.
We recognize that these increased fees necessary to recover MAP research and development costs are very substantial. It is essential, therefore, that we obtain advance information from users of the affected NBS services regarding the impact upon their operation. In particular, we need to know your expected requirements for affected NBS services before and after the increases in fees. If a major reduction in the number of users of MAP, RMAP, or calibration services will result, it will not be possible to continue the NBS research and development program for MAP's and RMAP's at the present level of $1,933K; in this case we must plan the termination of activities associated with the funding shortfall.

I would like to have the advice of your organization on the ways we can implement the change in cost recovery policy with minimum disruption to NBS customers. I also encourage you to propose alternate cost recovery plans; however, I emphasize the importance of the $1,933K level of income that is required. It is important that I receive your comments in this connection before February 1, 1983, since, if we do project a shortfall, we must initiate a reduction of programs and related staffing in order to reach the required levels at the beginning of the next fiscal year on October 1, 1983.

If you have questions or if you need additional information regarding the plans to recover research and development costs for NBS Measurement Assurance Programs, please contact me (301-921-2451) or Dr. Brian Belanger, Chief of the Office of Measurement Services (301-921-2805).

Sincerely,

Raymond Rammer
Deputy Director

Enclosures
- Summary Fiscal Impact
- MAPs and RMAPs in Service
NBS MEASUREMENT ASSURANCE PROGRAMS
SUMMARY FISCAL IMPACT OF DEVELOPMENT
COST RECOVERY

Development Costs (FY 1984 Budget):

<table>
<thead>
<tr>
<th>Type</th>
<th>MAPS (FY 1984 Budget)</th>
<th>RMAPs (FY 1984 Budget)</th>
<th>Total Development</th>
</tr>
</thead>
<tbody>
<tr>
<td>MAPS</td>
<td>$1,166K</td>
<td>767K</td>
<td>$1,933K</td>
</tr>
<tr>
<td>RMAPs</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Sales of Services (recovery of incremental costs, projected to FY 1984):

<table>
<thead>
<tr>
<th>Type</th>
<th>MAPS (50 users)</th>
<th>RMAPs (5 groups)</th>
<th>Total Sales</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Charge</td>
<td>$1,300</td>
<td>2,500</td>
<td>$77.5K</td>
</tr>
<tr>
<td>Total Sales</td>
<td>$500</td>
<td>12.5K</td>
<td>$77.5K</td>
</tr>
</tbody>
</table>

Alternative 1 - Recover Total MAP and RMAP Costs Directly

Average charge based upon full cost recovery from present users:

- MAPS (per user) $25K
- RMAPs $156K

Alternative 2 - Recover Total MAP and RMAP Costs Through Calibrations

One alternative basis for full cost recovery would spread Measurement Assurance Program development costs over all calibration service activity. In this case the average charge for a calibration would increase from $806 to some value between $1,500 and $2,500 depending upon the effect on total sales.

Alternative 3 - Reduce MAP and RMAP Service

Using either the approach of alternative 1 or 2, reduce MAP and RMAP development to level sustainable by fees. NBS estimates that a viable MAP development program cannot be continued if the fee income is not sufficient to allocate $300K for this purpose. In addition, it would be necessary to separately fund the portion of calibration R&D that was previously coordinated with MAP development; it would be necessary to recover this cost, at a level of $600K, through increased calibration fees.

1Measurement Assurance Programs for individual users.
2Measurement Assurance Programs for regional or industrial groups of users.
HIGHLIGHTS OF THE NCSL BOARD MEETING

OCTOBER 7-8, 1982

NBS, Gaithersburg

PRESIDENT'S REPORT - Dean Brungart

See Dean's Annual Report, page 5.

EXECUTIVE VICE PRESIDENT'S REPORT - Hartwell Keith

Hartwell reported that the responses to the survey conducted by the Ad Hoc Committee on the NBS Organic Act have been forwarded to the Secretariat.

The following appointments have been made for 1982:

Vice President Administration - Brian Werner
Vice President Measurement Requirements - Pete England
Vice President Laboratory Management & Operations - Doug Doi
Vice President Communications & Marketing - Edward Nemeroff

Directors:
- Harry B. Haymes (Regions 1 & 2)
- Clifford D. Koop (Regions 5 & 9)
- Robert M. Lady (Regions 4 & 6)
- Hugh C. Starling (Region 3)
- J. Graham Cameron (International)

1983 Board Meeting Schedule:

January 17, 18, & 19, Palo Alto, California at Hyatt Rickey's. (This is the same week and place as Measurement Science Conference.)

April 27, 28 & 29, Williamsburg, Virginia, at Hospitality House Motel.


October dates and location are open; planned for New England area.

SECRETARIAT'S REPORT - Selwyn Smith (read by Chet Crane)

The Secretary reports that there are presently 483 members in good standing with 62 still unpaid for 1982.

There were five companies which joined the ranks of the NCSL during the past quarter.

TREASURER'S REPORT - Gary Davidson

As of September 15, $27,800.00 of this year's budget had been spent. The income to that date was $45,600.00 for an increase in funds of $17,800.00. Current total assets stand at $45,900.00.

Projected expenses for the year are $44,700.00 with an income of $49,700.00.

SPONSOR'S DELEGATE - Bascom Birmingham

Dr. Stanley Warshaw, Director of the Office of Standards and Policy, was introduced. Bascom briefly alluded to new MAP cost recovery plan to be detailed by Ray Kammer.

President Brungart thanked Bascom for his six years of excellent service as a sponsor's delegate, and welcomed Bob Kamper as the new sponsor's delegate.

SECRETARIAT'S REPORT - Ken Armstrong

Ballots were mailed to 525 members with 293 being returned.

Capabilities questionnaires have been mailed to 701 laboratories; 539 are NCSL members.

It was reported that a contact will be listed in overseas areas who will distribute information on calibrations capability and availability.

The videotape library has two tapes with waiting lists into June of 1983. These are #104 and TA #111. A long list is also waiting for a pair of tapes, TA's #114 and #115 titled "Acoustic Theory of Sound Measurements," Parts I and II. The tape library index and usage need to be computerized to gain accessibility to usage report to include backlog and waiting list.
VENTFUL'S REPORT-MEASUREMENT REQUIREMENTS - Doug Dol

National Measurement Requirements - Del Caldwell. Five committees have been formed to update and summarize the responses received on the Measurement Requirements questionnaires:

- DC and Low Frequency - NBS expert N. Rebecki
- Microwave
- Electro Optical
- Lasers and Infrared
- Temperature and Pressure - NBS expert Bob Souler
- Physical Measurements - Dan Flynn and Merrill Hessel

Volunteers are needed to assist in these and other committees to be formed. Regional Coordinators are to look for recommendations to work on the committees. This information from the questionnaire should be made available to the membership in time to get inputs in a timely fashion. A complete technical summary report, including a detailed review of the committee, is planned by January 1983. Final survey is to be complete for March 1983.

Laboratory Evaluation Committee - R. E. Kidd. Ron reported that the laboratory accreditation workshops presented at the conference were well attended and very interesting with a well qualified panel of experts in Robert Gladhill, Charles Hyer and Charles Jost.

Ron has been nominated to serve on the National Voluntary Laboratory Accreditation Program Advisory Committee for Electromagnetic Testing (accrediting power and attenuation).

Ron reported that a draft of the NCSL Advocacy Position Guidelines has been prepared. Ron read them into the minutes of the BOD Meeting (see page 49).

A motion was made and seconded to accept the guidelines as submitted. The motion carried unanimously.

Biomedical and Pharmaceutical Metrology Committee - William Fitzgerald. Bill reported that the Health Industry Manufacturers Association (HIMA) is organizing a task force to discuss Metrology and Calibration within the health care industry. He will attend the organizational meeting to establish liaison between the HIMA task force and the NCSL Biomedical and Pharmaceutical Metrology Committee.

A draft copy of the document, "Medical Products Industry Calibration Control System Guideline," has been sent to the Recommended Practice Committee for review and comments preparatory to start the necessary procedures to make a Recommended Practice.

VENTFUL'S REPORT - George Rice

Calibration Systems Management Committee - Philip May. Phil May presented four possible organizational structures for the Calibration Systems Management Committee. The preferred option (option four) has four functional areas: (1) Management Information Systems; (2) Management Research and Applications; (3) Systems Management and Control; (4) Human Resources Management. The human resource process areas: (1) Surveys Subcommittee; (2) Standard Practices Subcommittee; and (3) Workshop Subcommittee.

Measurement Assurance Committee - Laurel Auxier. Laurel reported that the MAP training seminar has been rescheduled for January or February in California.

The MAP Handbook has been split into two sections and will be published as a General Section and a Statistics Section. The General Section is to be published before the end of January and the Statistics Section will be about three weeks later.

The first official Region 2 Voltage MAP is under way and scheduled for completion in November.

A Gage Block MAP/Round Robin is planned in Region 6, to begin this year.

A Gage Block MAP is planned and two 10 block sets ordered in Region 8.

Reverse Resistance Pilot MAP is nearing completion of Phase II. The NBS Resistance Transfer Standards are at the NBS for remeasure.

A planning meeting of participants in the MAP is tentatively scheduled for early November.

Automatic Test and Calibration Systems Committee - George reported that the committee chairperson was unable to attend. The overall committee activity plan and supporting subcommittee plans will be available by the January Board of Directors meeting.

George distributed copies of the Laboratory Manager's Guidebook. He discussed several possibilities for distribution.
including publishing it in the Newsletter or separately by the NCSL Information and Directory Committee.

**Vice President's Report, Communications and Marketing - P. England**

Information and Directory Committee - Ralph Bertermann. Ralph reviewed the status of and recommendations for the 1983-84 Directory. The color will be brown, the symbol "C" will be used to designate consulting service in the Laboratories and Capabilities section, and the terms "USA" and "non-USA" will be used to divide the listings in the Laboratories and Capabilities and Directory of Standard Laboratories sections.

**Vice President's Report - Administration - Bryan Werner**

Bryan is now in the process of organizing an Industry/Government Advisory Board for the Metrology Program at Butler College.

Meetings and Programs Committee Report - M. J. Corrigan, Jr. A new topic for discussion has been added: "Productivity in Metrology," to explore approaches that stimulate increased productivity in the metrology lab. A suggested topic for discussion is also the advocacy position guidelines and applications.

Education and Training Committee - John Martin. Mike Zall will assume responsibility for the Training Aids Library Subcommittee activity. A survey was made of user's preference for 3/4 inch or 1/2 inch format for video tapes. Response was poor with a majority preferring the 3/4 inch.

The first Training Information Directory has been prepared and mailed. Updates and additions will be listed in the Newsletter and an updated Directory will be published only once each year. This document replaces the Course Register.

The completion date of the Basic Metrology package is indefinite because the status of both members of the Adjunct Training Subcommittee has changed.

A status review meeting will be held with Will Loeffler, John Martin and Bryan Werner attending. The purpose of the meeting is to establish benchmarks and set a date for completion of the Basic Metrology Package.

The computer-assisted training course is also on delay because the company which was expected to loan the computer has declined to do so. Mr. Jones of Sandia is going to review the project to determine what is available and what would be required to complete the project.

All six of the original students enrolled in the Metrology Program at Butler Community College should graduate at the end of this school year. The new class just beginning has an enrollment of 14. Bryan Werner/John Martin were assigned an action item to obtain a profile on the graduating class of Butler students and send copies to the Board and to John Lee.

Jay Varvell reported on the metrology course and the development of course curriculum at the J.M. Perry Institute. The Institute is located in Yakima, Washington, and works closely with industry in the local area.

Milt Towne has completed a slide presentation in metrology. It will be displayed at the 1983 Measurement Science Conference.

**Regional Reports - Directors/Coordinators**

Region One - Harry Haymes. Region meeting will be held October 27 at Gen Rad West, Concord, Massachusetts. A new regional training coordinator will be recruited at this meeting due to the retirement of Mr. Herbert Barclay of GTE Sylvania.

Region Two - Ed Nemeroff. Joe Bunting has made a fully recovery from his illness but would not be able to continue as Regional Coordinator after this year. There have been no regional meetings during the past quarter.

MAP in Region Two is now in the final stage. A meeting of the participants with Norm Belecki was held on September 2 and results should be available in early November.

Region Three - Fred Kern. A regional meeting is scheduled for the week of December 6 at NASA Headquarters, Washington, D.C., to be hosted by Harry Quong.

Two regional meetings are scheduled for 1983; one in April at the Naval Ship Weapon Center, White Oak, Maryland, and one in October at the Applied Physics Laboratory, Laurel, Maryland.

Region Four - Bob Lady/John Riley. The next regional meeting will be held on November 9, 1982, and hosted by Richard Drew, Martin Marietta in Orlando, Florida. Agenda items will include "Automated Calibration Systems and Calibration Interval Attachment"; also probably the advocacy guideline.
Region Five - Doug Smith. A meeting was held at the Temperature Instrumentation Facility of Rosemont, Inc., in Egan, Minnesota. This meeting was poorly attended due to the economic state. For 1983 only one meeting is being considered at this time, in the Chicago area some time in March.

There was extensive discussion of possible ways to better serve the members of regions by providing more region meetings in more than one location. The possibility of making one or more new regions to reduce distance and travel time to meetings was also discussed.

Region Six - Bill Simmons. A regional meeting is tentatively scheduled for the first week in December for Dallas. The subject of MAPs versus regional round robins will be a major topic.

Regions Seven & Eight - Bob Weber. No Region Seven meeting since last report to the Board. The next region meeting will be held November 18, 1982, in the Sunnyvale area.

There are nine unpaid members. Carl Quinn has requested Ken Armstrong to invoice these nine.

Region Eight - Rolf Schumacher. The Education Committee has met to consider new approaches to the old problem of securing new technicians and of providing their training.

Goldenwest College in Costa Mesa is starting a new full two year metrology training program. The college has requested help from industry. The Education Committee is preparing to provide assistance.

Next Region Eight meeting is scheduled for November 17, 1982. The agenda will include the Goldenwest College program, Productivity in Metrology, MIL-STD-45662 and MIL-Handbook 52.

International Region - Graham Cameron. The next regional meeting will be held in November; agenda items include: customs clearance of standards and test equipment, movement of shock sensitive/RFI emitting equipment by commercial air carrier, highlights of symposium and regional meeting held at NCSL '82, National Accreditation of Testing Organizations, Bureau National de Metrologie audio visual availability of, Canadian DND Directory of Recognized Facilities.

The Canadian region will establish liaison with the National Research Council of Canada, with Revenue Canada, and with the Standards Council of Canada.

Hartwell Keith emphasized that there is a new requirement placed on the regional coordinators in the long range plan which requires that each region be surveyed regarding NBS services. An action item was assigned to Del Caldwell to coordinate a format for the NBS services survey.

LIAISON DELEGATES REPORTS

Hartwell reported on Precision Measurements Association and the FY '83 PMA officers:

- President - Carl Quinn
- Vice President - Arthur Plourde
- Executive Vice President - Mike Buon
- Secretary - Art Vogt
- Treasurer - Sonja Calicher
- Directors-at-Large - Hal Clark & Chet Crane

GIDEP

Nothing new to report; preparations for upcoming annual workshop and Metrology Committee meeting are in their final phases; Metrology Committee will meet November 8 and the workshop will be held November 9 to 11 in Chicago, Illinois.

Measurements Science Conference - Dean Brungart. Conference to be held January 20 and 21 at Hyatt Rickeys Hotel in Palo Alto; theme is Accuracy and Automation; keynote speech will be the Dave Mitchell of Rockwell International.

ASQC - Karl Speitel

The Standards Writing Group, sponsored by the Metrology Technical Committee of the ASQC to develop "Quality Standards for Calibration Systems and Measurements" has prepared Draft 2, Revision 9 of the Standard for Calibration Systems. Rolf Schumacher, as Chairman of the Writing Group, has formed an Intermediate Approval Group to review this draft; NCSL representatives are part of this group.

ISA

Mike Suraci has been appointed as ISA Liaison to NCSL as well as NCSL Liaison to ISA. The ISA Standard Practice Committee has a keen interest in the recent court decisions involving members preparing standards.

Council for Optical Radiation Measurements has decided that they will not participate at this time through liaison delegate channels.
OIML LIAISON - Brian C. Belanger

The international document, "Documentation for Standards and Calibration Devices" was received for U.S. review and comment. Brian reviewed the document and had copies sent to Al Kohler, Chairman of NCSL Recommended Practices Committee, and Rolf Schumacher, ANSI/ASQC Standards Writing Group.

Brian asked the Board's advice on who in NCSL should review documents of this type. He suggests that, due to the diversity of topics covered, the most expeditious method would be for him to make judgment calls and get some inputs since the time available is usually short.

A meeting will be held in October at BML in Paris to explore the concept of an OIML international certification system. The philosophy of this system is to have all members recognize the OIML "MARK" as proof of acceptance for members. Several U.S. organizations and some other member countries have developed a position which incorporates these points:

Two or more OIML members will sign a collective accord that would permit mutual acceptance of the mark on a legal measurement instrument.

Manufacturers from member states may apply for and receive the mark once an accord is established.

A condition for countries to participate in the accord would be a demonstration of consistency in test results.

A working group has been formed to provide oversight of USA responsibility for Pilot Secretariat 17 on "Measurement of Pollution." Reporting Secretariats will cover (1) air, (2) water, (3) radioactivity and ionizing radiation, and (4) pesticides and toxic substances. The USA is considering requesting responsibility for (2) and (4).

OIML intends to sponsor and international intercomparison on hardness standard blocks. ASTM Committee E-28 on Mechanical Testing is sponsoring U.S. participation in the intercomparison.

ANSI - Rolf Schumacher


ANSI/ASQC Quality Standard for Calibration Systems, Draft 2, Revision 9, has been voted upon by the Intermediate Approval Group. Some more work and additional revisions will be necessary before Draft 3 is submitted to the public, probably by mid-1983.

CPEM - Bob Kamper

The Conference on Precision Electromagnetic Measurements is an international conference held every two years addressing topics in measurement techniques and instrumentation for a number of areas. The application of automation and cryoelectronics to these measurements and general problems of calibration services are also included. The 1982 CPEM was held in Boulder, Colorado, last summer. Copies of the Conference Digest are available for $32.00 per copy. The full Conference Proceedings will appear as a special issue of the IEEE Transactions on Instrumentation and Measurement in March, 1983. The 1984 CPEM will be held in Delft, Netherlands. There is a subcommittee whose purpose is to maintain continuity between conferences; Bob is chairman of this subcommittee.

