NUCLEAR MATERIALS MANAGEMENT

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SUMMER 1981

JOURNAL OF THE INSTITUTE OF NUCLEAR MATERIALS MANAGEMENT

Feature Articles

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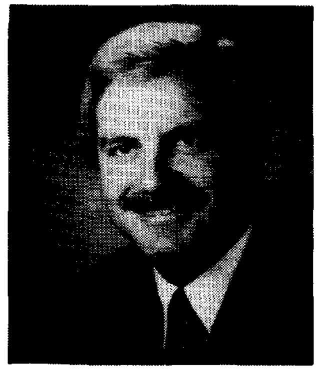


John E. Messervey, INMM Executive Director

INMM Selects New Management

The executive committee to the Institute of Nuclear Materials Management has announced the selection of Messervey & Company to serve as INMM staff. The announcement was made at the Institute's 22nd annual meeting July 12-16 in San Francisco, California. The selection concluded 16 months of search committee efforts to find a permanent management group for the Institute. E. R. Johnson and Associates of Reston, Virginia, served INMM during the search committee's deliberations.

John E. Messervey, President of Messervey & Company, will serve as Executive Director of the Institute. Messervey & Company is an association management firm based in the Chicago-O'Hare area. Messervey and the new INMM staff will assist the Institute in meeting and seminar management, Journal publication, government affairs counseling, and membership services. Although the Institute's selection will become effective October 1, 1981, program planning for several Institute projects has already begun at the new INMM headquarters.

The Institute of Nuclear Materials Management is a non-profit professional society of individuals working in govermental, industrial and academic institutions utilizing nuclear materials. The Institute's 700 members are concerned with nuclear safeguards, research, and professional education and training.

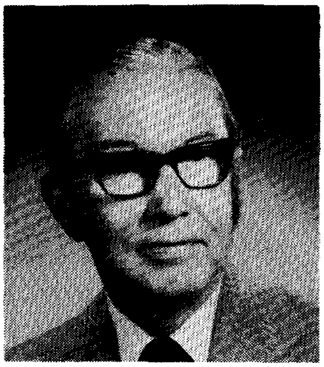
Left to right are Mr. K. Yoshioka and Dr. Y. Kawashima of the Nuclear Material Control Center, Ed and Jerry Johnson of the INMM Secretariat, M. Kawasaki, Science & Technology Agency and Dr. R. Hara of the Daini Seikosha Co.

INMM Secretariat Visits Japan Chapter

In June Ed and Jerry Johnson of the INMM Secretariat visited the Japan Chapter of INMM to discuss ways that the Secretariat could assist the Chapter in its activities. Three separate meetings were held and a good working relationship was established.

The Japan Chapter currently numbers about 70 members, most of which are members of management of key nuclear activities in Japan. Dr. Yoshio Kawashima, Director of Japan's Nuclear Material Control Center and Chairman of the Japan Chapter is optimistic about the chapter's future. He is hopeful that within a few years there will be several hundred members active in Japan - the potential is clearly there, and so is the interest and enthusiasm.

INMM Editorial



Dr. William A. Higinbotham
Brookhaven National Laboratory
Upton, New York

Every year it seems to be necessary to appeal to the membership to support the Journal. Several kinds of support would be appreciated by the editors, and should make the Journal more useful to the membership, and to others. For one thing, we need more technical contributions. The annual INMM and ESARDA symposia attract many contributions, since authors whose papers are accepted may be able to attend these interesting meetings. The Journal cannot offer that inducement. On the other hand, a paper in the Journal has more visibility, since there are no parallel sessions, and the competition is almost nil.

A typical proceedings issue contains about 90 papers, compared to only about 16 technical papers in all of the four regular issues in a year. There are a few conscientious contributors. If it were not for them, the Journal would be only a newsletter. If some readers feel that the technical papers are unbalanced, it is their duty to provide material to restore the balance.

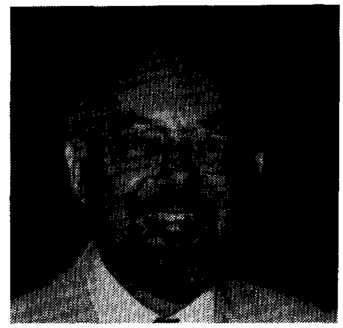
In addition to strictly technical papers, more general papers on safeguards objectives and designs are important. A year ago last January, I was able to recruit several such papers, which had been presented elsewhere. The logical place for such papers is the Journal. In this regard, the guest editorial on the Sahara Principle, volunteered by J. W. Carr for the Winter Issue, hopefully will stimulate other thoughtful members.

Finally, we need feedback. No one ever writes the editor to suggest improvement, or even to complain. There is no way for us to tell whether the members are satisfied, or what they think about the Journal. Maybe no one reads it.

In order to try to stir people up, the editors will publish comments. The comments might take issue with the tone or content of technical papers; they might complain about the editorials and other non-technical content; they might suggest how the INMM should develop in the next few years, a subject of great interest to the officers and to all of our membership.

As I have said before, this is your organization and your Journal. Don't expect the officers to provide all of the guidance, or the editors to obtain the technical articles. We exist to serve you.

Vice-Chairman's Report



John L. Jaech
Exxon Nuclear Company
Bellevue, Washington

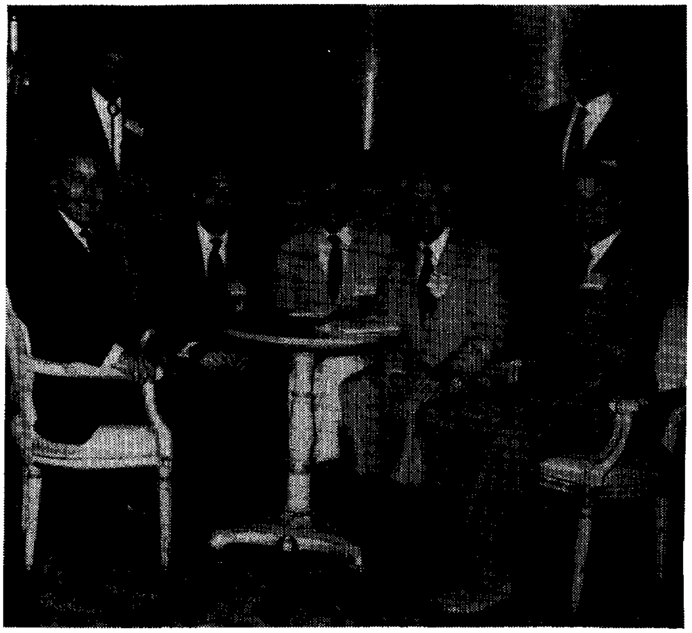
With the very successful San Francisco meeting behind us, detailed planning has already begun on the 1982 meeting to be held at the beautiful Hyatt Regency Hotel in Washington, D.C. on July 19-21, 1982. Planning and preparing for an annual meeting requires a long lead time and considerable effort on the part of a good many members, both before and during the meeting. Those on the Annual Meeting Committee have as their reward the awareness that with each taking care of his or her responsibilities in a professional manner, the meeting flows smoothly. The San Francisco meeting was a good example of this, and we owe a debt of gratitude to each member of the Committee.

I am pleased to report that all members of the Arrangements Committee, chaired by Tom Sellers, have agreed to serve again for the coming INMM year, with the exception that the Local Arrangements chairman for the Washington meeting will be J. Mark Elliott. He replaces Herman Miller on the Arrangements Committee. Herman was ably assisted by Dennis Bitz at San Francisco, and also by his wife, JoAnne Miller, who handled the Spouses' Program. The returning members of the Arrangements Committee are:

Duane Dunn - Registration Chairman
Mary Ellen Dodgen - Communications and Publicity Chairman
Tom McDaniel - Exhibits and Displays Chairman
Tony Kraft - Photography Chairman

The Technical Program Committee Chairwoman for the Washington meeting is outgoing Executive Committee member Yvonne Ferris. As of this writing, Yvonne is forming her committee. She asks that if you have anything you wish to share with her in her planning - comments on the San Francisco program, ideas, suggestions, whatever - give her a call at (303) 497-4867.

With Yvonne Ferris as Program Chairwoman, with Tom Sellers and Ray Lang returning as Arrangements and Site Selection Chairmen respectively, and with their collective track records of getting things done in a timely and efficient manner, I am confident that the Washington meeting will be another



Members of the 22nd Annual Meeting Technical Program Committee. Seated left to right are: J. Indusi, J. Glancy, R. Chanda, G. Huff and R. Keepin. Standing are R. Cardwell and J. Lemming.

Members of the 1980 Annual Meeting Registration Committee.

meeting to remember. Mark your calendar now, and make plans to attend.

Turning briefly to the INMM Technical Working Groups, it has been noted elsewhere that with Tom Sellers' appointment as Meeting Arrangements Chairman, he has been replaced by J. D. Williams as Chairman of the extremely successful Technical Working Group on Physical Protection. Activities of this Group are reported elsewhere. The success of this initial technical working group has far exceeded the goals implicitly set for technical working groups, and presents a challenge to all such groups as they will be formed in the future. The vision and hard work of Tom Sellers as the first chairman are worthy of special note.

The second INMM Technical Committee, one on Statistics, had its initial planning meeting at San Francisco with Carl Bennett as Chairman. The first workshop for this Group is tentatively planned for early spring at Idaho Falls. Watch for further announcements. A membership survey conducted some months ago indicated that about 25% of the membership who responded have an interest in the statistical aspects of safeguards. It would appear that workshops that concentrate on applied problems in statistics will be well attended, and we look forward eagerly to the first such endeavor.

I welcome, at any time, calls with respect to the Annual Meeting, the technical working groups, and/or site selection. You may reach me at (206) 453-4377.