ATTENDEES

D. Brungart  
Teledyne Systems

J. Lee  
USIR

H. Keith  
TRW

G. Davidson  
TRW

G. Rice  
Rockwell

D. Doi  
Lockheed Calif. Co.

P. England  
General Dynamics

B. Werner  
Westinghouse

E. Nemeroff  
Guildline Inst. Co.

L. K. Armstrong  
NBS

B. W. Birmingham  
NBS

B. Kamper  
NBS

B. Belanger  
NBS

B. Lady  
Lockheed Georgia Co.

C. Koop  
Rockwell

B. Weber  
Lockheed, Sunnyvale

H. B. Haynos  
Sanders Associates

G. Cameron  
Canadian Dept. of Defense

H. Starling  
General Electric Co.

W. Fitzgerald  
Baxter-Travenol Labs Inc.

H. A. Taff  
TVA

R. Betermann  
G.D. Serle & Co.

R. Schumacher  
Rockwell International

D. Caldwell  
Navy Metrology Engr. Ctr.

P. May  
The Bionetier Corp.

R. Kidd  
MACOM

M. Corrigan  
Lockheed Elect. Co.

B. Simmons  
Barrios Technology

D. Goodhead  
Westcon, Inc.

L. Auxier  
Beckman

J. Martin  
Westinghouse

K. Spoitel  
Eastman Kodak Co.

C. Crane  
Teledyne Microelectronics
CALL TO ORDER
The Member Delegates Meeting of the National Conference of Standards Laboratories was called to order at 9:20 AM on October 5, 1982, by President Dean Brungart.

The Member Delegates meeting was held at the National Bureau of Standards, Gaithersburg, Maryland, as part of the 1982 NCsL Conference.

WILDHACK AWARD
Dean Brungart announced that the recipient of the 1982 NCsL Wildhack Award was Dr. Churchill Eisenhart of the National Bureau of Standards. After a standing ovation, Dean presented Dr. Eisenhart with a special Wildhack Plaque and an honorarium of $1,000.00.

SPECIAL AWARDS
Dean announced that Bascom W. Birmingham of the NBS/Boulder Laboratories and NCsL Sponsor's Delegate will be leaving both of these positions. He will be taking on an internal reassignment to the newly formed Center for Chemical Engineering at Boulder. On behalf of NCsL, Dean presented Bascom with a Certificate of Appreciation and a check for $100.00 for his many years of outstanding service.

Dean announced that John Lee, the present Past President, will be leaving NCsL at the end of this year. For John’s many years of outstanding service to NCsL, Dean presented him with a Certificate of Appreciation and a check for $50.00.

MIL-STD-45662
Dean reported that when the final draft of the MIL-STD, as agreed upon on April 7th and 8th, 1982, at DARCOM Headquarters, was sent back to the various government agencies for their concurrence, two agencies took exception to the draft. One agency has since been persuaded, but the second party is quite adamant in its stand. Dean stated that if all parties could not agree, there would be a possibility of an addendum or option which would accompany the MIL-STD.

It would then be up to the contracting agencies whether this option would be enforced. He was informed that the final draft would be released within the next thirty to forty days.

ADVOCACY POSITION GUIDELINE
Dean reported that the NCsL Board had completed the task of finalizing the Advocacy Position Guidelines at a special Board of Directors meeting held on October 3, 1982.

CALIBRATION LABORATORY MANAGERS GUIDEBOOK
Dean reported that the Guidebook was now complete and was primarily intended for managers who were getting started in metrology and starting up a new lab. The manual will be mailed out to the membership in the future.

NCsL ADJUNCT TRAINING COURSE
Dean reported that there were setbacks in completing the course due to travel constraints and manpower difficulties of the people working on the course. The course is now scheduled to be completed early next year.

MESSAGE FROM INCOMING NCsL PRESIDENT (1983)
LONG RANGE PLAN (1983-1987)--Hartwell Keith announced that the Long Range Plan had recently been approved by the Board at a special Board meeting. He stated that copies were available to all interested Member Delegates by writing to the NCsL Secretariat.

HIGHLIGHTS
- A more vigorous membership marketing plan which included establishing two new committees "Publicity" and "Membership Promotion.
- Announced his intention to reappoint Graham Cameron as Director for the International Regions
- More emphasis on MAP programs
- Increased effort by Education & Training Committee to get young people interested in the metrology field.
- Secretariat now reporting to VP of Administration
- Advocacy position guidelines established
- Year end committee reports to be channeled through the cognizant VP
- Plea to delegates to get more involved with committees and attend at least one Regional meeting per year
Financial Status: Hartwell reported that as of September 15, 1982, the NCSL assets were $45,932.28.

BYLAW REVISIONS

Dean announced that the NCSL Bylaws had recently been reviewed, revised and approved by the Board, and would be distributed soon.

EDUCATION & TRAINING COMMITTEE REPORT

John Martin, Education and Training Committee Chairman, reported that Butler Community College will be graduating 6 metrology students in the fall of 1983, with 14 students enrolled in the 2nd year program.

J. M. Perry Institute, located in the Yakima, Washington, area is in the process of establishing a metrology curriculum. Chairman of the Board of Trustees, Fred Smith, discussed present and future courses at his school and welcomed inquiries about his training facilities.

CHANGES IN THE NBS BUDGET

Mr. Raymond Kammer, Deputy Director of the National Bureau of Standards, informed the NCSL membership about some developments and changes in the NBS budget which would have an impact on the metrology community.

Mr. Kammer stated that NBS had recently begun to prepare to recover the full costs of research and development for MAP and Regional MAP Programs. This would mean that beginning October 1, 1983, the annual $1.9 million R&D cost for MAP and regional MAPs would have to be recovered by the Bureau from customers. Currently the Bureau recovers only the cost of MAP and Regional MAP operation which is a little under $50,000. He stated that this magnitude of fee increase would likely terminate or markedly change the program.

One alternative to preserve MAP and regional MAPs would be to have the Bureau spread the cost over all or some of calibration fee schedules, which currently represents about $3 million in collections. The first alternative, of terminating or substantially increasing fees for MAPs and regional MAPs, would seriously affect the metrology community. The second alternative would affect virtually everyone.

Because the decision is so recent, Mr. Kammer stated that the Bureau had not as yet developed plans for implementing the decision. The Bureau's first step will be to consult with calibration/MAP users in order to try to determine the impact of this decision on their operation and to gather ideas on coping with the decision. One significant impact Mr. Kammer was already very much aware of was that this decision will reduce R&D support not only for MAP and Regional MAP programs, but also for a number of calibration services in areas closely related to MAPs and regional MAPs. This will reduce the Bureau’s ability to offer new calibration services in a number of cases, especially in electrical measurements. He further stated that he suspects it may restrict the Bureau's ability to continue some services that are currently being offered.

QUESTIONS AND ANSWERS

Question

Will the Bureau honor the prices on existing in-process MAP programs?

Answer

If the service has already been initiated, the Bureau will complete that service at the cost they quoted at the time they accepted the order.

All existing services provided after October 1, 1983, will be at some substantially higher fee.

Question

Would you like to speak to what the source of the policy is and what the membership may do in the future to influence getting R&D back into the Bureau's budget?

Answer

The source of the decision is a government policy to recover costs whenever specific users can be identified. (Hartwell Keith stated that as NCCLS is able to get more information on this decision, a NCCLS Ad Hoc Committee will be established and based upon their findings, will make a recommendation.)

1983 NCCLS CONFERENCE (July 18-21, 1983)


Gary announced that the theme of the Conference is "Metrology Meeting the Challenge of Change." After discussing the theme, he made a request for papers, and asked for comments and letters for additional suggestions.
Dr. Ernest Ambler, NBS Director, welcomes conference attendees.

An impressively large crowd listens to the Keynote.

Our helpful volunteers sign in arrivals.

Laurel Auxier gets a refill at the Attitude Adjustment Hour.

Some guys get all the girls.

Spouses Program meets at the NBS Hospitality Suite to plan the day.

Dr. Churchill Eisenhart receives his Wildhack Award.

Retiring Past President John Lee gets an award from Dean Brungart.
International attendees and NCSE hosts at special international dinner evening.

Brian Belanger, NBS, makes a point.

Pete England hosts a table.

International Director Graham Cameron dines with guests.

The Annual East-West Volleyball Game was re-cast into North-South (the West always won). This time the South won.

Well, hopefully they are better metrologists than volleyball players.

Horseshoes must be as frustrating as golf.
Board Meeting attendees at Carmel, California, July 1982.

Why is George Rice wearing sunglasses?

Treasurer Emeritus Bob DeLapp visits meeting.

Another day, another dollar.

Board Meeting attendees at Gaithersburg, October 1982.

Isn't anyone listening to the speaker?

Getting on with business.

Incoming President Hartwell Keith and wife Mary Lee enjoy Board dinner with other Board friends.
MEETINGS AND PROGRAMS ANNOUNCEMENTS

January 17-19, 1983
Board of Directors Meeting, at Rickey's Hyatt Hotel and Conference Center in Palo Alto, California.

January 20-21, 1983
Measurements Science Conference at Rickey's Hyatt Hotel & Conference Center in Palo Alto, California.

March 8-10, 1983
Microbial Corrosion: For Engineers and Scientists Concerned with Prevention of Corrosion Caused by Bacterial Activity, Mr. C. Barbour, The Metals Society, Telephone 01-839-4071.

March 7-11, 1983
Measurement Systems Engineering Course. Call Pete K. Stein at 602-945-4603 or 602-946-7333.

March 14-18, 1983
Measurement Systems Dynamics Course. Call Pete K. Stein at 602-945-4603 or 602-946-7333.

April 27-29, 1983
Board of Directors Meeting at Williamsburg, Virginia. (Hospitality House Motel)

May 2-5, 1983
Test and Measurement World Expo, San Jose Convention Center, for information call 617-254-1445.

July 18-21, 1983
NCSL 1983 Workshop and Symposium, Harvest House Hotel, Boulder Colorado.

July 21-22, 1983
Board of Directors Meeting at Boulder, Colorado.

October 10-13, 1983
ISA, Conferences and Exhibits, Houston, Texas.

October 18-20, 1983
Circuit Expo 1983, Centrum Civic Center, Worcester, MA.

1984
CPEM will be held in Delft, Netherlands, Conference Chairman will be Dr. Robert Kaars, National Service of Metrology, Box 654, Delft, Netherlands 2600 AR.

To have your organization's meetings and conferences announced, please send a note to M. J. Corrigan, Jr., Chairman, Meetings and Programs Committee.

REGIONAL MEETINGS SCHEDULE

REGION 1
Typically holds two (2) meetings per year, a regional business meeting and a technical session. Generally, meetings are held in the spring and fall of each year with the next meeting being planned for the spring of 1983.

REGION 2
Three (3) meetings are held each year, September, January or February and May. A February meeting is tentatively scheduled for the New York, Connecticut area.

REGION 3
Plans to hold two (2) meetings each year, spring and fall. The meetings are tentatively scheduled for the week of April 11, 1983, Naval Ship Weapon Center, White Oak, Maryland, Host - T.K. Hinders and the week of August 8, 1983, Applied Physics Laboratory, Laurel, Maryland, Host - George Skaggs.

REGION 4
Plans are to hold three (3) meetings each year. The 1983 regional workshop schedule has not been established as of yet.

REGION 5
Holds two (2) meetings each year. The next meeting is tentatively scheduled for mid-March at a facility in the Chicago area.

REGION 6
Plans to hold two meetings this year, dates will be announced later.

REGION 7
Plans to hold two meetings this year, dates will be announced later.

REGION 8
Plans to hold two meetings this year, dates will be announced later.

REGION 9
Plans to hold two meetings this year, dates will be announced later.

REGION 10
Plans to hold their next dinner meeting on July 19, 1983, at Boulder, Colorado.

Schedules will be updates as firm dates and locations are received.

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A FIRST LOOK AT A NEW TEMPERATURE SCALE

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ABSTRACT

The International Consultative Committee for Thermometry (CCT) is constructing a new temperature scale through the efforts of its working groups. When completed, perhaps as early as 1987, the new scale is intended to replace both the International Practical Temperature Scale of 1968 and the 1976 Provisional 0.5 K to 30 K Temperature Scale. In addition to the new scale, the CCT is contemplating issuance of two companion documents to assist thermometrists in their use of the existing Scale.

One document consists of supplementary information for users of the Scale itself; it includes historical information about previous international temperature scales as well as recommended techniques for the use of fixed points and standard thermometers. The other document, as yet unwritten, will contain recommended procedures for other high-precision thermometry. In this paper we present a brief status report on these three documents to acquaint the NCSL membership with their content and to provide a forum for discussion of their merits.

INTRODUCTION

As is the case with other physical units of measurement, responsibility for promulgating and modifying the international temperature scale rests with the General Conferences on Weights and Measures. There have been three such scales approved: the International Temperature Scale of 1927, or "ITS-27"; the International Practical Temperature Scale of 1948, or "ITPS-48"; and the International Practical Temperature Scale of 1968, or "ITPS-68". In addition, a provisional scale, the 1976 Provisional 0.5K to 30K Temperature Scale, or "EPT-76" has been put forth to supplement the ITPS-68.

The ITS-27 was intended to provide thermometrists with the ability to reproduce temperature measurements from laboratory to laboratory more precisely than could be done either by using existing national temperature scales or by employing thermodynamic thermometry. Each succeeding scale has been introduced for the purpose of extending the range of its predecessor and improving its accuracy with respect to the laws of thermodynamics.

Although it is the duty of a General Conference to decide whether a particular scale is to be promulgated, the International Committee for Weights and Measures has long since given to a Consultative Committee for Thermometry (CCT) the responsibility for construction of new temperature scales. In recent years, the CCT, which currently is composed of 15 institutional and three individual members, has met biennially to discuss the problems attendant to creation of a replacement for the ITPS-68. This writer has reviewed for readers of the NBS Dimensions Magazine the progress achieved during the CCT meetings in 1978 and in 1980.

Despite the continued improvement in international thermometry wrought by the promulgation of successively more extensive and precise scales, several problems have remained to inconvenience their users. These problems include the following:

1) Uncertainty in the accuracy of fixed-point temperatures used to define the Scale, especially those for temperatures below 0°C. Customarily these have been prepared in the laboratory of use and sometimes only for one use, so that no direct comparison with another laboratory of the temperature so provided can be made;

2) Uncertainty as to what constitutes adequate procedures to realize the Scale within a given precision, especially for laboratories whose personnel are not continuously occupied in that task; and

3) Uncertainty as to the level of Scale accuracy achievable with thermometers or procedures that are not prescribed for use by the Scale text.

After discussing the status of a draft scale presented to the 14th Session of the CCT, we shall outline the contents of two other documents under preparation by working groups of the Committee. By preparing these documents, the CCT hopes not only to extend and improve the ITPS-68, but also to alleviate the problems mentioned above.
Replacement of the IPTS-68 by a more extensive and thermodynamically more accurate scale is the current aim of the CCT. By agreement reached at the 13th (1980) meeting of the CCT, various tasks that contribute to that aim had been assigned to one or another of four working groups and the tasks assigned to them are summarized in Table I.

Examination of Table I shows that the tasks of Working Groups 3 and 4 must be accomplished before WG-1 can compose any but the most preliminary draft scale. Furthermore, it is plain that the PRT still is considered to be the most precise thermometer in its range. The absence of any comment on the temperature range above that defined by the PRT has the following significance: in the first place, it is the consensus of the CCT, expressed during earlier meetings, that the Type S thermocouple is less suitable than the PRT for defining temperatures between 900 K and 1337 K (1064°C, the freezing point of gold); and in the second place, it is the consensus of the CCT that the Planck Law of Radiation remains suitable for defining temperatures above 1337 K. Finally, it is apparent that Working Groups 2, 3 and 4 must collaborate in assigning "primary" and "secondary" status both to temperature fixed points and to thermometers.

In reports submitted to the 14th CCT meeting, held on March 30-April 1, 1982, at the conference hall of the BIPM, Working Groups 3 and 4 outlined the progress that has been made towards a new scale covering the range 0.5 K to 1337 K. These reports also noted several problems that remain to be solved before their tasks can be completed. The report of WG-2 contained a listing of some 15 temperature fixed points analyzed as to their precision measurement, supplementing two earlier analyses. Although WG-2 was unable to provide a draft document on recommended practices for secondary thermometry, they did furnish comments on likely sources of information about the use of secondary thermometers. Working Group 1 produced a draft scale text although they noted that it was mainly for discussion purposes since the tasks of Working Groups 2, 3, and 4 were not completed; WG-1 also provided a draft entitled "Supplementary Information for the IPTS-68 and EPT-76."

The discussion that took place during the CCT meeting focused upon the status of the new scale. We shall now summarize the situation with respect to the new scale. The reader should beware that what follows is the author's attempt to distill into a few paragraphs the essence of dozens of pages of reports and discussion.

### Table I

| PERSONNEL AND TASKS OF CCT WORKING GROUPS |

| 1. | M. Preston-Thomas, National Research Council of Canada (NRC); P. Bloembergen, Van Swinden Laboratorium, Delft, Netherlands; and T. Quinn, International Bureau of Weights and Measures, Sevres, France (BIPM). To prepare a draft replacement text for IPTS-68; to prepare a document containing supplementary information for scale users. |
| 2. | R. Bedford, NRC; G. Bonnier, Institut National de Metrologie, France; R. Maas, Amt fur Standardierung, Messwesen, und Warenprufung, East Germany; and F. Pavese, Istituto di Metrologia G. Colonnetti, Italy (IMGC). To continue evaluation of secondary temperature reference points with respect to temperature and precision; to prepare a document describing secondary level methods of thermometry. |
| 3. | L. Crovini, IMGC; P. Costes, National Physical Laboratory, England (NPL); W. Kemp, CSIRO, Division of Applied Physics, Australia; S. Ling, National Institute of Metrology, Peoples Republic of China; J. Schooley, NBS, USA; W. Thomas, Physikalisch-Technische Bundesanstalt, West Germany. To prepare new equations for the platinum resistance thermometer (PRT) throughout its useful ranges; to choose both an upper and a lower limit to that range (the latter in concert with WG-4); to choose the fixed points necessary to define the PRT range of the scales; to organize a cooperative study of high-temperature PRT's and evaluate the results; to review measurements of the thermodynamic temperatures of fixed points above 14 K. |
| 4. | R. Hudson, BIPM; M. Durieux, Kamerlingh Onnes Laboratorium, Netherlands; R. Rusby, NPL; and C. Swenson (Individual member) USA. To prepare recommendations for extension of the IPTS below the PRT range; with WG-3, to set the upper limit of that range. |
(a) "Practical" vs. "Precise." Once again, the CCT discussed the desirable level of "practicality" of the Scale—that is, the ease with which the Scale itself can be realized in a given laboratory—as opposed to the desirable level of precision of the Scale. There was no clear consensus on this matter, although the majority of those contributing to this discussion suggested that the CCT should construct the most precise and thermodynamically accurate Scale possible, even though only the advanced national laboratories might then be able to realize the scale. The provision of well-characterized secondary techniques would enable other laboratories to measure temperatures to a known accuracy with respect to it. The report of WG-3 explicitly recommended this course of action, suggesting that the reproducibility of the new Scale should be better than 1 mK for all temperatures below 273 K and preferably about 0.2 mK for temperatures below 20 K.