Secretary's Report

V. J. DeVito
Goodyear Atomic Corporation
Piketon, Ohio

INMM Officers Elected

According to Article III, Section 6, of the INMM Bylaws, the Secretary shall notify each member in good standing of the results of the election by November 15 of each year. This notice in the Journal shall be construed as having fulfilled that Bylaw requirement.

In accordance with Article III, Section 4 of the INMM Bylaws, the selection of candidates for the elected positions on the Executive Committee (officers and members) was received as scheduled by the Secretary. The Nominating Committee selected the following slate of candidates:

For Chairman - Gary Molen
For Vice-Chairman - John Jaech
For Secretary - Vincent DeVito
For Treasurer - Edward Owings

In accordance with Article III, Section 5, a ballot was mailed to each of the Institute's 684 members of which 358 returned ballots.

As a result of the balloting, the officers and the members of the Executive Committee for the terms of office beginning July 1, 1981, are as follows:

Chairman - Gary Molen
Vice-Chairman - John Jaech
Secretary - Vincent DeVito
Treasurer - Edward Owings

Carleton Bingham to September 30, 1982
Roy Crouch to September 30, 1982
Charles Vaughan to September 30, 1983
Glenn Hammond to September 30, 1983

There were no petitions for candidates to be added to the ballot; however, the following write-in votes were recorded:

For Chairman: John Jaech, Russ Weber, Yvonne Ferris, Robert Keepin

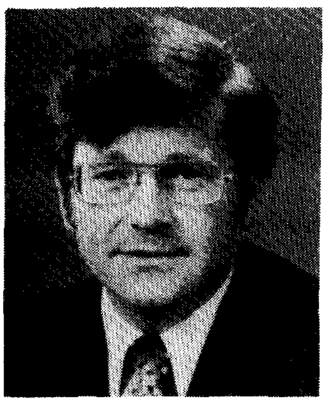
For Vice-Chairman: D. B. Smith, Yvonne Ferris, Gary Molen

For Secretary: Bill Brach, Ed Owings

For Treasurer: Vince DeVito

For Members at Large (Executive Committee): John Lemming, Leon Green, Ed Young

Safeguards Committee Report



Robert J. Sorenson
Battelle Pacific Northwest Laboratory
Richland, Washington

The Safeguards Committee met at the Sheraton Palace Hotel in San Francisco on both Sunday, July 12, and Thursday, July 16. In attendance at one or both meetings were Charles Vaughan, Dick Duda, Cookie Ong, Ralph Lumb, Jim DeMontmollin, Paul Persiani, Brian Smith, Wally Hendry, Ken Sanders, Mark Killinger, Marty Messinger, Bill Powers, John Jaech, Fred Tingey, and Bob Sorenson. We are pleased to see the interest in the committee's activities as indicated by the increasing attendance.

The purpose of the Sunday meeting was to discuss some of the recommended changes in safeguards requirements for low enriched uranium. While the committee is in essentially complete agreement regarding recommending the reduction in some of the requirements for low enriched uranium, the question of requiring the current limit of error calculation is still up in the air. It was discussed in great length with Fred Tingey and John Jaech. At the conclusion of our meeting, we decided that we would try to have a specific recommendation on the low enriched uranium question for our next meeting with the NRC.

The committee plans to draft a statement for the NRC regarding the proposed General Statement of Policy and Procedure for Enforcement Actions (re: 10 CFR Part 2) which was published for comment in the Federal Register last October 7, 1980. We understand that the NRC is currently receiving submissions regarding this proposed rule change. Because low enriched uranium is of such low strategic value, we believe that the NRC enforcement policy should not require a significant fine for non-compliance.

The subcommittee for government liaison chaired by Dick Duda is currently preparing comments for an August meeting at the IAEA regarding international plutonium storage (IPS). More specifically, the subcommittee is reviewing some of the technical views regarding buffer storage requirements envisioned for U. S. mixed oxide fuel plants for either LWRs or LMFBRs. On September 1, Dick plans to hold a one day meeting on international plutonium storage at the Westinghouse Waltz Mill Site.

We spent some time developing an agenda for our next meeting with Bob Burnett and his staff at the NRC. This will be our second quarterly dialogue meeting with the NRC and we are looking forward to discussing a number of timely issues.

Mr. Homer Faust of Battelle-Columbus and Mr. and Mrs. "Cookie" Ong of NRC at the 22nd Annual Meeting.

N14 Standards Committee Report

James R. Clark
Nuclear Fuel Services
Rockville, Maryland

An Opportunity Accepted

In June, the American National Standards Institute chose the INMM as the new Secretariat for the N14 Standards Committee on Transportation of Fissile and Radioactive Material. The INMM and other professional societies had actively sought this Secretariat. Our Institute has accepted this opportunity to extend our arena of service. Obviously, we have also accepted responsibilities that must be satisfied very well if the INMM is to continue in the high regard that it earned by its N15 Standards Committee efforts.