The suggestion was made that the word "practical" should be omitted from the title of the Scale if the goal is to be sought in its construction at the expense of its ease of realization.

(b) Lower limit of the scale. Working Group 4 suggested that 0.5 K be adopted as the lower limit of the new Scale. Since researchers in the field of cryogenics have expressed a need for defined temperatures well above 0.5 K (perhaps as low as 0.001 K), no entirely satisfactory scheme for defining temperatures below 0.5 K was put forward at the meeting.

(c) 0.5 K to 4.2 K. Working Group 4 also suggested that the vapor pressure vs. temperature relations for helium three and helium four be used to define this range, for which the upper limit would be the normal boiling point of helium four. The relations have been newly re-examined with a precision of a few tenths of a millikelvin. It was pointed out that in the region of overlap (0.5 K to 3.3 K), the use of both relations would induce an uncertainty of as much as 0.08 mK into the Scale—considerably more than necessary.

(d) 4.2 K to the lower limit of the PRT range. Working Group 4 suggested that the interpolating gas thermometer be used to define the scale in this range. They also suggested that the lower limit of the PRT range should be set at the triple-point temperature of neon (24.6 K), eliminating the need for intervening fixed points. There was no unanimity of opinion on either suggestions, however. The reproducibility of the interpolating gas thermometer has not been demonstrated at the submillikelvin level, and furthermore, the statement has been made that the PRT must be calibrated below 24.6 K in order to guarantee its precision above that temperature.

(e) 13.8 K to 273 K. Working Group 3 suggested that 13.8 K be retained as the lower limit of the PRT range, with fixed points at 13.8 K (the boiling point of equilibrium hydrogen at a pressure of 33,330.6 Pa), 20.3 K (the normal boiling point of equilibrium hydrogen), 83.8 K (argon triple point), 116 K (krypton triple point), and 273.16 K (water triple point, correct by definition). An exact function would be specified for generating the PRT resistance-temperature relation. The same report, however, emphasized that not all fixed point temperatures are known well enough at this time to be considered useful, so that the calibration function cannot be constructed yet, either. In the discussion of this point, there was an opinion that a least-squares technique employing a redundant fixed point could provide an equally satisfactory scale. The importance of the new sealed-cell concept to the scale reproducibility in this range was noted by all in attendance; an intercomparison, just completed (8), has shown clearly the value of triple-point temperatures up to 133 K. Temperatures above 29 K, however, so few of these thermometers have been available that little detailed information is known regarding their properties. Now, however, workers at the NBS have exchanged sets of three high-temperature PRTs with their colleagues at the MTM in the People's Republic of China; other sets of these thermometers have been loaned by the Chinese to national laboratories in England, Australia, West Germany, Italy, Canada, and the BIPM.

Working Group 3 also pointed out that of the fixed points recommended to be used to define the scale above 273 K, only the thermodynamic temperatures of the freezing points of tin (505 K), and zinc (693 K) are acceptably
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TABLE II

ABRIDGED OUTLINE OF "SUPPLEMENTARY INFORMATION FOR THE IPTS-68 AND EPT-76"

1. INTRODUCTION
   1.1 Scope
   1.2 Historical Background
   1.3 Numerical (scale comparisons)
   1.4 Tables, Figures, and References

2. FIXED POINTS:
   2.1 Triple Point of Water
   2.2 Ice and Steam Points
   2.3 Metal Fixed Points
   2.4 Cryogenic Fixed Points
   2.5 Pressure Measurements
   2.6 Tables, Figures, and References

3. REALIZATION OF THE EPT-76 (0.5 K to 30 K)
   3.1 Reference Points
   3.2 Differences from the IPTS-68 (13.8 K to 30 K)
   3.3 Differences from Laboratory Scales
   3.4 Vapour Pressures of Helium (0.5 K to 5 K)
   3.5 Interpolating Instruments
   3.6 Resistance Thermometry in the EPT-76
   3.7 Tables, Figures, and References

4. PLATINUM RESISTANCE THERMOMETRY
   4.1 Platinum Resistance Thermometer Construction
   4.2 Platinum Resistance Thermometer Use
   4.3 Mathematics
   4.4 Tables, Figures, and References

5. Pt-10% Rh vs. Pt THERMOCOUPLE THERMOMETRY
   5.1 Specifications
   5.2 Construction
   5.3 Annealing
   5.4 Calibration
   5.5 Recalibration
   5.6 Sources of Errors
   5.7 Tables, Figures, and References

6. OPTICAL PYROMETRY
   6.1 Optical System
   6.2 Filters
   6.3 Detectors
   6.4 Tungsten Strip Lamps
   6.5 Establishment of the IPTS above the Gold Point
   6.6 Automatic-Balancing Optical Pyrometer
   6.7 Sources of Error in Pyrometry
   6.8 Tables, Figures, and References

7. CALIBRATIONS AND COMPARISONS
   7.1 Tables, Figures, and References

APPENDIX

well-known. Those of aluminum, silver, and gold still require more accurate measurement, presumably by the technique of gas thermometry. Major points of discussion on this part of the new scale centered on the most appropriate tests and measurements to be made with the new high-temperature PRTs, on the likelihood of timely measurements being completed of the thermodynamic temperatures of the upper fixed points, and on the advisability of choosing the upper limit of the PRT range to be 1323 K rather than 1337 K because of the possibility that the new thermometers might perform stably only up to the lower (silver freezing point) temperature.

Above the PRT range, the consensus opinion during the CCT meeting was that the Planck Radiation Law could be used to define temperatures above 1337 K as is done in the IPTS-68. While the radiation thermometer is not thought to be the equal in precision of the PRT even at 1337 K, little further penalty in precision should accompany its use down to 1235 K.

"SUPPLEMENTARY INFORMATION FOR THE IPTS-68 AND EPT-76"

Prior to the CCT meeting, WG-1 had prepared several drafts of a type of document that is new to the CCT. It is intended for the guidance of all thermometers who wish to realize the international temperature scale. In the IPTS-68 text, 1 supplementary information is presented in Section III on a dozen topics, including the standard PRT, the standard thermocouple thermometer, pressure measurements, and the various defining and secondary fixed points. However, the material is very brief and, because of the infrequent modifications to the scale, very difficult to revise to include newly-developed techniques. In the EPT-76, too, only sketchy guidance on techniques is given.

During the past several meetings, the CCT has discussed possible remedies for the lack of uniform guidance on scale thermometry. Finally, it was agreed at the 13th meeting in 1980 that WG-1 should prepare a trial draft of a guidance document for review by the CCT. The resulting document, although incomplete, contained 140 pages. An abridged outline of the material is given in Table II.

It is readily apparent that this new document can be a really comprehensive guide to scale thermometry, incorporating as it does material similar to that contained in NBS Monographs 125 and 126, 13, 14 ASTM Manual STP 470 and in similar
Those attending the 14th meeting of the CCT received the new document enthusiastically, and a decision was reached to publish it through the BIPM as soon as it is complete. It is quite true that some of its material would become inappropriate as soon as a new international temperature scale might be adopted, but the point was made that such information can become part of the document to be discussed next in this paper. Subsequent modifications to the document, such as those occasioned by changes in one or another thermometric technique, can readily be made by issuing the "Supplementary Information" as needed.

The CCT expressed an interest in knowing the reactions of users of the IPTS-68 and the EPT-76 to the new guidelines.

**MONOGRAPH ON SECONDARY THERMOMETRY TECHNIQUES**

The CCT also has discussed for a long time the desirability of a second document on good thermometric practice. This one would offer guidance on the best procedures for obtaining thermometric precision with thermometers or methods that do not conform to the requirements of the current international temperature scale. The writing of a draft of such a document was part of the assignment given to WG-2 during the 13th CCT meeting of 1980. Unfortunately, no draft was produced. The WG-2 report mentioned two reasons for this delay: preoccupation of its members with other activities such as the 6th Temperature Symposium, and uncertainty as to the form such a guide should take.

During the 1982 meeting of the CCT, there was again considerable discussion of the latter point. Most of the people in attendance expressed enthusiasm for the idea of providing a guide to thermometry practice at the secondary level but, as before, there was little unanimity of opinion to the exact form that such a help should take.

It was suggested that advice on this topic might come from those people or organizations in various countries whose work mainly requires secondary-level thermometry. It should be reemphasized here that the term "secondary-level thermometry" is not at all to be construed as referring to the inferior work, but merely to indicate measurements made with instruments or methods that are not specified in the current international scale.

Topics that the WG-2 report suggested for incorporation in a guide of the type under discussion include the following:

- Liquid-in-glass thermometry;
- Thermometers for use below 273 K;
- Resistance thermometers;
- Thermocouple thermometers;
- Radiation thermometers; and
- Use of secondary techniques, such as the fitting of a quadratic equation by the least-squares technique to the fixed-point calibration of standard PRTs over a limited range of temperature.

The opinion was expressed that, in any treatment of topics such as those listed above, the approved practice should be given in sufficient detail that a temperature uncertainty with respect to the official Scale could be ascribed to the procedure, and that, furthermore, all possible use should be made of existing literature on the topic. The WG-2 report offered many examples on this latter point, for instance References 16, 17, and 18 on liquid-in-glass thermometry.

**CONCLUSION**

In this brief paper, we have summarized the deliberations in the Consultative Committee for Thermometry on three topics--a possible replacement for the IPTS-68 and the EPT-76, a document offering supplementary information for users of these scales, and a similar document intended to assist those engaged in other high-precision thermometry. The author encourages comment on all these topics, whether to himself, to his colleagues at the NBS, or directly to the CCT file at the International Bureau of Weights and Measures.

**REFERENCES**


7. The official minutes of CCT meetings, written in French, are available from the BIPM, Pavillon Breteuil, Sevres, France.


INDUSTRIAL ROBOTS--TODAY AND TOMORROW

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ABSTRACT

This paper will define the Industrial Robot, identify successful areas of application, discuss the current Robotic state-of-the-art and examine future trends.

Ladies and Gentlemen, it is a pleasure to be with you and it's a pleasure to be dealing with my favorite subject. My charter today is to bring you up to speed in the field of robotics. My experience with robotics has been a graduate thesis identifying potential robot applications at the GMAD, Baltimore Plant as well as my present job with UNIMATION as District Sales Manager for the Virginias, Carolinas, Maryland and D.C.

This first slide is a good place to start. When Charlie Chaplin made the movie "Modern Times" in 1936, he already sensed the abuse of mankind at the hands of its machinery. But, as the situation stood in 1936, labor was cheap and it was plentiful. Moreover, the technology necessary to create an industrial robot was not available.

By the end of the 1950s, the situation had changed. Labor costs had increased, and there had been significant technological gains born of war time, such as servo dynamics and solid state electronics. During this time a group named UNIMATION was formed to develop an industrial robot. Throughout the 1960s, this group was pretty much alone in striving to create universal automation. By 1977, there had been over 150 attempts to develop an industrial robot. Today, over half of these attempts have been aborted and only a couple dozen manufacturers have machines that are in series production and are application supported.

There is considerable confusion as to what defines a robot, and this probably accounts for discrepancies in the reported number of robots in use. Webster's defines the robot as "An automatic apparatus or device that performs functions ordinarily ascribed to human beings or operates with what appears to be almost human intelligence." The Robot Institute of America is more precise, "A robot is a reprogrammable, multifunctional manipulator designed to move materials, parts, tools, or specialized devices through variable programmed motions for the performance of a variety of tasks."

Whatever the definition, one important feature that a device must possess if it is to rank as a robot is the ability to operate automatically, on its own. This means that there must be built-in intelligence, whether it be a programmable memory or simply an arrangement of adjustable mechanisms that command manipulation. For these reasons, four types of devices cannot be classified as robots. These are prostheses, exoskeletons, telechecics, and locomotion devices.

Prostheses are artificial replacements for parts of the human body, exoskeletons are frames which surround human limbs, telechecics is the name given to remote manipulators that add distance and strength to human limbs, and locomotion devices imitate men or animals by walking on legs instead of the more usual method of wheels or tracks. All of these devices share technology similar to the robot and indeed are related.

Here we see the many activities in which robots have established a beachhead. We'll be looking at these applications on film in a few minutes, but a few words first...........

Back in 1958 when UNIMATION started its development, we were sure that the main activity would be operating machine tools. However, as it turned out, machine tool people never really gave us a chance. There were all kinds of excuses such as tool breakage, factory layout problems, parts introduction problems, etc. We were left with a solution looking for a problem.

We found our first problem in die casting. This was an unpleasant and dirty activity and the robot could be moved in with only a modest installation cost. Today, some 400 UNIMATES operate diecast machines and peripheral equipment as trim presses.

No one in UNIMATION even thought about spot welding when we were first studying the marketplace. It turns out that spot welding has become our most important robot activity. There are now about 900 UNIMATES engaged in the spotwelding of sheet metal subassemblies. Most of you have probably seen pictures of our UNIMATE Robots spotwelding Chrysler K-Cars.

A most cost-effective activity for a robot is investment casting. This is the process where successive coats of slurry and
sand and are built up around a wax mold. In making the shell for investment casting, the robot is unparalleled. Quality and yield are greatly increased over that available using human operators.

Other major areas of application include plastic molding, arc welding, forging, presswork, spray painting, deburring, palletizing, and glass and brick manufacture. It should be emphasized that all of these tasks are performed by the same configuration of a standard industrial robot.

Whatever the intentions of their creators, robots are always going to be compared with men in terms of their abilities and general behavior. Although they are just fine for doing repetitive, dirty, boring, dangerous jobs in factories, robots remain stupid, insensitive and limited devices when they are compared with human beings.

No robot can hope to match man with his sharp senses, ability for free thought and judgment, artistic appreciation, capability for self-reproduction, efficient conversion of food into energy, and properties of recovery from many illnesses and injuries. The gulf between man and robot will always remain, but, although it cannot be closed, this gap is going to be reduced as technology advances. I will examine some of the characteristics that might be developed in the foreseeable future and go on to discuss how these additional or improved capabilities might affect the general application of robots.

But, before we discuss future capabilities, I would like to briefly describe existing robotic capabilities that are presently commercially available. At the top of the list are six infinitely controllable degrees of freedom. Existing sophisticated robots have the capability to move their arms six different ways and can be programmed to move each joint at the proper speed and distance to result in precise positioning of the hand extremity.

Existing teach and playback facilities require little formal training and are fairly instinctive on most machines. On the UNIMATE Robot that I just showed you, programs are created by moving the robot through the desired path with a teach pendant. The pendant is hand-held and is basically the shape of the UNIMATE. There are two buttons for each of the available robot motions. And, by the appropriate button, the UNIMATE can be led by the hand through the required articulation.

The third and fourth items on our list of existing capabilities have to do with program storage and retrieval. Most present day robots have good-sized standard memories that can be easily expanded and very few applications require more memory space than can be optionally ordered. Once a program is created, it can be transferred to any number of media for off-line library storage, such as on cassette tape, floppy disc, or tape/reel.

Random program selection is a capability where programs in the active robot memory are automatically extracted as required based on real time process flow. Perhaps the best examples of RPS are the automatic robotic spot weld lines. Each of the robots on the line are programmed to weld whatever body style comes along, whether it be a 2-door, 4-door, wagon or whatever. A system of switches or electric eyes, interfaced with a controller, determines what type of body style is entering the robotic line and selects the appropriate weld program from the robots' memories.

The next items, number five and six, give you an idea of the accuracy and weight carrying capacity of existing robots. However, no one machine will give you both. The maximum weight carrying capacity of the robot that gives you .001" positioning accuracy is ten pounds and the positioning accuracy of the robot that lifts 300 pounds is about .080".

Present day robots also offer number seven; point-to-point control and continuous path control. Point-to-point control is adequate for most parts handling jobs where the endpoints of a move are of primary importance and the path between these points not so critical. However, applications such as arc welding, spray painting, deburring, polishing and machining require close control of the velocity and path of the tool. Continuous path control provides this. Some of the more advanced robots on the market even offer computer directed appendage trajectories, enabling simple geometric shapes to be traced out in space, like straight lines or circles.

Number eight, synchronization with moving work pieces, or otherwise called line tracking, gives some of today's robots the ability to do their jobs while the work is moving past. This true line-tracking ability requires the taught manipulation program to be continuously updated with incremental changes in the position of the workplace.

Some of the more complex robot applications out there utilize number nine, interface with a computer. In those applications, a host computer instructs the robot what motions or programs to follow, based on inputs from peripheral equipment.

Palletizing and depalletizing capability are really only extensions of other present day capabilities previously mentioned. But, I thought it would be interesting to
let you know that robots can and are handling 200-pound Howitzer shells, bottles of hand cream, ceramic magnets, catalytic converters and many other parts in this fashion.

Without number eleven, high reliability, many of today's robots would be simply impossible to justify on many high-volume production jobs. Fortunately, many of today's robots have exhibited up times of 98% or better.

I wasn't sure whether to add the last item, rudimentary vision, or not. While some existing vision systems are quite good at identifying a dark part against a light background and determining its orientation, the capability to have a robot look into a box of jumbled parts and pull them out, one by one, is years away.

At this time I would like to show you our ULIMATE Robot film. This should give you a fairly good idea as to what industrial robots are doing today.

Features which are considered to be very desirable goals for future robots are listed above. State-of-the-art technology already places several of these characteristics within the grasp of the robot designers, and some can be seen on experimental robots operating in laboratories. The more sophisticated these devices become the more they will obviously cost. But, as labor costs inevitably get higher and higher, it is likely that these advances will become economically viable sooner rather than later.

If the features listed above are difficult to achieve, some of them become even more difficult when attempts are made to combine them with other features of the same robot. For example, it is possible to mount a small video camera at the end of a robot arm to provide some sort of visual signals, but this would work against item seven on the list, minimized spatial intrusion. Another important factor in any new development is the effect on robot reliability. Unless special care is taken in the design and selection of components, and in the quality of construction, added complexity will down-grade the 98% up-time already achieved.

In the listing of robot qualities sought for the future there is reason to add some explanation. Right off, it must be noted that number one on the list is number one. Sophisticated vision will have the most profound effect in broadening the application base of robotics. Right behind vision is tactile sensing and this, too, is a great improvement of capability. No other future capability has enjoyed more intense research and development than these two at the top of the list. In vision, solutions will come by making cameras cheaper, resolution higher, computers faster and more powerful, and human smarter who write the algorithms. The solution will have arrived when a robot, by "seeing" up to 16 levels of gray, will be able to identify jumbled parts in scene and extract them one-by-one. It's really something when you think that this task is well within the capability of any human being, yet years away in robotic development. It gives one an appreciation of our ability to recognize subtle graduations in color and shape.

After dwelling so long on vision, it is important to give proper respect to tactile sensing. It is well established that a blind person can be effective in a number of activities that depend upon the sense of touch. A robot with tactile sense could use its capabilities to recognize parts just as most humans can detect what something is in a darkened room.

But, for a robot, the more important tactile sense is the sense that tells the robot somehow what is going on during the interactions of parts or tools in its hand. This has been called physical interaction data. We all have the experience of putting a nut on a bolt in a blind location. We almost instinctively backthread until we feel a click and then we run the nut forward, ever sensitive to the possibility of jamming if we should get a crossed thread. This is a tactile sensing experience we would wish to add to the sensory perception of a robot.

Many industrial jobs require number three, multiple appendage, hand-to-hand coordination. So one of the needs for robotics is choreography that will enable two robot arms to work in unison just as do the two arms of human assembly workers.

Number four, mobility, has been successfully applied to a few near relations of robots for simple handling or delivery tasks. You've probably seen or heard of these devices delivering mail on handing down a package. However, for the bulk of the true factory robot jobs, the robot stands in a single station just as did his human predecessor. In fact, the factory job that has an operator moving busily outside a two-meter radius is probably inefficiently designed. Still, there are jobs for roving operators who must tend stations that are widely separated and only need service periodically. For this, mobility is needed. So far this mobility has been delivered in a heavy-handed fashion. That is, robots have been mounted on rails to travel between work stations. What is needed is a robot that can literally stroll around.

Future robots will also require number five, minimized spatial intrusion. Most
robots require substantially more floor space than do their human counterparts. This can actually eliminate the potential use of the robot because the cost of laying out equipment in a new fashion and providing for factory floor space can kill the economic justification for using the robot in the first place. We designed factories for many years to match the human physique. This may be easier than to produce manufacturing plants matched to the spatial demands of current-day robots.

General purpose hand, number six, will greatly expand application possibilities. Human hands are simply awesome in their capability. Thus far, no robot activity has attempted to duplicate the human hand. Rather, special-purpose hands have been developed and built to match specific tasks. Robot manufacturers with many machines in the field have a good sized library of hand designs upon which they can draw to meet customer requirements. Usually, if the job changes, the hand must be changed. This is not an incapacitating handicap. When a robot is reassigned, there are probably many other application changes going on and a hand redesign can be accomplished. If hand designs are created as a standard fixture, the robot then selects from a nest the appropriate hand for that portion of the job. This is somewhat like a numerically controlled machine selecting from a bank of cutting heads. However, if time is of the essence, it is distressing to have a robot continually return to a home position in order to exchange hands. One would prefer to have a more universal gripper which could cope with a range of gripping activities. It might have three opposing fingers and these might each have articulations of their own. Tactile sensing might broaden the flexibility of such a gripper.

Number seven, energy conserving musculature, is an invention statement to be extended to the robotic community. Robots today use substantially more energy to accomplish their work than does the incumbent human operator. Rarely does the human operator deliver more than 1/20th H.P. to accomplish his job and it is not uncommon for a robot to soak up 3 H.P. to 10 H.P. in the same activity. Energy use is not yet a central issue in robotics, but it can become so and the comparison between robot-power drain and human-power drain is a strong argument for improvement.

To date, man-robot voice communication, number eight, has been something of a gag, since programming robots is not all that rough and the robot’s intelligence has not yet advanced to the point where a few subtle suggestions will motivate the robot to take desired action. On the other hand, a growing library of robot programs is being accumulated, and the robots are gaining adaptive features such as rudimentary sensory perception. Also, in due course the robots will be granted a model of their surrounding environment. With so much in hand, it may be attractive to allow the human boss to use plain English in instructing a robot as to its ongoing work. Moreover, the robot which is likely to be highly sophisticated could, with justification, respond to the human boss with synthesized speech to explain its view of the work situation. Or, its speech might be used to explain internal problems which need service attention.

The trend toward sophistication in robotics is relentless. And, as the robot becomes easier and easier to assign to factory tasks, it will become even more internally sophisticated. Whatever the level of robot sophistication, it is crucial that the machine exhibit an on-the-job reliability competitive to that of a human worker. The robot must have a long mean time between failure and a short mean time to repair. If the machine is an elegant one, then repair will be intellectually demanding. What is needed and what will be provided is, number nine, a self-diagnostic software package that pinpoints a deficiency under any failure condition and directs the human service staff in efficient repair procedures.

Isaac Asimov, in 1939, wrote a book familiar to many of us. It was entitled, "I Robot," and was an ingenious and fascinating collection of nine stories of robots in the future. Asimov’s robots were not creaky gothic menaces, but were benevolent servants. The Three Laws of Robotics were firmly embedded in each robot’s software to insure their always keeping their place. The three laws were:

1) A robot must not harm a human being, nor through inaction, allow one to be harmed.

2) A robot must always obey human beings, unless that is in conflict with the first law.

3) A robot must protect itself from harm, unless it is in conflict with the first or second laws.

As robots become more competent and as they are utilized in more intimate relationships with other human workers, inherent safety, such as outlined in these laws, will be a necessity. The ten future capabilities I have just described will open the door for many new applications, as listed on the next slide....
There is no end to the exciting prospects for enhancing robot capability and broadening their application base. Even today, robots are performing tasks that were only dreams when Asimov wrote his book. The future will find robots shouldering an increased share of the drudgery of the world's work, so you and I can have more time to enjoy life's joyous and creative aspects.

REFERENCES


ABSTRACT

Sensors and Transducers have a very important role in process and industrial control. Manufacturers are constantly developing new or improved devices. Their role is improving and shifting because of changing technologies. This paper will cover some of the ones introduced in the last 18 months.

Let's start with the process field. While there are many variables in various processes that are measured and controlled, most of the effort concerns those old reliable, flow, pressure, temperature and level.

Because of man's nature I suppose, it seems that all of us are always interested in the newest—the newest car, the newest clothes—the newest investment opportunity, and at work—the newest tool, device or technique. Nowhere is this continuing quest for the newest, and presumably the best, more evident than at a magazine such as Instruments & Control Systems.

Literally hundreds of new product releases come into our office every day. They cover every type of sensor or transducer imaginable and some not so imaginable. In spite of the newness of these products, however, it's amazing how many of them are still based on ideas or principles developed hundreds of years ago.

Take flow measurements for example. Orifice plates were used to meter water in Caesar's time. A very common pressure sensor, the Bourdon tube is more than 100 years old. The thermocouple is probably the most popular temperature sensor and its principle, the Seebeck effect, was first described by John Seebeck in 1821.

FLOW

With that preamble, let's get started by talking about flow. There is presumably no process variable measurement more important than flow. For the most part, the measurements are made to determine the material balance for processing units. In addition, the ever rising cost of energy and raw materials has caused even low cost fluids such as steam and cooling water to be metered.

Of all the flow measuring devices used today, the orifice plate/differential pressure combination is the most popular. The reasons aren't hard to find. They include:

- Low cost;
- Applicable to all fluids, including corrosives;
- Easy to install and calibrate;
- Can be used on all line sizes;
- No moving parts.

Although many new methods are being used for measuring flow, the orifice plate/dp combination will probably remain dominant in the foreseeable future chiefly because of continuing refinements in differential pressure transmitters.

One of the newest for example, is the Rosemount Model 1151 dp transmitter. It has signal conditioning that performs square root computations and outputs a signal that is directly proportional to flow.

Variations of the orifice plate are widely available. A typical one is the wedge sensor from Taylor Instruments. It has about half the pressure drop of a conventional orifice plate, minimizes plugging and corrosive erosive effects, and has an accuracy of 0.5%. So far, it's been used for fuel oil, tar, iron ore slurry, paper stock, crude oil, molten sulphur and sodium hydroxide.

There have been some interesting changes in old stand-by flowmeters. Magmeters are a good example of an improved product. They always were popular because they are non-obstructive, have better than 1% accuracy and a linear output. They are unaffected by changes in viscosity, temperature, pressure and conductivity. In addition, they have a broad range, being able to handle flows from 0.1 gpm to thousands of gpm's. However, they were always big, heavy and expensive. Now things have changed.

Recent magmeters show a trend towards dc pulse excitation instead of ac. They are smaller in size, less weight and use less power. The Mini-Mag from Fischer & Porter and the similar Series 600 from Sparkling Div. of Envirotech are good examples. The Mini-Mag features a wafer body design that weighs only 30 lb in a 4-in. size. Pulsed dc coil excitation provides an accuracy...
of +1% of rate. Power consumption is less than 15 W. Range is 10:1 for any span setting from 10 to 100% of meter capacity.

Some companies have adopted the magmeter principle to flow tubes that insert into the pipe. The Monitek 84 Flo-Probe sensor, for example, inserts into the pipe at a 45° angle, has a 4-20 mA output, an accuracy of ±2% FS, and can be installed via a hot tap. The electrodeless design is made of Kynar and the probe can be used where chemicals or other substances might coat the sensor.

Ultrasonic sensors have come for improvement too, mostly through better signal conditioning. Clamp-on types are being used in large numbers on lines that cannot be shut down. Polynics uses automatic signal tracking in its Model DHT Hydra doppler flowmeter. When the auto-trak detects flow changes that exceed 2% of the last reading, it reduces its time constant to track the flow signal. This eliminates the slow response to flow changes of many ultrasonic flowmeters.

Leeds & Northrup has a 775 Series doppler flowmeter with microprocessor-based controls and signal conditioning. It captures keyboard entry of flow and process parameters for on-line calibration, and several alarm totaling and signal conversion functions. Relay, 4-20 mA and 2 mA “low sig” outputs can be used for flow or batch control.

Vortex meters are popular because they can handle applications from cryogenics to high pressure steam. They have other advantages that include no moving parts, operation at flows to 250 fps, simple construction and high accuracy.

Foxboro now offers versions of its E38 series vortex flowmeter for both corrosive and sanitary services. In the corrosion resistant version, wetted parts are made from Hastelloy C or stainless steel. This makes the meter useful for fluids such as chlorine, brines, and nitric acid. The sanitary version has crevice-free construction of stainless steel. The meter can be cleaned in place or steam sterilized at 175°C.

The pressure loss in a vortex meter is small because the sensing element—a strut across the pipe—is narrow. This makes some vortex meters ideal for hot-taps in existing pipes. A typical insertion-type vortex meter is the V1700 TR from J-Tech Associates, Inc. When mounted on a hot tap, the sensor head can be inserted (or retracted) into a pipe at pressures up to 60 psi.

Perhaps because of an increased interest in insertion meters, a large number of new turbine meters have appeared during the past year. These include insertion-type turbine or propeller meters such as this one from Electronic Flo-Meters Inc. Engineering Measurements Co., Hoffer Flow Controls and Mead Instruments Corp. also have insertion meters.

In the in-line category, Rockwell International now offers a twin-turbine gas meter that checks itself for errors. A microcomputer system compares signals from two rotors and compensates for wear or rotor failure. Accuracy of the Auto-Adjust Turb O-Meter is ±1%.

One of the newest devices is this acoustic flowmeter developed by NBS. It measures the volume and flow rate of any fluid by measuring the speed of sound through a pipe. Preliminary test data indicate a sensitivity of ±1% of full scale and it can be used in pipes up to 4 inches in diameter.

Many industries are turning to mass flow measurement and control, especially in processes that involve gases. One advantage is that the result needs no correction for temperature and pressure. Typical of mass flow sensors recently introduced is this Model 5850 from Brooks Instrument Div. Basically it’s a thermal based device used to measure the mass flow of gases. It produces a 0-5Vdc output. Various models cover a range of 0 to 20,000 standard cubic centimeters per minute. Accuracy is ±1% of full scale.

PRESSURE

We could spend the rest of the day on flow devices, but it’s time to turn to a somewhat related subject—pressure. Probably the fastest growing types of pressure sensors are those based on strain gauges. They have been widely accepted for pressure measurements for several reasons. In general, they are easy to use, available in a wide range of configurations and have good temperature and mechanical stability. However, high temperatures and hostile environments may be a problem.

A common solution to making measurements in hostile environments is to isolate the strain gauge element. One way to do this is by using a sealing diaphragm and a fill fluid at the "wet end." It is also done with remote seals and capillary tubing as in this unit from Dynisco. It can measure pressure to 20,000 psi at temperatures to 650°F.

The Model 8500 PFP transducer from Bourns Instruments has two bonded strain gauge sensors: one measures differential pressure, and the other measures absolute pressure. The transducer has two separate

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Most strain gauge sensors must be kept away from high temperatures because of problems with stability. The most stable strain gauge sensors are thin film gauges—either vacuum deposited or sputtered devices.

A typical sample of the use of remote seals and capillary tubes to protect the sensing element is this Gould Measurement Systems Div. P3018. It uses a minimum oil fill (3.00 cc) and maintains an accuracy of ±0.25%. The temperature effect is only ±1% for ranges from -20 to 180°C.

The process control field seems to be turning to the solid state sensor for use in pressure transmitters. Typically this is a diffused silicon chip containing a strain gauge and a Wheatstone bridge circuit. National Semiconductor has a new series of temperature compensated pressure sensors that are able to operate over a -40 to +125°C range. Full compensation is provided over the entire range, making the hysteresis and repeatability error typically less than 0.1%.

The series LX06 is available in absolute, gauge and dp versions in ranges from 0-5 and 0-100 psi. Similar devices are available from the CEC Div. of Bell and Howell and Foxboro/ICT.

Two wire, 4-20 mA process transmitters based on diffused silicon sensors are available from several companies including Honeywell Process Control Division, Bailey, and Ametek Controls.

Although strain gauges are very popular, many other pressure sensors are available. For example, Foxboro offers a resonant wire pressure transmitter that has many of the features of strain gauges, plus a few more. The Model 821 has a 0.2% accuracy (of span) stability of 0.1% of reference over 6 months, is corrosion resistant, works at temperatures to 250°F and handles pressures to 6000 psi.

Another interesting sensor is an eddy current transducer from Raman Instrumentation. The KP-1911 operates in gases or liquids and provides temperature compensation to 100°F at pressures to 10,000 psi.

Dresser Industries is currently developing a two-wire, 4-20 mA transmitter based on its optical sensor. The sensor uses an LED and two diodes—a reference and a receiving unit—to measure the deflection of a vane attached to a diaphragm. The output signal is digitized and transmitted in frequency shift keying ASCII over a twisted wire pair.

A popular transducer found in both the process and industrial fields is the linear variable differential transformer. It measures pressure by detecting the position of a core element between a pair of transformer coil windings. An LVDT can use many kinds of wet end sensing elements including a Bourdon tube, diaphragm, cantilever beam or bellows.

DP transmitters based on capacitive sensors are widely used in the process industry. They are also being used in heating, ventilating and air conditioning systems, pollution control and stack monitoring applications. This is because the transducers can detect very low air pressures, have good accuracy and are inexpensive. For example MKS Instruments is working on a new version of its Type 400 DP Cell that will meet industrial mounting standards of dp transmitters. A single Type 400 is able to cover a range from 0.5 to 200 in. of H₂O dp—allowing it to operate in flare stack monitoring operations. Other features are high resolution of 0.0001 in. of H₂O and accuracy of 0.001 in. of H₂O over a 0.04 to 40 psi span.

**TEMPERATURE**

Obviously there is a great deal more that could be said about pressure, but let's get into what is probably the single most measured variable of all—temperature. With few exceptions, there isn't much new to report in thermocouples, RTD's, thermistors and solid state devices. Most of the work with these sensors has been devoted to improving the existing product. There are exceptions, however. One exception is an ultrasonic temperature sensor from Sandia National Laboratories for use above 1000°C. Above 1000°C, accuracy is ±1°C; below 600°C, ±5°C.

For some time now there has been a controversy over the Microsil/Nisil thermocouple. People couldn't agree on whether or not it was necessary, and if it was, what should it be called. In its Monograph Number 161, NBS took the bull by the horns and called it Type N. The first commercial product for the Type N thermocouple is this temperature transmitter from Wahl Instruments. It covers a range of 0 to 1100°C, has a 4-20 mA output with an accuracy of 0.1% of span.

Insulations and coatings are the big news in thermocouples. For many years asbestos has been used to insulate T/C's and extension grade wire. However, with the emphasis on health and safety replacement materials are used. One of them is the ceramic fiber group for high temperatures. When used with ISA Type K (Chromel vs. Alumel) T/C grade wire, this material...
offers a wide temperature range of -300 to 2,600°F, while remaining intact and maintaining flexibility. It is also an economical replacement for ceramic bead K/C insulation, especially where long lengths are needed.

Polyamide fiber is also a good substitute for asbestos insulation on K/C extension wire. This fiber resists abrasion and has an upper temperature limit of 500°F, making it a good choice for high temperature extension wire leads.

For applications near 1,000°F fiberglass-based insulation can be used. For example, Alpha Wire offers an s-glass insulation made from fiberglass braided with silicon; the insulation handles continuous temperatures to 1,200°F, and has mechanical properties like those of asbestos.