In the Winter 1980 issue of the Journal, Dennis Bishop summarized the history and status of N14; however, let me reiterate the scope of N14:

> SCOPE: *Standards for the packaging and transportation of fissile and radioactive materials but not including movement or handling during processing and manufacturing operations.*

Mr. Jim Clark and wife Mary shown with Carleton Bingham.

Within this scope, twenty-five task groups either write new proposed standards or revise previously approved standards. The N14 Committee members individually review and evaluate these standards throughout their development and eventually the Committee members ballot towards a consensus. The N14

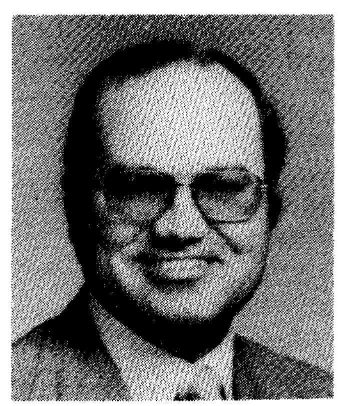
Committee membership is presently about fifty and includes a broad spectrum of interest and expertise in the packaging and transportation of radioactive materials. To supplement and support the work of the N14 Committee, a five member Management Committee has been assembled and will monitor the performance of the individual task groups and will develop long range plans.

The end of the INMM's first year as Secretariat of N14 will about coincide with the 23rd Annual Meeting. If significant N14 achievements are to be reported, we will need the active support of INMM members throughout the year. We would especially welcome the participation of new members. Give me a call at (301) 770-5510.

N14 Management Committee

Name	**Affiliation**
Jim Clark, *Chairman*	Nuclear Fuel Services, Inc.
Ed Tarnuzzer, *Vice Chairman*	Yankee Atomic Electric Company
Art Trujillo, *Secretary*	Sandia Labs
Cal Brantley	New England Nuclear Corporation
Arvil Crase	U. S. Ecology, Inc.
Phil Eggers	Ridihalgh, Eggers & Associates
Dick Haelsig	Nuclear Packaging, Inc.
Jim Lee	Tri-State Motor Transit

Membership Committee Report



J. E. Barry
Gulf States Utilities
Beaumont, Texas

Annual Meeting Postscript

To paraphrase a paraphrased title of one of the many papers of importance and interest delivered at the just ended Annual Meeting in San Francisco, a funny thing happened on the way to the membership questionnaire promised in last quarter's report. I discovered we already had one! You, the INMM membership, had in fact already responded quite well to a list of questions put together by Tom Gerdis and submitted to you in your FY 1981 dues statement. Due to the logistics of the

Secretariat assuming editorship of the *Journal* and my taking over as chairman of this committee, I overlooked a summary of the responses prepared by Edward Owings.

Questionnaire Results

Four hundred and twenty-five members returned their forms. Significant interest was shown in INMM committee and working group participation and lists of such members were turned over to the Executive Committee for distribution and use by the respective groups. Respondent breakdown with respect to professional interest and affiliation were as follows:

Areas of Interest
(check if interested)

- International Safeguards - 183
- Domestic Safeguards - 116
- Inventory Control - 115
- Audits and Accounting - 102
- Instrumentation - 86
- Statistics - 74
- Safeguards Education and Training - 70
- Transportation - 67
- Calibration - 59
- Emergency Planning - 42
- Others - 29

Affiliation*
(check one)

	Number Answering	% of Answers*
DOE Contractor	146	41.4
Private Industry	82	23.2
U. S. Government	47	13.3
International Unit	31	8.8
Others	22	6.2
Utility	12	3.4
Other National Government	11	3.1
Supplier	2	0.6

*353 answers, 11 with more than one choice; 83 returning questionnaires did not indicate affiliation.

Future Directions

During the Annual Meeting the full committee (Vince DeVito, Ed Owings, Jim Lee, Frank O'Hara and myself) met and moved to support modification of the membership application and renewal forms to facilitate regular input from members on their interests, preferences and affiliations for guidance of the officers, standing committees and our new executive director. We are very enthusiastic about John Messervey's plans for organizing and stimulating individual and company membership and activity in the INMM.

Correction: In our last report I noted that Jim Patterson was leaving the INMM. No so! I apologize to Jim; I didn't catch the error before press time.

The following eleven individuals have been accepted during the period April 16, 1981 through June 30, 1981. To each, the INMM Executive Committee extends its welcome and congratulations. New members not mentioned in this issue will be listed in the Fall 1981 (Volume X, No. 3) issue.

INMM New Members - April 16-June 30, 1981

Nancy Karen Canody, Measurement Control Coordinator, Babcock & Wilcox Company, P.O. Box 800, Lynchburg, VA 24502, (804) 384-5111, Ext. 6202

James Richard Clark, Manager, Quality Assurance and Licensing, Nuclear Fuel Services, Inc., 6000 Executive Blvd., Rockville, MD 20852, (301) 770-5510.

Bernard Clement, Chef de Service, Commissariat A l'Energie Atomique, IPSN.DSMN B. P. No. 6-92260, Fontenay - Aux-Roses, France

Alfred F. Endler, Jr., Nuclear Materials Auditor, U. S. DOE, P.O. Box A, Aiken, SC 29801, (803) 725-3856

Michael T. Franklin, Scientific Officer, Joint Research Center of E.E.C., Bat. 36, Euratom, 21020 Espra, Prov. Varese, Italy

Ann Gibbs, Staff Chemist, Box 6624, N. Augusta, SC 29841

Jacek T. Kaniewski, Safeguards Inspector, International Atomic Energy Agency, Vienna International Centre, P.O. Box 200, A-1400 Vienna, Austria

Eugene U. McDonald, Vice President, Globe Security Systems, Inc., P.O. Box 209, East Lyme, CT 06333, (203) 739-2171

M. Teresa Olascoga, Member of Technical Staff, Sandia National Laboratories, P.O. Box 5800, Albuquerque, NM 87185, (505) 844-6796

Syed Y. Raza, Assistant Engineer, Pakistan Atomic Energy Commission, P.O. Box 1114, Islamabad, Pakistan

Walter R. Thoma, Regional Manager, Interstate Security Services, Inc., P.O. Box 209, East Lyme, CT 06333, (203) 443-5900

Pacific Northwest Chapter

Curtis A. Colvin
Rockwell International
Richland, WA

Pacific Northwest Chapter activities have focused in two primary directions: (1) education of the membership, their families and immediate associates; and (2) informative presentations to interested public groups.

A dinner meeting featuring an illustrated overview of the Basalt Waste Isolation Project at Hanford as related to the National Waste Terminal Storage Program was so well received that a tour of the Rockwell facility was arranged. The Project involves testing of the effect of heat sources on basalt formations, access to which are through tunnels within a mountain.

Members and spouses were treated to another tour which features two nuclear reactors which are in different stages of construction. Washington Public Power Supply System hosted the tour of their reactors, providing either technical or cursory explanations as requested by the particular group.

Other informative meetings have featured Carl Bennett of Battelle's Human Affairs Research Center speaking on International Safeguards; and Hanford Engineering Development Laboratory's (Westinghouse) computer controlled access to nuclear materials management via hand geometry (Identimat) program.

We were fortunate at our last meeting, August 13, 1981, to have two speakers from the International Atomic Energy Agency. They are in the United States on business, inspecting the faciities of Exxon Nuclear. Messrs. M. Ferraris, and Gonzales-Montes discussed Safeguards implementation in North America and progress in achieving the goals of the US/IAEA Safeguards agreement.

Roy Nilson, past chairman of the Chapter spoke at a two-day Nuclear Energy meeting of the State League of Women Voters. His subject was Non-Proliferation and The Effect on Domestic Nuclear Industry. Information has also been presented at the local chapter of the American Society of Women Accountants.

Vienna Chapter

W. A. Higinbotham
Brookhaven National Laboratory
Upton, New York

During visits to the IAEA last fall and winter, I had the pleasure of attending four meetings of the Vienna chapter of our Institute.

The first fall meeting was a dinner meeting at a heurigen or wine-garden attended by 18 members, 13 wives and guests. Vince DeVito, secretary of the INMM gave an interested talk about Institute affairs, anti-nuclear activities in the U. S., and plans for the centrifuge enrichment plant being constructed in Ohio. Peggy and I enjoyed the opportunity to get acquainted, and we sang a few songs before going home.

The Honorable Andre Petit addressed the second meeting in October. Mr. Petit is the French member of the Standing Advisory Committee on Safeguards Implementation (SAGSI) of the IAEA. He lived up to his reputation for being provocative. It was a stimulating talk and discussion.

The next meeting that I attended was, like the 2nd meeting, a luncheon at a nice restaurant in the beautiful park that almost surrounds the UNO building. Since I was the featured speaker, I will only say that the members in attendance were kind and considerate.

The 4th event was most impressive. In the fall, the chapter sent out a notice inviting member to contribute papers for consideration for presentation of the forthcoming annual INMM meeting in San Francisco. From the contributed papers, six were selected for presentation in a symposium, held in a big auditorium in the UNO building, where the IAEA is located. Les Thorne, chairman of the Vienna chapter presided. The Canadian ambassador to the IAEA gave a very sensible introductory talk on the importance of international safeguards and on the challenge to the IAEA, after which the six papers were presented and discussed. The meeting lasted from 2 until after 5 p.m. A very large fraction of IAEA's safeguards personnel attended, as well as several officers and inspectors from Euratom.

This was a most impressive and inspiring performance. The papers were excellent. It is significant that this event had the support and the participation of the Deputy Director General for safeguards, and the active participation of so many extremely busy Agency people.