All of you are probably familiar with the advertising campaign that says “You’ve come a long way baby.” Well so have thermistors since their use really got underway in the early 50s. The most significant developments in thermistor technology in recent years have been improvements in long-term stability, interchangeability of sensors, and methods of making lead-wire contacts. These improvements have made thermistors much more useful, especially in industrial applications.

Basically, thermistors are ceramic semiconductors that change resistance with changes in temperature. The most common types of thermistors are beads or discs, but they are also available as washers, rods, chips, and flakes for special-purpose applications. Most bead thermistors are enclosed in glass and are relatively small. Because of this, beads tend to be more stable, can operate at higher temperatures, and have faster time constants than other types. The big problem is that they are not generally interchangeable in either slope (R vs. T function) or resistivity. This requires recalibration of the temperature measuring apparatus whenever the thermistor is changed.

Fenwal solves the interchangeability problem with thermistor matched pairs. Two bead thermistors that complement each other are carefully selected and wired in series or parallel. If a user wants a 100 K thermistor, Fenwal might select a 45 K and a 55 K thermistor. The matched pair provides the necessary accuracy and stability, and can be interchanged with another pair (from the same batch) without the need for recalibration.

Disc thermistors, on the other hand, with interchangeability tolerances of +0.1°C over temperature ranges of -40 to 125°C have been available for some time. Yellow Springs Instruments now has a series of interchangeable, highly stable disc-type thermistors. These have tolerance levels of +0.05°C (+50 millidegrees) over a slightly narrower temperature range of 0-80°C. Any thermistor of that type can be exchanged with any other, and the resulting error will be no more than 50 millidegrees Celsius over the specified temperature range.

Contact reliability has improved thanks to new methods developed by several manufacturers. These new methods are closely kept trade secrets, and few details are available. For example, Fenwal is now able to offer hermetically sealed, glass-encapsulated thermistor chips that operate to 300°C, thanks to their method for making contacts without using silver solder.

While thermocouples are still the most popular way to measure temperature, the use of RTD's is growing. It's not hard to see why. All three types of RTD's--wire would, thick film and thin film--have become more stable and accurate.

Recent developments in wire wound RTD's have involved the use of ceramic materials and the development of better sensor mounting methods. The ceramic materials extend the life of RTD's that operate at temperatures in excess of 800°C. The combination of new materials and better mounting methods have improved the thermal hysteresis of wire wound RTD's.

The use of film RTD's is steadily increasing. In thick film devices improved manufacturing methods have successfully minimized contamination and thermal hysteresis problems. As a result, thick film RTD sensors are cost competitive with comparable wire wound sensors. Their typical temperature range is -200 to 500°C. The size of a thick film sensor is comparable to that of a wire wound sensor.

Thin-film RTD's are a product of solid state technology. They are manufactured by depositing a thin film of platinum onto a ceramic substrate. Then a pattern is etched out of the film to provide the desired resistance. Recently, a temperature coefficient (β) of 0.00385 A/v°C has been consistently obtained, making thin-films on a par with wire-wound RTD's. Their temperature range is comparable to that of thick film.

Thin-film RTD sensors are having a major impact in two areas: OEM products and fast-response applications. For OEM's, their low cost and excellent accuracy make them ideal for use in microprocessor-based industrial controllers and readouts. The sensor can work at temperatures of 1,000°F, which gives them more flexibility than other low-cost devices, such as solid state sensors.
In HVAC (Heating, Ventilating and Air Conditioning) systems and other applications where a fast response sensor is needed, the thin-film RTD offers a lightweight, low-mass package, that is very competitive with thermocouples. In fact, thin-film RTD's are available that are virtually interchangeable with comparable thermocouples.

Like many other things in the world, temperature sensors are fast going solid state. Depending upon the type, a solid state device will exhibit a change in resistance, frequency, current or voltage as the temperature changes. These sensors offer several features, such as ease of interfacing to control systems, linearity, long-term stability and repeatability, ease of calibration, and low cost.

The simplest type of semiconductor temperature sensor is a bulk silicon resistor, or thermistor previously mentioned. Another type is based on the temperature sensitivity of a pn junction. Both diodes and transistors have pn junction but transistors work better if the application requires interchangeability because they can be easily matched.

The base-emitter voltage change of a transistor with temperature is extremely linear and relatively large (-2.25 mV/°C). In some cases, a transistor sensor may interface directly with A/D converters without extra linearizing or amplifying circuitry. While any transistor will work, the A to D converters must be carefully chosen. Motorola's HMC-102--can be selected specifically for temperature sensing applications where repeatability and interchangeability are important. The performance of such sensors rivals that of a platinum resistance thermometer, and they are matched to give a ±2°C interchangeability.

A third kind of semiconductor temperature sensor is the integrated circuit whose outputs--voltage, current or frequency--are functions of temperature. These IC's range in complexity from relatively simple devices requiring user-calibration to highly sophisticated sensors that are factory calibrated using laser trimming methods.

A typical IC temperature sensor is National Semiconductor's LM335. This unit has a 10 mV/°C output and an uncalibrated temperature error of ±2°C at ±25°C. At the other end of the scale, National offers the Model LM35 and Intersil has the ICL8073 sensors, both with 0.5°C accuracy.

Voltage-type IC's have an output that is directly proportional to absolute temperature. Typical sensitivity is 1 mA/°K. The major advantage of using a current output sensor comes when the sensor (or sensors) must be located a long distance from the monitoring circuit. Here, lead resistance and noise pickup would appreciably degrade a mV type signal. Also, a lighter gage, unshielded wire can be used.

Another IC sensor that can be used to transmit data over long distances or in noisy environments is a voltage/frequency (V/F) device that has a temperature output. The Analog Devices AD537, for example, has an internal current generator that produces a frequency output scaled in °K.

The major advantages of semiconductor temperature sensors are their inherent linearity, higher sensitivity, long-term stability (20 ppm/month), and low cost. The major disadvantages are limited packaging and their limited operating temperature range (-55°C to 150°C).

While semiconductor temperature sensors are available in very low-cost, non-hermetic plastic packages (TO-92/SOT-23) and hermetic sealed metal can type packages (TO-46/TO-52), they are not generally available in probe forms. Only the Analog Devices AD590 is available as a probe. This means that the user must put these sensors in probes if the application demands it.

**LEVEL**

A measurement almost as popular as temperature is level. To give you an idea of the interest in level, it's worth noting some survey results. Last year I&C S did a survey on "What's new in level monitoring," and 130 companies responded. This year the same survey produced almost 200 responses. The technologies covered in these replies ranged from a simple electro-mechanical float switch to a laser-based detector for use in molten glass applications.

Let's start with some simple ones. The Gems Sensors Division of Transamerica Delaval has introduced a float switch that detects temperature as well as level. The temperature ranges covered are 120°F to 150°F, and the switch will withstand pressures up to 150 psig.

Switches used in monitoring the level of dry bulk materials or powders haven't been neglected either.

The Z1-Tech Division of Aikenwood Corp. has a new reciprocating paddle switch. The stroke is 0.4 in. at 6 cycles/min. The unit is heat resistant and will operate at temperatures up to 300°F.
Delavan Electronics, Inc. has a new switch that operates on the magnetostriuctive principle. The displacement sensor is contained in a probe that goes into a bin or silo, and the electronics are in a standard NEMA 7 or 9 housing. The switch's operating temperature range is -60°F to 150°F and its pressure rating is 100 psig. Repeatability is quoted at ±0.1 in.

Bubbler systems have been around for a long time and one of the newest is from Computer Instruments Corp. Their 1600 Bubbler system is a transmitter for continuous level measurement. Calibration seems to be increasing and repeatability are also good, being 0.02% and 0.1% of range respectively.

Another new bubbler system is Cutler Controls' Air-Lock. The air-back pressure system has a 0.2 in. off-on differential. It provides ±0.05% in. accuracy and uses instrument air, argon, or nitrogen at the bubbler source. The bubbler tube can be up to 30 ft. long. The system comes in a 6 in. x 6 in. x 4 in. NEMA 12 enclosure. The total package includes a pressure regulator, 2-micron filter, and a coalescing type oil removal filter.

To get into more sophisticated devices, let's take a look at RF capacitance systems. Monitoring and control devices based on RF (Radio Frequency) capacitance continue to gain in popularity. In addition, the use of circuitry for self-calibration seems to be increasing.

Drexelbrook Engineering Company has a new two-wire TruLevel™ transmitter that automatically recalibrates itself for all changes in material, density, or temperature. The recalibration maintains the accuracy at ±0.5%. The pressure rating at the maximum temperature rating of 300°F is 300 psi.

Endress + Hauser, Inc.'s LSC-1132 series RF capacitance switch is also self-calibrating and features self-contained electronics. Model 1132 uses 115 Vac for power while Model 1133 uses 24 Vdc power. Both units are explosion proof. Their operating temperature range is -4°F to 212°F (electronics, 0°F to 140°F).

Still another way to measure level is to use lasers. Gould's Measurement Systems Division has a new line of remote diaphragm gauge pressure transmitters. These provide a 4-20 mA output with an accuracy of ±0.25% of the calibrated span including linearity and hysteresis. Zero and span adjustments are not interacting. The MPG3018 transmitter is available in four ranges from 0 to 1000 psig. The temperature range for the electronics is -20°F to 180°F, and the capillary length can be up to 40 ft. This is the same transmitter mentioned earlier in the discussion on flow.

Another new remote seal transmitter is Rosemount's differential pressure unit. Model 1151DP, typical of the line, provides a 4-20 mA or 10-50 mA output. There are 5 ranges covering from 0 in. H2O to 1000 psi. Temperature limits are -20°F to 200°F for the amplifier and -20°F to 220°F for the sensor. Zero and span adjustments may be made externally.

Schaeftelzv Engineering has a new LVDT-based, very low pressure transmitter. It can measure level from 0 to 200 ft. of any liquid with a specific gravity of 1. It's available in both gauge and differential pressure versions. Output of the P-0381 is 4-20 mA, and it's powered from a 10-32 Vdc loop supply.

Non-contact operation and computer compatibility are the main reasons for the boom in ultrasonic level devices. Typical of introductions in the past year is Fischer & Porter Company's Series 50U2000. The two-part unit measures the level of liquids and solids in all types of vessels. The transponder is submersible and level measurements can be made up to a depth of 33 ft. Accuracy varies with span from ±0.8% to ±0.6% at 33 ft. The transmitter has a meter for local indication and BCD switches for selection of zero and span.

Not every ultrasonic device has to be super sophisticated to be worthwhile. National Sonics Div., Xertex Corp. has an ultrasonic level switch. In operation, liquid filling the gap between the prongs in the sensor changes the on-off position. Model 002 measures just 5 in. x 1.4 in., and will operate at pressures up to 50 psig and in temperatures ranging from -4°F to 185°F.

Wesmar has added a new unit to their DLM series, the DLM50. It's used for solids measurement and control over a range of 50 ft. Interface versatility is helped by an adjustable current loop output of 0-20, 4-20, and 10-50 mA. Standard outputs are 0-5 Vdc and 0-1 mA.

One of the more exotic ways to measure level is with lasers. Selective Electronics, Inc. calls their level device an Optocator. Originally designed for dimensional measurements, it's now being used to measure the level of molten metals. A pulsed beam laser creates an illuminated spot on the surface of the metal. A change in the level of the surface changes the location of the image in the detector from its original location is a measurement of level.
The air cooled Optocator has a range of 0.3 in. to 10 in. Accuracy is 0.05% of the measuring range. The output can be either 5 Vdc or a 16 bit TTL compatible signal.

Another laser level detector for molten metals and glass is the Comax system from Courser, Inc. In this system, the laser source and detector are separate units mounted on opposite sides of the flowing material being measured. Both the laser source and the detector are water cooled.

The range covered is a function of the angle between the laser beam and the process surface. At 15°C, for example, the range is 0.61 in.; at 85°C, 6.81 in. The maximum possible distance between the laser source and the detector is 40 ft. Accuracy is ±0.005 in. and outputs are 4-20 mA, 0-10 Vdc, and -5 to 0 to +5 Vdc.

**INDUSTRIAL MEASUREMENTS**

So far we've covered the basic sensors and transducers used in the process field. I would like to spend a few minutes on some of the sensors found in the industrial or factory field. Obviously some of the variables measured for process control will also be used for industrial control. Typical of these are pressure and temperature. And of course the same devices, although usually in a different configuration or housing, are used to do the job.

It is impossible in a short presentation such as this to cover all of the things measured in industrial operations. I will devote some time though to one of the most important ones—position sensors. Position sensors are usually divided into two groups—presence sensors and displacement sensors. Presence sensors detect the presence or absence of an object, while displacement measure an object's distance from a reference point.

Presence sensors include limit switches, proximity switches, both electrical and pneumatic, and photoelectric devices.

Displacement sensors include LVDT's, potentiometers encoders, and synchros. With that preamble, let's get to some highlights on current developments in these areas. Incidentally, I'm leaving limit switches out of this discussion because there are dozens of types. For the most part they have been around for years and are simple, well understood electromechanical devices.

Proximity switches differ from limit switches in that they don't touch the target. The most common types are inductive, capacitive, Hall effect, eddy current, photoelectric and air jet.

Inductive proximity switches such as this one from Veeder-Root are the most widely used type with any metallic object. Most types are made as direct replacements for electromechanical limit switches. Their housings have the same mountings and configurations and their output is the same 120 Vac. They can sense from millimeters to about 2 inches. Suppliers include Gould Dennison and Banner Engineering.

With solid state circuitry, they can be much smaller. These new units from Gould Dennison provide an 8 Vdc output. They are self-contained, can be flush mounted in almost any material and can be inputted directly into programmable controllers and computers.

Photoelectric sensors offer an operating range (to about 30 feet) and functions not available with either limit or proximity switches.

The newest such as this one from Veeder-Root, use a pulsed infrared LED emitter and a phototransistor receiver. Because the receiver responds only to the pulse frequency of the emitter, pulsed LED units are practically impervious to ambient light. Generally they are used in three ways—opposed or beam break, retro-reflective for translucent objects, and proximity for transparent objects.

Banner Engineering provides them in fiber optic versions for bad atmospheres. Photoelectric switches generate an analog signal (up to 200 mA) proportional to the amount of light reflected by the receiver.

Hall effect sensors respond to the presence or absence of magnetic fields. Their sensing range is about 1/10 of an inch. They operate from dc supply of 5-16 V. Most of them provide a 4-20 mA output. Their main advantage is a small size and high speed. Standard Hall effect sensors are available from Micro Switch that handle from 25,000 to 100,000 pulses per second.

Eddy current or ECKO (Eddy Current Killed Oscillator) work when a metal target passes by a sensor generating a magnetic field from a coil imbedded in its face. Depending on make and model they operate on 6-30 Vdc or 120 Vac. Range can be from .25 millimeter to about 1-3 inches. Outputs can be 10-120 mA or pulse. Major suppliers of these devices are Micro Switch and Kaman Instrumentation.

Air jets make good proximity switches. Depending on the shape of the nozzle, they can be routinely used to measure distances 0.1 to 4 inches. Again depending on the nozzle, input requirements vary from 30 to
100 standard cubic per hour at 3 psi. A typical output signal produces a change 0.2 psi for a target motion of 0.2 inches. Festo Pneumatic and Cutler Controls both supply these devices.

As mentioned before displacement sensors are used to measure movement and to provide feedback to positioning devices such as servo motors. They can measure either linear displacement or angular rotations with great accuracy at a fairly high speed.

Displacement potentiometers are usually wire wound or conductive plastic type. Linear versions usually cover a range of a \( \frac{1}{2} \) of an inch to 36 inches. Rotary versions typically cover up to 340°. They are the lowest cost displacement sensor and provide an analog output. They do suffer from wear, however, and they can generate RFI.

LVDT's, our old friend from pressure sensing, make an excellent position sensor. They provide virtually infinite resolution and are generally used over a range of 0.005 in. to about 20 in. Output is either mVAC or 0-10 Vdc. Rotary versions measure angular displacement. They are good for hostile environments and have a very long life. However, they require high frequency (2500 Hz) excitation and cannot be used in strong magnetic fields. There are dozens of companies supplying LVDT's. The ones shown here are from Schaevitz Engineering.

Synchros are used to measure shaft angle or rotary displacement. Basically, they are a rotary transformer. The primary winding is on the rotor and the secondary winding is in the stator. A voltage induced in the stator is a measurement of shaft angle. Brushless versions are available for high shock and vibration applications. While the output is analog, synchros manufacturers sell a package which includes the electronics necessary to give a readout in degrees. Typical accuracies for instruments such as this one being tested on a North Atlantic phase angle voltmeter is \( \pm 2\% \).

Early problems in digitizing the output of synchros, gave the encoder business a big boost. Encoders are an optoelectronic device that translate rotational movement into a digital signal. The output is a square wave which is converted by electronics to a digital reading of shaft position. Naturally there is a type for almost every application. One of the newest is Hewlett-Packard HED-6000. It has TTL compatible digital output, operates from a 5 Vdc power supply. It operates at 1000 CPS and resolution can be between 200 and 1000 cycles per revolution.

That about does it for this overview of what's new in sensors. I'm sure you all realize that I've only touched the high spots and if I've left out your favorite company--I'm sorry--we only had half an hour--not a week. Now it's time for lunch. Thank you for listening.
NBS engineers and scientists, using Josephson-junction technology, have built and tested a binary counter designed to operate at 100 GHz. The superconducting device uses direct current SQUIDs (Superconducting Quantum Interference Devices) as flip-flop circuits that communicate by sending and receiving single quanta of magnetic flux. Simulations and preliminary testing show that the counter is sensitive to input pulses with as little as $10^{-18}$ joules energy and appears to count at rates of more than 100 GHz while dissipating only about 1/10 microwatt total power. In addition to its use as an events counter, the device may make possible the development of analog-to-digital converters which are either very fast (5 GHz sample rate with 4 to 8 bits resolution) or very accurate (22 bits or more of resolution at sample rates of a few kilohertz). All of these applications are needed to extend NBS' metrological capability to meet new technological challenges. The new device is the fastest counter, and perhaps the fastest digital circuit of any kind, ever demonstrated.