The Vienna chapter is healthy and effective. It has a number of unique advantages: a large group of safeguards experts in one place, members directly involved in international safeguards, and members from many nations who have an interest in discussing safeguards with each other.

Because IAEA personnel travel throughout the world to participate in meetings and to perform inspections, I look to them to encourage those engaged in safeguards in other countries to join the Institute so that we can become a truly international organization to promote cooperation on international and on national safeguards.

Letter to the Chairman

During the annual business meeting in San Francisco I announced that the IAEA would sponsor an international safeguards symposium in Vienna during the week of 8-12 November 1982. A question was raised but not publicly answered concerning participation in such meetings. I believe the question is of more general interest and deserves a more public answer.

It is true that the IAEA requires governmental sponsorship for participation in such symposia. It is my understanding, however, the the U. S. government in general is willing to sponsor anyone who:

a. Has a logical basis for being interested in the subject of the meeting, and
b. Does not wish travel costs to be paid by the U. S. government or by a government cost-type contractor.

Persons who meet the first criterion but not the second understandably may have more difficulty gaining sponsorship.

The IAEA at its discretion may also admit any non-sponsored individual as an observer, a distinction which relates mostly to color of badge. The INMM members wishing to attend (but not necessarily to present a paper at) the IAEA Safeguards Symposium, I suggest that the most serious problem is who will pay travel costs. Individuals who have solved that problem and think they still have some other problem are invited to write me, care of the IAEA, P.O. Box 200, A-1400, Vienna, Austria.

Jim Lovett
International Atomic Energy Agency

Special Announcement

Openings for technical personnel are announced frequently to the national members of the International Atomic Energy Agency. The national governments, in turn, notify institutions and individuals. The INMM Journal would appear to be an appropriate medium for such announcements. Candidates must be suggested through government channels.

The following openings in safeguards were announced during February-March 1981:

- 9 in Safeguards Operations (inspection)
- 4 in Safeguards Evaluation
- 3 in Safeguards Development and Technical Support

Also announced were:

- 3 openings in the Division of Scientific and Technical Information
- 3 openings in the Division of Nuclear Fuel Cycles
- 3 openings in the Division of Isotope and Radiation Applications for Food and Agriculture Development.

INMM members will wish to see that well qualified individuals will be considered for the safeguards appointments. U. S. members of the INMM can obtain additional information as to the nature of the positions and on whom to contact by writing the technical editor, Brookhaven National Laboratory, Upton, New York 11973. Members in Europe or Japan would write to the Vienna or Japanese INMM chapter.

Dr. Rifaat El-Shinawy, Head, Research Division, Egyptian Atomic Energy Establishment, Cairo, Egypt, presenting the results of one of the workshops on designing a safeguards system to his fellow participants in the training course. Dr. El-Shinawy was a participant in the USDOE/IAEA International Safeguards training course held in the spring of 1981.

Preliminary Announcement

A technical workshop on the application of statistical methods of problems in nuclear materials safeguards will be conducted by the INMM Statistics Technical Working Group in March 1982 at University Place, Idaho Falls, Idaho.

The purpose of the workshop will be to discuss specific technical and operational problems incidental to the management and control of nuclear materials in the nuclear fuel cycle.

For more information, please contact:

Dr. C. A. Bennett
Battelle Human Affairs Research Center
4000 N.E. 41st Street
Seattle, WA 98105

Technical Group on Physical Protection Report

J. D. Williams
Chairman, Technical Group on Physical Protection
Sandia Laboratories
Albuquerque, New Mexico

INMM Workshop Held on Physical Protection with Emphasis on Intrusion Detection Systems

Sixty-five people attended the INMM Workshop on Physical Protection with Emphasis on Intrusion Detection Systems sponsored by the Technical Group on Physical Protection, held March 9-12, 1981 at the Sheraton Hotel in Charleston, South Carolina. This is the third workshop which has been sponsored by the Technical Group on Physical Protection (the first was on Intrusion Detection Systems as reported in Nuclear Materials Management, Spring 1981, pp. 28-29 and the second was on Guard Training as reported in Nuclear Materials Management, Fall 1980, pp. 14-15). Special thanks go to **D. A. McDaniel** (Debbie), Arrangements Chairman, Columbia LNG Corporation, and to **J. C. Hamilton** (Jim), Program Chairman, Goodyear Atomic Corporation. Each of the session moderators also did an outstanding job in making major contributions to the successful outcome of the Workshop.

The Workshop began on the evening of March 9, 1981 with a registration and "get acquainted" cocktail party. Participants represented a wide range of organizations including private utilities, commercial security organizations, engineering and consulting firms, and government agencies.

Following the moderators' breakfast on March 10, all participants met in a general workshop orientation meeting and were welcomed by **Gary Molen**, INMM Chairman; **T. A. Sellers**, Chairman at the time of the INMM Technical Group on Physical Protection; D. A. McDaniel, and Jim Hamilton. Following the general meeting, the participants separated into four separate small session workshops for the remainder of the morning. They then attended a different set of four workshops during the afternoon. The small group sessions were conducted by individual volunteer moderators.

Prior to the meeting, each attendee had been asked to rank order their preference of topics from a broader list than those actually covered at the Workshop. The preference list was used by the Program Committee to finalize the program, select Session Moderators, and schedule the separate Workshop sessions for minimum conflict of interest areas. Four simultaneous sessions were also held on Wednesday morning and Wednesday afternoon with a final plenary session being held on Thursday morning. Additionally, short summary sessions were held on Wednesday and Thursday mornings in which the session moderators of the sessions that had been held the previous day summarized for the entire group the main points which had been covered during their various sessions. The purpose of these summary reports was to allow people who were unable to attend the sessions concurrent with the one which they were attending to have knowledge of the highlight information that was interchanged during the meeting.

Representing a broad spectrum of interest in physical security, the Workshop participants enaged in the total two and one-half days of intensive group discussions on a range of topics related to physical security including:

A. Exterior CCTV and Motion Detection Systems
B. Systems Approach by a Combination of Sensors with Optimum Combination of Standardized Sensors by Typical Conditions of Climate, High Voltage, etc.
C. Design of an Intrusion Detection Devices and Concepts
D. Interior Intrusion Detection Devices and Concepts
E. Computer Managed Monitoring Systems (Alarm Assessment/Event Recording)
F. Access Control/Positive Identification Systems
G. DOE Rules and Regulations Review
H. NRC Rules, Regulations and Experiences with NRC Conducted Inspections
J. Upgrading Existing Systems
K. Analysis Techniques (Threat Analysis, Target Attractiveness, Tactic Analysis, Scenario Development)
L. Overview of New Sensors and Technology

There were a total of 17 workshops, they included the 11 topics listed above with 6 of the more popular topics being repeated once. Each workshop was attended by 12-20 persons. Workshop A on *Exterior CCTV and Monitoring Detection Systems* was moderated by **Chelk Jin**, Ontario Hydro. Video motion detection was a very popular topic during this workshop. Workshop B, *Systems Approach by a Combination of Sensors with Optimum Combinations of Standardized Sensors by Typical Conditions of Climate, High Voltage, etc.,* was moderated by **Ted Aichele**, Rockwell Hanford. The popular topic of this workshop was methods of combining sensors in order to compensate for weaknesses of individual sensor types. Workshop C, *Design of an Intruction Detection System for a New Facility,* was moderated by **Mel Soper**, Vitro Engineering Corporation. A number of design considerations relating to intrusion detection systems for new facilities were discussed during this session. Workshop D, *Interior Intrusion Detection Devices and Concepts,* was moderated by **Gary Crandall,** Goodyear Atomic Corporation. The major items of discussion during this workshop were testing and maintenance of interior sensors.

Workshop E, *Computer Managed Monitoring Systems,* was moderated by **John Jennings,** Mason and Hangar. Since most physical protection systems combine automated access control systems with perimeter intrusion detection systems, the methods of accomplishing this and the hardware required were the main topics of this session. Workshop F, *Access Control/Positive Identification Systems,* was moderated by **V.**

Keith Smith, Sandia National Laboratories. Some of the topics covered during this workshop are vital area access, vehicle portals, material access/contraband detection, positive identity verifiers and credential systems, personnel portal systems, and maintenance of all of these systems. Workshop G, *DOE Rules and Regulations,* was moderated by **J. D. Williams,** Sandia National Laboratories. The emphasis of this workshop was on a paper "Department of Energy Requirements for the Physical Protection of Special Nuclear Material," by **Barry L. Rich,** Chief, External Coordination Branch, Office of Safeguards and Security, U. S. Department of Energy, Washington, D.C. 20545, which was presented at the 1980 INMM Annual Meeting (see 1980 INMM Proceedings, pp. 73-80). Workshop H, NRC Rules, Regulations, and Experiences with NRC Conducted Inspections, was moderated by **M. Teresa Olascoaga,** Sandia National Laboratories. Items discussed during this workshop included interpretation of NRC regulations, experience with NRC inspections, experience with fuel cycle upgrade rules and design guidance, new NRC requirements, and design basis threat.

Workshop J, *Upgrading Existing Systems,* was moderated by **Richard Clarke,** Black and Veatch Consulting Engineers. A variety of topics were covered during this session with the major ones falling in the areas of reasons for upgrading and the major items to be considered when an upgrade is contemplated. Workshop K, *Analysis Techniques,* was moderated by **Leon Chapman,** Sandia National Laboratories. The techniques for analyzing system effectiveness were the main topics discussed during this workshop. Workshop L was a plenary session in which **J. D. Williams** and **V. Keith Smith** reviewed new sensors and new technology development in the areas of intrusion detection systems and entry control systems.