CONTACT: Ken Armstrong, 301/973-3787

NBS ESTABLISHES ACOUSTICS LABORATORY ACCREDITATION PROGRAM

NBS has established a laboratory accreditation program (LAP) for acoustical testing services. There are 34 test methods for which laboratories can be accredited: measurement of sound absorption and transmission properties of materials, sound power and pressure levels, and measurement of product noise. The LAP is administered under the National Voluntary Laboratory Accreditation Program (NVLAP), for information on the acoustics LAP, or for the application package for laboratories interested in becoming accredited, contact: Manager, Laboratory Accreditation, Technology Building B141, National Bureau of Standards, Washington, D.C. 20234, telephone: 301/921-3431.

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GREENE SELECTED CHAIRMAN OF NCWM AT 67th ANNUAL MEETING

Charles H. Greene was selected chairman of the National Conference on Weights and Measures (NCWM) at the July 1982 Atlanta meeting. NCWM is an organization of state, county, and city weights and measures enforcement officials, and associated business and consumer representatives.

NCWM is sponsored by NBS to promote uniformity and sound metrological principles among the states, and through the Office of Weights and Measures, the bureau provides technical assistance to NCWM and its committees. Greene, who will serve as chairman for one year, is Chief, Division of Administrative Services, New Mexico Department of Agriculture, New Mexico State University, Las Cruces. For information on the conference, write to the National Conference on Weights and Measures, P.O. Box 3137, Gathersburg, MD 20878.

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INVENTIONS FOR MACHINE CONTROL, NDE WIN I-R 100's

Researchers at NBS have won two 1982 I-R 100 Awards for advances in control systems for automated manufacturing machinery and neutron radiography imaging systems. Kenneth Yee and Donald Bloomquist of the NBS Automated Production Technology Division won an I-R 100 Award for inventing a device that monitors the behavior of any machine engaged in drilling holes and sends a warning signal when it senses that a drill is about to break. Dr. Ronald Schrack of the NBS Nuclear Radiation Division won an award for the design of a two-dimensional imaging system for resonance neutron radiography that can selectively display the position and concentration of any isotope or element in a complex specimen. I-R 100 Awards are made annually by Industrial Research & Development magazine to the "100 most significant new technical products" of the proceeding year.

CONTACT: Michael Baum, 301/921-3181

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NBS DEVELOPS PIEZOELECTRIC POLYMER FILM ACCELEROMETER

NBS researchers have developed a thin film accelerometer that has wide application as an aerospace and weapons sensor. The device is approximately 1.5 cm in diameter with two sheets of piezoelectric polymer stretched on two inner cylindrical rings with a solid inertially-responsive mass at the center between the films. Metal electrodes are attached to opposite sides of the sheets and then to a coaxial cable and measuring device. Any increase in the tension in one of the sheets created by the acceleration-responsive movements of the mass causes polarity of electrical charges in the inner and outer electrodes of that sheet to change direction and be aligned the same as the polarity of the other sheet caused by a decrease in tension. The inventors are NBS researchers Seymour Edelman and Beverly F. Payne, who have received a patent on the device.

CONTACT: Roger Rasmberger, 301/921-3181
TESTING THE INTEGRITY OF MICROELECTRONIC PACKAGES

NBS has published a report on the use of acoustic emission (AE) test methods to determine the integrity of large, sealed microelectronic packages such as those used for hybrid circuits. Several years of NBS research are summarized in this test, which covers vibration experiments (designed with avionic applications in mind) and a high-temperature leak test, a thermal shock test, and bonding damage tests. The Use of Acoustic Emission to Determine the Integrity of Large Kovar Glass-Sealed Microelectronic Packages (SP 400-70) is available from the National Technical Information Service, Springfield, VA 22161 for $10.60 prepaid. Order by PB #82-234485.

MEASURING MOISTURE IN HERMETIC SEMICONDUCTOR DEVICES

NBS has published the proceedings of a 1980 workshop on moisture measurement technology for hermetic semiconductor devices which was sponsored by the Bureau and the Rome Air Development Center (RADC). All 36 papers from the workshop are included in this publication, grouped under the general headings of mass spectrometry measurement of moisture, moisture sensors, process control, moisture physics, packaging and hermeticity. Moisture-induced failure in hermetically packaged devices is a well-known phenomenon, but controlling it has been difficult, in part because of the lack of accurate and reliable measurement techniques. Some of the key researchers on this problem, from industry, academia and government, are represented in Moisture Measurement Technology for Hermetic Semiconductor Devices, IL (SP 400-722), available for $8.50 prepaid from the U.S. Government Printing Office, Washington, DC 20402. Order by stock no. 003-003-02402-3.

NBS AWARDS 2 PRECISION MEASUREMENT GRANTS

NBS has awarded two Precision Measurement Grants to Princeton University scientists for research on a new primary standard of electrical resistance and for an experiment in high-precision spectroscopy that may serve as a test of the theory of quantum electrodynamics (QED). The $30,000 grants were awarded to Professor Daniel C. Tsui, who is working with NBS, Bell Laboratories, and the Naval Research Laboratory on a project to develop the quantized Hall resistance phenomenon (von Klitzing Effect) to the point where it can serve as a useful resistance standard for calibration laboratories, and to Professor Robert W. Dunford, for a series of measurements of the Lamb shift in the spectral lines of ionized helium, measurements which may help resolve a present discrepancy between experiment and theory in an area close to the heart of QED theory. Tsui's work will be important to the precision measurement of the fine structure constant, also a key element of QED theory.

CONTACT: Michael Baum, 301/921-3181

NBS DEVELOPS HIGH TEMPERATURE OPTICAL FIBER THERMOMETER

A new high-temperature optical fiber thermometer made from a single crystal sapphire has been developed by the Commerce Department's National Bureau of Standards (NBS). The instrument will permit scientists and engineers to measure temperatures to 2000°C--an increase of 500°C above the maximum operating temperature of the present thermocouple standard. The new device has the potential to be 10 times more accurate than the existing standard.

Because of its accuracy and stability, it is possible that the new thermometer will eventually replace the ANSI Type S thermocouple, which was originally developed in 1886 and is currently used to realize the International Practical Temperature Scale from 630.74°C to 1064.43°C. Moreover, the NBS optical fiber thermometer can extend this temperature range to approximately 2000°C.

In contrast to the present thermocouple standards that are based on calibration and interpolation between fixed points, the optical fiber thermomter is based on fundamental radiation laws, and may be used to measure thermodynamic temperatures directly.

CONTACT: Roger Rensberger, 301/921-3181

AIA TMC PROJECT 117-1, MATRIX OF GOVERNMENT PUBLICATIONS

This matrix contains Department of Defense and related Government procuring activity documents which apply to the subjects shown. These subjects were selected because they are of major interest and concern to aerospace contractors' functional organizations and program managers. Knowledge of the contents of these documents is of value in the preparation of proposals, in conduct of contract efforts, and various aspects of management planning.

This matrix is maintained for the Technical Management Committee of the Aerospace Industries Association. It is updated
at four-month intervals and is usually republished in February, June, and October. It is intended for unrestricted distribution and use by all AIA member companies and their employees. Comments concerning its content and usefulness are encouraged.

Reference is provided to documents affecting the design development, management, and operational support of embedded computer software, an area of increasing interest and expenditure.

For information and instructions requisitioning publications listed refer to TMC release 77-39, dated June 3, 1977, "Guide for Private Industry to Obtain Copies of Specifications and Standards."

SPONSOR: J. R. Bain, Corporate Representative, General Dynamics Corporation, AIA Technical Management Committee

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JLC PANEL PROGRAM REVIEW A SUCCESS

The Joint Logistics Commanders (JLC) Panel on Automatic Testing conducted its Fourth Annual Program Review, 14-17, September, 1982, at Wright-Patterson Air Force Base, Dayton, Ohio.

The Review was extremely successful. Several accomplishments have accrued over the past year, including completion of several subtasks. National Bureau of Standards Special Publication 615, Sensor Handbook for Automatic Test, Monitoring, Diagnostic, and Control Systems Applications to Military Vehicles and Machinery has been published. It will be coordinated as a JLC document in FY 83. A revised draft MIL-STD 1519A, Test Requirements Documents/Test Program Sets has been developed and is being coordinated. The ATE Newsletter and Automatic Testing courses sponsored by the JLC Panel continue to be successes. Through the review process, the Panel and subtask focal points also modified several other subtasks.

LTCOL Churchill, JLC Panel Chairman, announced the Panel has initiated a major effort to restructure both the Panel operation and the subtasks. The goal is to make the JLC effort more productive and efficient. The results of the restructuring initiative will be announced soon.

The Panel extends its appreciation to all who supported the review. They look forward to similar significant achievements in the Joint Services' effort through the coming year.

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INTERNATIONAL TRADE TO BE FACILITATED BY NBS RECOGNITION OF FOREIGN LABORATORY ACCREDITATION SYSTEM

The first international agreement between the Commerce Department's National Bureau of Standards (NBS) and a foreign laboratory accreditation organization has been established.

The agreement provides for mutual recognition of testing laboratories which are accredited by the NBS National Voluntary Laboratory Accreditation Program (NVLAP) and the Australian National Association of Testing Laboratories (NATA). Under the agreement, mutual recognition means that NVLAP will recognize NATA-accredited laboratories as being equivalent to those of NVLAP, and test data reports issued by one accredited laboratory will be recognized on the same basis by both national accreditation systems.

Even though NVLAP and NATA are established to serve each country's domestic needs, test data produced by accredited laboratories under each system may also describe the performance or other characteristics of products which are subject to trade between the United States and Australia.

The agreement—signed on September 24, 1982, in Sydney by Mr. E. E. Bond, Chairman of the NATA Council, and signed earlier by NBS Director Ernest Ambler—is viewed by the signatories as being in harmony with the provisions of the Standards code of the General Agreement on Tariffs and Trade (GATT) that is designed to minimize barriers to trade.

The laboratory accreditation systems administered by each of the parties to the agreement are voluntary; participation is not mandated by law. NVLAP and NATA base their decision to accredit a testing laboratory on similar, but not identical criteria. Officials responsible for administering each system have participated in assessment visits to testing laboratories accredited under the other systems and are familiar with each other's procedures.

The NVLAP program, established in 1976 and managed by the NBS Office of Product Standards Policy, is a voluntary "umbrella" system designed to assess the competence of laboratories to perform specific tests. "Competence" is determined by evaluating applicant laboratories to assure that they have the equipment, staff, and procedures necessary to perform prescribed tests in accordance with nationally or internationally accepted standards or test methods.
Currently, there are laboratory accreditation programs (LAPs) being administered for thermal insulation, carpet, concrete, solid fuel burning devices, and acoustic testing services. These programs involve more than 100 laboratories nationwide. A LAP is being developed for electromagnetic calibration services and one has been requested for doors and windows. The Nuclear Regulatory Commission (NRC) has also requested a LAP on personnel dosimeters.

NATA, established in 1947, is Australia's national laboratory accreditation system. It provides government, industry, and commerce with a nationwide network of laboratories of demonstrated competence and reliability, operating throughout science and technology. NATA-accredited laboratories are assessed for compliance with accepted criteria of sound practice by specialists acting in an honorary capacity. Currently there are more than 1200 laboratory registrations in nine fields of testing: metrology, mechanical, electrical, optics and photometry, heat and temperature measurement, non-destructive testing, chemical, biological, and acoustic and vibration measurement.

For further information on NATA, or the NBS NVLAP program, contact: Manager, Laboratory Accreditation, Technology Building B141, National Bureau of Standards, Washington, DC 20234, telephone: 301/921-3431.

LOW-LEVEL LASER MEASUREMENTS

NBS has announced a special measurement service for low-level laser energy and power in the near infra-red region (1.064 micrometers). Expected to be especially useful to manufacturers of military laser range finders and receivers, the service is being offered prior to establishing a calibration service certified by the NBS Calibration Advisory Group after a period of experience and review. The special measurement service will evaluate lasers with pulse durations of 10 to 20 nanoseconds, peak power from 10^-7 to 10^-4 watts, and energy from 10^-14 to 10^-11 joules. For more information, write or call Aaron Sanders 724.02, National Bureau of Standards, 325 Broadway, Boulder, CO 80303; telephone: 303/497-5341.

NSIA SELECTS AUTOMATIC TESTING GROUP FOR PERMANENT COMMITTEE STATUS

On the 18th of June, the National Security Industrial Association, through its Executive Committee, selected the Automatic Testing Group for permanent status as a full-fledged Committee of the Association. The ATC now joins the Logistics Management and Reliability and Quality organizations, among others, as a recognized discipline supported by Industry and Government.

Final approval by the NSIA President, Wallace H. Robinson, Jr., awaits the submission of a charter covering the defined objectives and operational goals of the Committee. Mr. Frank McGinnis, Sperry Division Headquarters, will continue as Chairman until a new slate of officers has been voted into office. The Nominating Committee is now being selected.

The Automatic Testing Group started operations early in 1980 as a continuation of the work of the Industry/Joint Services Automatic Test Project. Several national meetings have been held, including a landmark Testability Conference in November, 1981. A recently completed meeting (June, 1982) integrated the interests of various space and missile testing groups with the ATC.

Information concerning membership in the new committee can be obtained from the Committee Executive:

Col. Charles Curtis
NSIA
1015 15th St., NW, Suite 901
Washington, DC 20005
(202) 393-3620
You should have received your most recent copy of the NCSL Training Directory. It was mailed to all members in October.

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SUB-PPM CALIBRATION OF DC VOLTAGES

NBS researchers have developed a unique, automated system capable of measuring any dc voltage from 1 to 10 volts to an accuracy of 0.2 ppm. The system, which was designed to test and calibrate Zener voltage references, is automatically calibrated against saturated standard cells in a sequence performed before each set of measurements. All major sources of error introduced by instruments connected to the reference system—zero error, gain error, non-linearity, and leakage resistance error—are evaluated during this procedure. A specially-constructed electromechanical scanner allows up to 60 different voltage sources to be connected to the system, which may be measured any number of times in any order according to preprogrammed instructions. This new system is from five to ten times more accurate than any other known voltage calibration system in this range.

CONTACT: Michael Baum, 301/921-3181.

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TIME DOMAIN MEASUREMENTS


Order by PB #83-234501.

CONTACT: Ken Armstrong, 303/497-3787
NCFL REGION 2 COMPLETES MAP

The first East Coast National Conference of Standards Labs (NCFL) Regional Measurement Assurance Program (MAP) in DC Voltage was completed in October 1982 at Lockheed's Instrumentation Measurements Laboratory (IML). Measurement Assurance Programs demonstrate that total measurement uncertainty including random error and systematic components of error relative to NBS, or other designated standards, are quantified and qualified. MAP breaks from the more traditional methods of achieving traceability to the NBS by transporting portable standards to the NBS for calibration and returned to the user for use as primary standards. MAP evaluates the instrument, system/method and the operation and judges the performance and capabilities, providing a more meaningful calibration/certification.

As the pivot lab, IML received the transfer standards (standard cell banks) from the four other companies—RCA, Grumman Aerospace Corp., Standard Reference Labs, and carried from NBS to the IML for the comparison. IML's metrologist Bill Gould made the comparisons with the NBS standard. After the measurements were completed, the transfer standard was returned to the NBS for re-measurement. After the completion of the data analysis by NBS, each company will receive a calibration certificate that testifies to the measurement uncertainty of each participant.

Measurements were in the range of 1.0151524 ± 0.0000005 or ± 0.5PPM Volts DC. The IML measured cell differences from 0.1 microvolt to 300 microvolts with a resolution of 0.01 microvolts with a standard deviation of less than 0.05 microvolts.


AD-HOC COMMITTEE COMPLETES NCFL ADVOCACY POSITION GUIDELINES

I. Purpose

To establish guidelines for the NCFL Board of Directors in taking advocacy positions on behalf of the NCFL.

II. Scope

When deemed to be in the best interest of the NCFL, the NCFL Board of Directors may, by two-thirds vote of the entire Board of Directors, take an advocacy position in areas not prohibited by the NCFL Bylaws. NCFL should not lobby or give the impression of doing so.

III. Methodology

A. The position proposed by vote of the Board of Directors shall be presented to the membership for a vote and comments on the proposed position. An appropriate time shall be allotted for the membership response.

B. Whenever time permits, the position shall be an agenda item at regional workshops prior to or in conjunction with the position survey.

C. The NCFL Board of Directors shall encourage its membership to submit individual company responses to issues whether or not a NCFL advocacy position is taken.

IV. Identification of Results

A. When surveys are taken, the response to the poll will be identified, recorded, and stored.

B. Minority positions will be considered. The decision on whether to include a minority position with the majority position will be made by the Board of Directors. This decision will be made based on the magnitude of those taking opposition to the majority position.

C. It is recognized that each advocacy issue proposed by the Board of Directors (see Paragraph III) may have a differing constituency within the NCFL. Therefore, a standard quorum shall be established by a two-thirds vote of the entire NCFL Board of Directors for each advocacy question to be submitted to the membership.
Committee News

Fewer responses than the standard quorum set for an issue shall be an indication that an advocacy position should not be taken by the NCSSL because of a lack of interest.

D. There may be instances where a conflict of interest disclaimer (or "strategy") should be identified. The benefit of legal counsel, either from a member company's counsel or an independent source, should be sought in matters of this nature.

V. Action

If the results of the membership survey support the NCSSL proposed advocacy position, the Board of Directors through the office of the President, or his delegate, shall implement the proposed action. Such proposed action will be reported to the NCSSL membership.

VI. Summation

Advocacy positions taken by the NCSSL Board of Directors should be minimal. Since the "fairness" of conducting advocacy positions will always be challenged and scrutinized, only issues considered extremely important to the NCSSL should ever be considered for advocacy.

AUTOMATIC TEST & CALIBRATION SYSTEM COMMITTEE

Chairman Bob Smith has revised and updated the tape/disk inventory data for calibration programs. It is printed on the following pages. Contact Bob for more information.
THE NCSL CALCULATOR PROGRAM
TAPE/DISK LISTING

Prepared by
Automatic Test & Calibration System Committee
Revised October 1982

TAPE EXCHANGE PROCEDURE

1.0 All participating organizations/laboratories must have a signed Release Form on file with the NCSL Automatic Test & Calibration Systems Committee. If you wish to participate in this project either as a SUBMITTOR or as a REQUESTOR and do not have a Release Form on record, reproduce from attached form, complete, sign and mail to the COORDINATOR at the following address:

P. O. Box A, MS EV-26
Newport Beach, CA 92663
ATTENTION: R. R. Smith
(714) 720-4820

2.0 If you have a Release Form on file and wish to contribute a new program(s) to the listing, submit the following directly to the COORDINATOR:
   a) Program title
   b) Calculator and peripherals required
   c) Brief description of the program's purpose or use
   d) Name, address and telephone number of the contact for that laboratory.

3.0 If you have a Release Form on file and wish to obtain a tape program call or write to the COORDINATOR and request the tape(s)/disk(s) by number and title.

4.0 The COORDINATOR will supply you an Organization's name and the contact information of a possible SOURCE.

5.0 The REQUESTOR then contacts the SOURCE and requests the desired program(s). If the SOURCE agrees the REQUESTOR sends the SOURCE the following:
   a) A blank cassette/cartridge tape/disk for each program desired.
   b) A return address label.
   c) Stamps to cover postage.

6.0 If the SOURCE declines for any reason, the REQUESTOR recontacts the COORDINATOR for another SOURCE.

7.0 The SOURCE laboratory duplicates the requested program on the REQUESTOR's tape/disk and sends it back to them.

8.0 The REQUESTOR then becomes a SOURCE for the next request.

9.0 After receiving the program tape(s)/disk(s), the REQUESTOR must notify the COORDINATOR of receipt in order to maintain listing records.

10.0 All participating members are encouraged to update their listing as revisions to this document are mailed.

11.0 DEFINITIONS
a) PARTICIPANT - Any organization/laboratory who has a signed Release Form on file with the NCSL Automatic Test & Calibration Systems Committee.
b) SUBMITTOR - The original developer and contributor of the program tape/disk.
c) SOURCE - Any organization or laboratory who may be in possession of a listed program tape/disk.
d) REQUESTOR - Any organization/laboratory requesting a program take/disk.
e) COORDINATOR - The individual who compiles, develops, updates and distributes a listing of available programs and descriptions. He also provides the contact SOURCE and any other information that may be requested concerning this program.

NCSL CALCULATOR PROGRAM LISTING

001 HP9830 Error Ratio Check Program:
Prints out the ERROR RATIO by comparing the accuracy specifications of two instruments. Simplifies the calculation of accuracy ratio by reducing total accuracy to % input. User inputs accuracy values and nominal calibration points.

002 HP9830 Data Sheet Program:
Creates a standard data sheet for use in calibration. Calibration points, accuracy specifications, model no. I.D. no., etc. are inputted by user. Prints out heading, nominal calibration points, minimum and maximum test values.

003 HP9830 Electronic Counter Drift Rate Program:
User inputs drift data and program calculates a straight line drift rate using a least square solution. Data and slope values are printed out.

004 HP9830 Fractional Deviation Counter Drift Rate Program:
User inputs drift rate data from nominal and computer calculates the value based on the standard deviation of X, Y, data. Data and results are printed out.
005 **HP9830 Data Reduction Program for North Atlantic Phase Angle Voltmeter:**
User inputs tested data values (Phase angle, In Phase and Quad Voltages). The program reduces data by computing the ARCTANGENT values for comparison of actual readings. Data values and results are printed out.

006 **HP9830 Calibration Procedure Program:**
A universal string oriented program for creating a one-of-a-kind printed calibration procedure with data sheet. Originally conceived as a Text Editor for writing procedure with expected expansion.

007 **HP9830 Ratio Transformer Data Sheet Program:**
Creates a printed data sheet which includes calculated accuracies of minimum, maximum values for calibration purposes.

008 **HP9830 Basic Real Time Program for Flow Transducers:**
A basic program to interface three instruments (temperature and pressure) for data reduction for the calibration of certain flow transducers (meters).

009 **HP9830 Basic Real Time Program for Linear Accelerometers:**
A basic program to interface DVM to LINEAR accelerometer output in order to perform a semi-automatic “real time” calibration of these transducers. Solutions to a least square of \( x, y \) data is printed out. It also includes hysteresis, repeatability and deviation, RCV printout in data sheet format.

010 **HP9830 Basic Real Time Program for Servo Accelerometers:**
Same as item 9.

011 **HP9830 Basic Real Time Program for Load Cells:**
A basic program to interface DVM to LOAD CELL output, etc. for the purpose of performing on-line semi-automatic calibration of various LOAD CELLS. Includes a 22 point least square solution of \( x, y \) points, hysteresis, repeatability and deviation values. Print out is a complete data sheet with flagging of O/T values. This program has been expanded to include various models of different ranges of transducer. Includes the calibration of four transducer on-line at the same time, producing four data sheets.

012 **HP9830 Charge Amplifier Calibration Program:**
Two separate programs to perform real time calibration of ENDEVCO 271.3 and 2735 Charge Amplifiers using the JRL Locost AC-signal sources. Instructions step by step calibration of parameters and automatic step calibration for linearity test. Complete data sheet and test results are printed out.

013 **HP9830 Data Reduction Program for Voltron Transducers:**
A series of nine programs for the data reduction of input/output values. Least square solutions are provided and a complete data sheet is printed out. The programs are for various transducer measureands such as DC, WATTS, AC VOLTS of different models.

014 **HP9825 NMTBA Statistics Plot — Machine tool calibration calculates accuracy, standard deviation of repeatability and last motion.

015 **HP9825 Error Plot — Machine tool calibration, plots deviation from nominal value for linear accuracy.

016 **HP9825 Gage Block Statistics — Gives mean value and standard deviation for repeated measurements on a small set (10) of gage blocks, when measurement is made directly using laser interferometer.

017 **HP9825 Straightness and Squareness — Machine tool calibration, calculates straightness and squarness relationship between two axis of a machine tool; must be used with straightness adapter for H-P laser interferometer.

018 **HP9825 Optical Polygon/Rotary Table Absolute Calibration**
This program is used in the data reduction of the absolute calibration of an optical polygon having an even number of faces and the rotary table that is used to position the polygon. The data is recorded on mark sense cards. Equipment required:
- Test polygon (Davidson Model D633-12)
- Test rotary table (Ultradex Model B)
- Two autocollimators (Hilger Watts TA53-2)
- HP 9825A Calculator
- HP 9817A Impact Printer
- HP 9869A Card Reader

019 **HP9825 Gage Block Calibration**
Three programs are used. The first is used to establish a history of a gage block set on magnetic tape. The second is the controller for the laser gage block comparator operation and the third is used to produce a report of the calibration results. Equipment required:
- Laser Gage Block Comparator
- HP 5526A Laser Interferometer System
- HP 9825A Calculator
- HP 9871A Impact Printer

020 **HP9825 Thermocouple Reference Tables (NBS 125)**
This program is used to derive the temperature (°C or °F) versus EMF or the EMF versus temperature for seven thermocouple types. The Seebeck coefficient is also available. The equations listed in the National Bureau of Standards Monograph 125 “Thermocouple Reference Tables Based on the IPTS-68” are used. Equipment required:
- HP 9825A Calculator

021 **HP9825 Humidity**
The following programs are available:
a) Enhancement Factor for Moist Air.
The temperature \( T \) (°C IPTS 68) and pressure (pascals are used in the Enhancement Factor calculation in the range of -100°C to 100°C from 0.1 to 2 MPa.

b) Vapor Pressure of Water
The vapor pressure of water or the dew point is calculated.

c) Humidity Functions.
This program includes conversion functions between parts per million, dew point and percent relative humidity. Also included are functions for determining saturation or test chamber pressures and temperatures required for a given set of conditions in a two temperature two pressure humidity generator.

Equipment required: HP 9825 Calculator.

022 HP9825 Platinum Resistance Thermometer Equations:
This program contains nine functions that are used to handle the IPTS-68 Platinum Resistance Thermometer equations that are defined in "The International Practical Temperature Scale of 1968" (April 1969). The functions are intended to be used in other general purpose platinum resistance thermometer programs.

Equipment required: HP 9825A Calculator.

023 HP9845 Basic Measurements Program for HP8507
A translated version for use with the HP9845, of programs supplied by Hewlett-Packard for operation of the HP8507 with the HP9830 Calculator.

024 HP9845 Accuracy Improved Measurement for HP8507
A translated version, for use with the HP9845, of programs supplied by Hewlett-Packard for operation of the HP8507 with the HP9830 Calculator.

025 HP9845 Linear and Log Sweep
A linear and log sweep program with printed or plotted (HP9862) output data for the HP 3042.

026 HP9830 Linear and Log Sweep
A linear and log sweep program with printed or plotted (HP9862) output data for the HP 3042.

027 HP9825 Instrument Calibration
The following instruments may be calibrated using an HP 9871A printer and a FLUKE 5100A Calibrator:

<table>
<thead>
<tr>
<th>FILE</th>
<th>Instrument</th>
<th>Value</th>
</tr>
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<td>30</td>
</tr>
<tr>
<td>12</td>
<td>Keithley</td>
<td>179</td>
</tr>
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</table>

028 HP9825 Instrument Calibration
The following instruments may be calibrated using an HP 9871A printer and a FLUKE 5100A Calibrator:

<table>
<thead>
<tr>
<th>FILE</th>
<th>Instrument</th>
<th>Value</th>
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</thead>
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029 HP9825 Instrument Calibration
The following instruments may be calibrated using an HP 9871A printer and a FLUKE 5100A Calibrator:

<table>
<thead>
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<td>Keithley</td>
<td>178</td>
</tr>
<tr>
<td>11</td>
<td>Keithley</td>
<td>160</td>
</tr>
</tbody>
</table>

030 HP9825A Surface Plate Data Reduction
This program uses the Moody system for calculating relative values from points on 8 lines of the surface plate, diagonals, perimeters and bisectors. A numeric data plot is then given.

031 HP9825A Surface Plate Analysis
This program analyzes the data from the Surface Plate data reduction program and gives average values and standard deviation for each line.

032 HP9825A Thread Wires
Given the readings over the wire and the pitch this program gives the average value and the C-value.

033 HP9825A Butress Threads
This program determines the effective pitch from the following inputs: nominal pitch, reading over the wire, wire diameter, trailing and pressure flank angles.
034 HP9825A Unified Thread
This program determines the pitch diameter from the following inputs: measurement over wires, half angle of threads, number of threads per inch, mean diameter of threads and the angle between wire axis and the plane perpendicular to the thread axis.

035 HP9825A Determination of Temperature from Resistance of Standard Platinum Resistance Thermometer
This program determines temperatures sensed by a platinum resistance thermometer given its resistance. The ice point resistance and calibration from the calibration of the thermometer must be known. Temperatures are given in Kelvin, Celsius, Rankine and Fahrenheit.

036 HP9825A Determination of Resistance for Mueller Bridge from Temperature of Standard Platinum Resistance Thermometer
This program is the same as 035 except that resistance values are determined for given temperatures.

037 HP9825A Platinum Resistance Thermometer Fit and Interpolation
This program fits temperature and resistance ratio data to a two degree polynomial equation and then gives a table of values at a selected interval.

038 HP9825A Thermistor Fit and Interpolation
This program fits temperature and resistance data to a three degree polynomial equation and then gives a table of values at a selected interval. Ice point resistance must be known.

039 HP9825A Thermocouple Fit and Interpolation
This program gives a table of emf's difference emf's, percent error and Seebeck coefficients when given at least four temperature, emf pairs. It is used for most types of thermocouples and the coefficients for the thermocouples come from NBS Monograph 125.

040 HP9825A Pyrometry Fit and Interpolation of Temperatures and Currents
This program determines coefficients of fit for an eight degree polynomial given temperature and current data. The data is fit with temperature as a function of current and also with current as a function of temperature. A table of values at a selected interval is given. Coefficients are stored in a data file for later use.

041 HP9825A Lamp Fit and Interpolation of Temperatures and Currents
This program is the same as 040 except that it is for lamps.

042 HP9825A Transmission Factor Determination
This program computes the transmission factor @ .65 microns for optical pyrometer calibrations using neutral density filters.

043 HP9825A A-Factor Determination
This program determines H-factors for optical pyrometers given the number of ranges and the temperatures on those ranges.

044 HP9825A Gold Point Lamp Interpolation
This program determines either temperature or current from inputted currents or temperatures, respectively for a gold point lamp.

045 HP9825A Working Lamp Interpolation
This program is the same as 044 except that 044 is for a standard lamp and this is for a working lamp.

046 HP9825A Standard Pyrometer Interpolation
This program is for an automatic optical pyrometer. Given the range and temperature or current data it will give the current or temperature values correspondingly.

047 HP9825A Standard Pyrometer Tables
This program gives a table of currents for preselected temperatures for each range of the automatic optical pyrometer.

048 HP9825A Pyrometry Coefficients for Pyro Interpolation or Tables
This program determines coefficients of fit for the four programs above (044, 045, 046, and 047) and stores them in data files used by the programs.

049 HP9825A Pressure Transducer
This program fits pressure and voltage output data from a pressure transducer and gives a table of interpolated data. Hysteresis, Linearity, repeatability and shunt test information are also given.

050 HP9825A Fused Quartz Pressure Gauge
This program is the same as 049 except that it is for fused quartz transducers.

051 HP9825A Harwood Model 200 Deadweight Tester
This program determines pressures given the nomenclature of weights for the Harwood 200 deadweight tester. Provision is made for changes in data from the deadweight tester calibration report.

052 HP9825A Pressure Determination for Ruska DWT’s Models 2400HL and 2450HL
This program is the same as 051 except that it is for the above listed Ruska deadweight testers.

053 HP9825A Weight Determination for Ruska DWT’s (Model 2400HL and 2450HL)
This program is the same as 052 except that it determines which weights will produce the desired pressure.
054 HP9825A Ruska Tilting Piston Gage
This program determines pressures given the nomenclature of weights for the Ruska tilting piston gage. Provision is made for changes in data from the piston gage calibration report.

055 HP9825A Ruska Tilting Piston Gage Tables
This program gives tables for 054 tape.

056 HP9825A Capsule Fit and Interpolation Tables
This program gives tables of counts for the Ruska 3850 bourdon tube system when given the corresponding pressures for each bourdon tube. Pressure units are selectable.

057 HP9825A Pressure Transducer Automatic
Instruments: Fluke 8500 dvm, HP 59306 relay actuator and Fluke 3330B. This program is for use with any pressure generation system. Used with the Ruska 3850 it will supply counts to be set and automatically take the reading from the transducer. With a dead-weight tester it will notify the user when he is within 20% of the desired pressure. The 3330B calibrator is used as a power supply and is automatically set to the desired excitation voltage. Both a HP 98034A HP-IB interface and a HP 98032A 16 bit interface are needed to interface the instruments. Shunt tests are done automatically via the relay actuator.

058 HP9825A Mr Load Cell
This program fits force and voltage output data from a load cell and gives a table of interpolated data. Hysteresis, linearity, repeatability, span and shunt information are also given.

059 HP9825A Load Cell Kit
This program is the same as 058 except that it is for load cell kits.

060 HP9825A Hydraulic Force Cell
This program is for a Ruska hydraulic force cell system and gives the needed weights for a given force that are loaded on the deadweight tester. This is only within the resolution of the weights, therefore the correct force is also given.

061 HP9825A Compressible Fluid Flow Nozzle Data Correlation
This program provides a means for determining fluid flow parameters for sonic nozzles by evaluating data given in the calibration done by Colorado Engineering Experiment Station, Inc.. From these parameters, the parameters for subsonic flow nozzles can be found. Namely, the discharge coefficient as a function of the Reynolds number is determined for both types of nozzles, from which all other parameters can be evaluated. All functions are for air, since that is the medium which calibrations are performed. Coefficients for the critical flow factor were derived from fitting of tables in NASA TN D-2565, 'Real Gas Effects in Critical-Flow-Through Nozzles and Tabulated Thermodynamic Properties' by Robert C. Johnson. Compressibility and Viscosity coefficients were derived from fitting of tables in NBS Circular 564, "Tables of Thermal Properties of Gases", Formulae for fluid flow characteristics are from ASME's "Fluid Meters", 6th edition.

062 HP9825A Density of Fluids Using Mettler Paar DMA 50
This program calculates the density of fluids at a given temperature using periods read from the Mettler Paar DMA 50.

063 HP9825A Determination of Viscosity
This program determines viscosity in centipoise at any selected temperature given parameters from the viscosity standard used for the calibration.

064 HP9825A Vacuum
This program is for vacuum ion gauges and will cover ranges from 10^-8 to 10^13. True values are stored in the program so that only the indicated values are entered. A table is given for each range and filament. The indicated values are incremented and the values given for each.

065 HP9825A Impactograp
This program is for impactographs and from the inputted true G's will give a best line regression of the data and provide a table of values.

066 HP9825A Polyfit
This program uses a Gaussian reduction method for a least squares analysis of entered data pairs. Resulting coefficients, the index of the determinant and the standard error are given along with the calculated values and differences.

067 HP9825A Polyformat
This program is the same as 066 except that provision is made for and table of interpolated data.

068 HP9830 Syncro-Resolver
This program converts output readings to degrees.

069 HP9830 Synchro-Resolver (.001° - 10°)
This program converts output readings to degrees.

070 HP9830 Standard Cell
This program measures one standard cell directly.

071 HP9830 Standard Cell
This program measures three (3) standard cells in series-parallel.

072 HP9830 Standard Cell
This program measures four (4) standard cells in series-parallel.

073 HP9830 Standard Cell
This program measures six (6) standard cells in series-parallel.
074 HP9830 Surface Plates
This program calculates surface flatness from data taken from either levels or collimator.

075 HP9825A Fluke 8500A DMM
This program performs calibration on a FLUKE model 8500A digital multimeter. Requires peripheral equipment.

076 HP9825 HP 5328A Counter
This program performs calibration on an HP 5328A counter. Requires peripheral equipment.

077 HP9825A HP 3455A DMM
This program performs calibration on an HP 3455A digital multimeter. Requires peripheral equipment.

078 HP9825A HP 98032A
This program performs a performance verification routine on HP 98032A 16 Bit Interfaces. Requires peripheral equipment.

079 HP9825A HP 98033A
This program performs a performance verification routine on HP 98033A BCD Interfaces. Requires peripheral equipment.

080 HP9825A HP 98034A
This program performs a performance verification routine on HP 98034A HP-IB interfaces. Requires peripheral equipment.

081 HP9825A HP 59306A
This program performs a performance verification routine on HP 59306A Relay Actuators. Requires peripheral equipment.

082 HP9825A HP 59308A
This program performs a calibration routine on HP 59308A Timing Generators. Requires peripheral equipment standards.

083 HP9825A HP 59309A
This program performs a performance verification routine on HP 59309A Digital Clocks. Requires peripheral equipment.

084 HP9825A HP 59313A
This program performs a performance verification routine on HP 59313A A-D Converters. Requires peripheral equipment.

085 HP9825A HP 3325A
This program performs a calibration routine on HP 3325A Synthesizers. Requires peripheral equipment/standards.

086 HP9825A HP 8672A
This program performs a performance verification routine on HP 8672A Signal Generators. Requires peripheral equipment.

087 HP9825A HP 9872A
This program performs a performance verification routine on HP 9872A Graphic Plotters. Requires peripheral equipment.

088 HP9825A HP 5363A
This program performs a calibration routine on HP 5363A Time Interval Probes. Requires peripheral equipment/standards.

089 HP9825A Wavetek 152
This program performs a calibration program on Wavetek 152 Waveform Generators. Requires peripheral equipment/standards.

090 HP9825A Wavetek 159
This program performs a calibration routine on Wavetek 159 Waveform Generators. Requires peripheral equipment/standards.

091 HP9825A System-Donner Power Supply
This program performs a calibration routine on Systron-Donner DPSD-50 Power Supplies. Requires peripheral equipment/standards.

092 HP9825A PRT
This program performs general data reduction/table generation routines. Requires printer.

093 HP9825A Resist
This program performs general data reduction/table generation routines on Standard Resistors. Requires Printer.

094 HP9825A STDCEL
This program performs general data reduction/table generation routines on Standard Cells. Requires printer.

095 HP9825A Weight
This program performs general data reduction/table generation routines for Balances. Requires printer.

096 HP9825A Flow
This program performs data reduction routines on flowmeter data. Requires printer.

097 HP9825A Accel
This program performs general data reduction routines on accelerometers. Requires printer.

098 HP 9825 Transducer, Bridge Type
Eleven or twenty-one data points; with R-Cal.

099 HP 9825 Strain Link Bridge Type
Eleven data points; with R-Cal and SR-4 data.
100  HP 9825 Load Cell, Bridge Type
Twenty-one data points; with R-Cal and SR-4 data.

101  HP 9825 Gas Flow
Volume Vs Time; 100 SCCM to 15 CFM, ranged via 5 GK-P tubes of different sizes.

102  HP 9825 Gas Flow
Nozzle Standards Utilized; 0.5 SVFM to 730 CFM.

103  HP 9825 Liquid Flow
Mass Vs. Time; 0.1 gpm to 50 gpm.

104  HP 9825 Liquid Flow
Turbine standard utilized; 5 gpm to 100 gpm.

105  HP 9825 Universal Ratio Set Data Reduction
Contains present correction factors of DRS, resolves calculations of data sets obtained during resistance comparisons.

106  HP 9825 Accelerometer Calibration
Resolves calculations and produces certificate of accelerometers calibrated by ENDEVCO reciprocity calibration method, using a type 2270 primary accelerometer set-up.

107  HP 9825 Saturated Standard Cell Calibration Data Reduction
Resolves and reports data of NBS-type standard cell inter-comparisons such as 2 x 3, 2 x 4, 4 x 6, etc. matrices.

108  HP 9825 Unsaturated Standard Cell Data Reduction
Calculates and reports the mean value and related statistical data of calibration of unsaturated standard cells.

109  HP 9825 Decade Resistor Calibration
With the help of a Fluke 8500A GPIB equipped DVM, it calibrates, calculates the values of, and reports test results for a wide variety of decade resistors.

110  HP 9825 Surface Plate Calibration Data Reduction
Calculates and reports final results of surface plate calibration.

111  HP 9825 HP 5340A Microwave Counter Verification
Check HP-IB operation, inputs, self-check and resolution. Requires microwave signal generator.

112  HP 9825 HP 5328A Universal Counter Verification
Requires no peripheral equipment.

113  HP 9825 HP 436A Power Meter Verification
Requires no peripheral equipment.

114  HP 9825 AC Digital VM Calibration
This program will calibrate any AC Digital voltmeter. Utilizes Fluke 5200–5205 AC Calibrator.

115  HP 9825 AC Analog VM Calibration
Similar to AC Digital Voltmeter program of (114). Requires a Fluke 5200–5205 AC Calibrator. Programs include Ballantine 300G and 310A and Fluke 873A.

116  HP 9825 IC Cross Reference
This program cross references Generic IC numbers with HP, Fluke and Tek equivalent part numbers.

117  HP 9825 General Purpose Log/Linear Plot Program
Program is an auto scaling log/linear plot for plotting calibration data. The main program computes the appropriate scale from the entered values for X min, X max, Y min, and Y max. Requires HP 9862A Plotter.

118  HP 9825 Resistance to Temperature Conversion
This program was developed to aid the users of 25.5 ohm (nominal) platinum resistance thermometers such as the Leeds and Northrup 8163 series or the Rosemont 162C series.

119  HP 9825 Ruska Weight Selector Program
For Ruska 2451-606-8600 DWT. Program selects weights for any entered pressure value. Will also generate tables on a printer if desired.

120  HP 9825 Ruska Weight Selector Program
Weight selector program for Ruska 2465-701 DWT. Same as (119) but for a different DWT.

121  HP 9825 DWT Calibration
This program reduces data for the calibration of working level DWTs as calibrated against a Ruska 2451 DWT used as a standard.

122  HP 9845A HP 436A Calibration
This program using the 9845A computer prints out power in watts and dBm. The reading is compared with specifications and if the reading is out of limits an error is noted.

123  HP 9845 HP 8660C Calibration
This program using the 9845A computer prints out power, frequency and modulation readings. The reading is compared with specifications and if the reading is out of limits an error is noted. All RF plug-ins can be checked.

124  HP 9825 Number System Conversion
Converts a decimal number to hexadecimal, octal, binary or gray code or converts a number in any of these bases to a decimal number.

125  HP 9825 Arctangent (SIN/COS)
Calculates the angle in the correct quadrant from inputs of sine and cosine values.

126  HP 9825 RMS-MEAN-Standard Deviation
Calculates the rms, mean and standard deviation from any list of values.
127 HP9825 Gas Flow
Program permits operator to calibrate a rotometer with non-explosive medium. The program instructs the operator to simulate the conditions of the explosive working gas when using a non-explosive calibration gas. Also generates a calibration curve for the flowmeter under test.

128 HP9825 Thread Gage Dimensions
Program computes the minimum maximum major diameters and pitch diameters for unified thread gages. Also computes dimension for setting thread gages. Based upon Handbook H-28 and ANSI B1.2.

129 HP9825 “TRANWT”
Reduces the calibration data for class S, S-1, and P weights during the single transposition method and lists the results in tabular form.

130 HP9825 3320B
Automatic calibration program for the HP 3320B Frequency Synthesizer.

130 HP9825 3437A
Automatic calibration program for the HP 3437A High Speed System Voltmeter.

132 HP9825 CEC
Data reduction for the CEC Primary Pressure Standard. Prints out the combination of weights required to produce nominal pressure values.

133 HP9825 DEDWGT
Data reduction for the Ruska 5100.8 Primary Pressure Standard. Prints out the combination of weights required to produce nominal pressure values.

134 HP9825 436A
Automatic calibration program for the HP 436A Thermocouple Power Meter.

135 HP9825 8375A
Automatic calibration program for the Fluke 8375A Digital Multimeter.

136 HP9825 8502A
Automatic calibration program for the Fluke 8502A Digital Multimeter.

137 HP9825 8400A
Automatic calibration for the Fluke 8400A Multimeter.

138 HP9825 8800A
Automatic calibration program for the Fluke 8800A Multimeter.

139 HP9825 8520A
Automatic calibration program for the Fluke 8520A Multimeter.

140 HP9825 619
Automatic calibration program for the Keithley 619 Electrometer/Multimeter.
RELEASE FORM
Desk Top Calculator Program Exchange

Company ___________________________ Delegate ___________________________

Please check the appropriate boxes below:

☐ We would like to participate, and have programs to share.

☐ A list of programs available are attached, with the appropriate program
descriptions and the calculator's manufacturer/model number for which
it is applicable.

☐ We will supply the listing and descriptions later.

☐ We would like to participate, but have no programs to share at this time. We
will cooperate in duplicating any we receive or generate in the future.

Person assigned as the CONTACT for your laboratory:

Name: ___________________________ Telephone ___________________________
(print or type)

Address: ___________________________

The undersigned warrants that using or duplicating the programs will not constitute or
give rise to a cause of action for unauthorized use or infringement. Further, that NCSL
and/or the laboratory supplying the tape shall be held blameless from any and all claims,
demands, settlements, judgments, and damages as a result of such use.

Delegate's signature ___________________________ Date ___________________________

After completion please return to: Ford Aerospace & Communications Corp.
Aeronutronic Div.
P. O. Box A, MS-EV-26
Newport Beach, CA 92663
ATTENTION: Robert R. Smith
(714) 720-4820

-59-
ASTM RELEASES MANUAL ON THE USE OF THERMOCOUPLES IN TEMPERATURE MEASUREMENT

Information on the principles, circuits, standard electromotive force (emf) tables, and stability and compatibility data are presented in the special technical publication, Manual on the Use of Thermocouples in Temperature Measurement, (STP 470B) recently published by ASTM, the internationally recognized standards-writing organization. Also included is information on installation techniques and calibration methods.

STP 470B contains principles of thermoelectric thermometry, thermocouple materials, typical thermocouple designs and applications, sheathed compacted ceramic-insulated thermocouples, emf measurements, and cryogenics. Fifty-four figures and 65 tables enhance the text as well as a comprehensive subject index.

Editorial Coordinator R. P. Benedict, Westinghouse Electric Company, notes that the manual offers practical information to aid both the beginner and the experienced in the use of thermocouples. An important feature of this latest work is the addition of a chapter on measurement uncertainty.

Further information on STP 470B can be obtained from ASTM Sales Services Department, 1916 Race Street, Philadelphia, Pennsylvania 19103, 215/299-5585.

PRICE: $24.00
Less 20% to ASTM Members

PUBLICATION CODE: 04-470020-40

***********************************************************************
SUPPLEMENTAL COURSES TO TRAINING
INFORMATION DIRECTORY

***********************************************************************

COURSE TITLE: ELECTRONIC DEVICES & SYSTEMS
COURSE TOPICS: A new course providing an update on characteristics and applications of the latest current and widely-used active and passive electronic devices and how they can be interconnected to perform complicated functions; the use of electronic devices in analog circuits; the application of electronic digital systems, the electronic properties of input and output devices and their operation; analog systems, and digital systems.

CONTACT: ENGINEERING TECHNOLOGY, INC.
P.O. Box 9000
Waco, TX 76710
(817) 772-0082

COURSE LENGTH: 4 Days
Cost: $760.00

DATES: March 26 - April 4, 1983 (East Course, MA)
CONTINUING EDUCATION UNITS: 3 CEUs

***********************************************************************

COURSE TITLE: LASER/ELECTRO-OPTIC SHORT COURSES

COURSE TITLE: LASER SPECTROSCOPE
COURSE TOPICS: The combination of narrow spectral linewidth, brightness, and the stability available from lasers has facilitated the attainment of very high resolution spectra, far beyond that available with even the best conventional spectrometers. The capabilities of the laser have led to a qualitative revolution in this branch of analytical techniques. This new course seeks to provide in a one-week course most of the use of internal, brand, and an elaborate lecture source as a valuable analytical tool by combining techniques in laser spectroscopy theory and techniques with highly practical case studies and problem solving workshops.

CONTACT: ENGINEERING TECHNOLOGY, INC.
P.O. Box 9000
Waco, TX 76710
(817) 772-0082

COURSE LENGTH: 5 Days
Cost: $1700.00

DATES: March 21-24, 1983 (Dallas, TX)
CONTINUING EDUCATION UNITS: 3 CEUs

***********************************************************************

COURSE TITLE: LASER/ELECTRO-OPTIC SHORT COURSES

COURSE TITLE: LASER ELECTRO-OPTIC INTERFERENCE FINGERPRINTING
COURSE TOPICS: The combination of narrow spectral linewidth, brightness, and the stability available from lasers has facilitated the attainment of very high resolution spectra, far beyond that available with even the best conventional spectrometers. The capabilities of the laser have led to a qualitative revolution in this branch of analytical techniques. This new course seeks to provide in a one-week course most of the use of internal, brand, and an elaborate lecture source as a valuable analytical tool by combining techniques in laser spectroscopy theory and techniques with highly practical case studies and problem solving workshops.

CONTACT: ENGINEERING TECHNOLOGY, INC.
P.O. Box 9000
Waco, TX 76710
(817) 772-0082

COURSE LENGTH: 5 Days
Cost: $1700.00

DATES: March 21-24, 1983 (Dallas, TX)
CONTINUING EDUCATION UNITS: 3 CEUs

***********************************************************************
LASER/ELECTRO-OPTIC SHORT COURSES

COURSE TITLE: LASER FUNDAMENTALS & SYSTEMS
COURSE TOPICS: Basic elements of a laser, power and wavelength measurement, optical amplifiers and gain, single and frequency lasers, optical cavity and mode structure, characteristics of laser materials, optical cleaning methods, laser calculation workshops, analysis of several specific lasers and survey of commercial laser systems.
CONTACT: ENGINEERING TECHNOLOGY, INC.
P.O. Box 9000
Waco, TX 76710
(817) 772-0082
COURSE LENGTH: 5 Days
COURSE TIMING: 5 Day(s)
COURSE TOPICS: Laser safety
COURSE DESCRIPTION: Laser output characterization, characterisation and potential hazards of laser effects on the eye and skin, laser measurement, exposure criteria, safety standards, control measures, medical surveillance, safety program management.
CONTACT: ENGINEERING TECHNOLOGY, INC.
P.O. Box 9000
Waco, TX 76710
(817) 772-0082
COURSE LENGTH: 5 Days
COURSE TIMING: 5 Day(s)
COURSE TOPICS: Laser safety
COURSE DESCRIPTION: Laser output characterization, characterisation and potential hazards of laser effects on the eye and skin, laser measurement, exposure criteria, safety standards, control measures, medical surveillance, safety program management.
CONTACT: ENGINEERING TECHNOLOGY, INC.
P.O. Box 9000
Waco, TX 76710
(817) 772-0082
COURSE LENGTH: 5 Days
COURSE TIMING: 5 Day(s)
DATES: February 11-14, 1983
CONTINUING EDUCATION UNITS: 3 CEUs
COURSE TITLE: USE OF INDUSTRIAL LASERS IN DYNAMIC HOLE DRILLING, CUTTING, MARKING & SINTERING APPLICATIONS
COURSE DESCRIPTION: Designed specifically for product managers, production engineers, physicists, design engineers, and laser system operators whose primary concern is the use of industrial laser systems in specific materials processing applications where material is required or otherwise removed from the workpiece. Important features include problem solving workshops and evening operational classes in a local laser development and production facility where corporate product engineers will demonstrate the use of industrial lasers in laser-induced material removal applications, productive techniques, and work positioning and motion parameters.
CONTACT: ENGINEERING TECHNOLOGY, INC.
P.O. Box 9000
Waco, TX 76710
(817) 772-0082
COURSE LENGTH: 2 Days
COURSE TIMING: 2 Day(s)
COURSE TIMING: 2 Day(s)
DATES: January 21-23, 1983
CONTINUING EDUCATION UNITS: 2 CEUs
COURSE TITLE: LASER SAFETY
COURSE TOPICS: Laser safety
COURSE DESCRIPTION: Laser safety is the study of how light rays (including laser beams) penetrate through optical systems. Some systems may be as simple as a single fiber, while others may be sophisticated combinations of lenses, prisms, and mirrors carefully arranged to meet special needs. This course begins with the fundamentals of reflection and refraction, geometric techniques, and analyzes optical elements (such as ray tracing and matrix polynomials), discusses aberrations and their effects on field stops, and emphasizes the practical aspects of optical component selection and evaluation.
CONTACT: Jim L. Noll
ENGINEERING TECHNOLOGY, INC.
P.O. Box 9000
Waco, Texas 76710
(817) 772-0082
COURSE LENGTH: 5 Instructional Modules
COURSE TIMING: 5 Day(s)
COURSE TIMING: 5 Day(s)
COURSE TIMING: 5 Day(s)
DATES: February 11-14, 1983
CONTINUING EDUCATION UNITS: 5 CEUs
COURSE TITLE: WAVE OPTICS
COURSE TOPICS: Wave optics
COURSE DESCRIPTION: Wave optics is a self-paced, highly practical course which provides the student an in-depth study of the generation, measurement, and wave nature of light. The first lesson provides the basis of the study by addressing the fundamental origin of light, different types of light sources, and characteristics of light sources, radiation, and photography. The next five lessons are concerned with the wave nature of light, which is in sharp contrast to the geometrical ray nature of light treated in Geometrical Optics. These lessons consider reflection, refraction, and propagation of light from the viewpoint of wave optics. They treat the potential principles of interference, diffraction, and polarization of light and all wave phenomena. The content of this course is important to a sound understanding of laser/electro-optics technology.
CONTACT: Jim L. Noll
ENGINEERING TECHNOLOGY, INC.
P.O. Box 9000
Waco, Texas 76710
(817) 772-0082
COURSE LENGTH: 12 Instructional Modules
COURSE TIMING: 12 Day(s)
COURSE TIMING: 12 Day(s)
DATES: January 17-19, 1983
CONTINUING EDUCATION UNITS: 12 CEUs
COURSE TITLE: LASER SAFETY
COURSE TOPICS: Laser safety
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DATES: January 21-23, 1983
CONTINUING EDUCATION UNITS: 2 CEUs
COURSE TITLE: GEOMETRICAL OPTICS
COURSE TOPICS: Geometrical optics
COURSE DESCRIPTION: Geometrical optics is the study of how light rays (including laser beams) penetrate through optical systems. Some systems may be as simple as a single fiber, while others may be sophisticated combinations of lenses, prisms, and mirrors carefully arranged to meet a special need. This course begins with the fundamentals of reflection and refraction, geometric techniques, and analyzes optical elements (such as ray tracing and matrix polynomials), discusses aberrations and their effects on field stops, and emphasizes the practical aspects of optical component selection and evaluation.
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<td>(206) 396-4558</td>
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<th>ANSI</th>
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<td>Dr. Robert A. Kamper</td>
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<td>National Bureau of Standards</td>
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