The summaries mentioned earlier by each session moderator were typed and distributed to all attendees within a few weeks after the Workshop. Copies of these summaries are available from James C. Hamilton, Program Chairman, Goodyear Atomic Corporation, P.O. Box 628, Piketon, Ohio 45661 (614) 289-2331, ext. 2204.

Both the verbal and written responses from the participants indicated that the Workshop was indeed a complete success. The majority of participants felt that another workshop in this area should be held within a year. It is the intention of the INMM Technical Group on Physical Protection to continue to hold such workshops and to expand into other areas in the coming year. The second Guard Training Workshop will be held October 14-16, 1981. Information about it is contained elsewhere in this issue of the Journal. A workshop being considered is one on Central Control and Information Display Systems. It would consider topics related to controlling and displaying security, fire, safety and other information, and how to integrate such systems into a facility operation plan. If you would like to participate in such a workshop, please contact **Larry Barnes,** AGNS, P.O. Box 847, Barnwell, SC 29812, telephone (803) 259-1711.

Titles and Abstracts

Recent Reports from New Brunswick Laboratory

The following titles and abstracts have been taken from DOE Report NBL-297, "Progress Report for the Period October 1979 through September 1980," dated April 1981.

"Uranium Determination by Constant-Current Coulometric Generation of Pentavalent Vanadium," by W. G. Mitchell and K. Lewis.

Abstract - Accuracy and precision of 0.05% (relative) has been demonstrated over a sample range of 10-40 mg uranium using a single generation current with no special indicator electrode treatment. It was shown that ~95% of the required titrant must be generated within five minutes from beginning titration in order to avoid negatively biased results. The modified end point approach is being programmed for routine application by the Automated Titrator. A successful series of titrations was made using a carbon "cloth" electrode rather than the gold used in the Automated Titrator.

"Determination of Nanogram Quantities of Uranium by Pulsed-Laser Fluorometry," by A. C. Zook and C. E. Pietri.

Abstract - The application of a pulsed-laser fluorometric method for the determination of uranium has been reported. Over the concentration range of 0.008 to 4 μg U/g soln, the accuracy on prepared standards was 100.0% with a precision (% RSD) of 3%. The method has been applied to a variety of samples. Studies were carried out on the effect of acid concentration and of diverse anions and cations.

"Second-Generation Design for Disposable Filament Assemblies Used for Mass Spectrometry Measurements," by V. E. Connolly.

Abstract - The design of a disposable glass bead type filament assembly for mass spectrometry is described.

"Fission Fragment-Induced Desorption Mass Spectrometer, A Progress Report," by W. H. Ulbricht, Jr.

Abstract - Additional modifications to the prototype fission fragment-induced desorption mass spectrometer have eliminated the need for an external neutron source and have demonstrated complete resolution of peaks at masses 267 ($^{235}UO_2$) and 270 ($^{238}UO_2$).

"Determination of Uranium by Isotope Dilution Mass Spectrometry (IDMS)," by D. W. Crawford.

Abstract - Weighted aliquants of a calibrated ^{233}U spike solution and of a standard ^{235}U solution were mixed to provide a series of standard-spike solutions, each containing about 1 mg U. Over a period of five months, 120 of the mixed solutions were analyzed by isotope dilution mass spectrometry. The assigned concentration value of the ^{235}U solution was reproduced within ±0.1% (RSD).

"Certification of NBL Uranium and Thorium Counting Standards," by A.M. Voeks and K. S. Scheidelman.

Abstract - Measurements for the certification of uranium and thorium counting standards are described. A set consists of five standards covering the concentration range from 1% to 0.001% uranium or thorium.

"Preparation and Certification of NBL Phosphate Rock Reference Material (NBL RM #1-A)," by W. Nichiporuk.

Abstract - Certification of a Phosphate Rock uranium reference material is described. NBL RM #1-A is certified to contain 0.0153 ± 0.0002 wt% uranium.

"Reverification of Isotopic Ratios $^{233}U/^{235}U$ for NBL Reference Material #117," by D. W. Crawford and N. M. Trahey.

Abstract - Results of recertification measurements for a mixed $^{233}U/^{235}U/^{238}U = 1:1:1$ reference material are presented.

"Verification of Reference Values for Uranium Concentration and Isotopic Abundances in SALE Uranyl Nitrate Solution Samples," by W. Nichiporuk.

Abstract - A summary is presented of the procedures used to verify the reference values for uranium concentration and isotopic abundances of uranyl nitrate solutions used in the SALE Program.

"NBL NDA Prototype Reference Materials Evaluation Program," by N. M. Trahey.

Abstract - The status of an interlaboratory NDA measurement comparison program is described. Measurement results from all domestic participants are expected to be received by September, 1981, at which time data evaluation can begin.

News Release

Palladino Named New NRC Chairman

Nunzio J. Palladino was sworn in as an NRC Commissioner on June 24, 1981, replacing two-time chairman Joseph M. Hendrie, whose term expired June 30, 1981. Dr. Palladino became NRC Chairman on July 1, 1981. He has served as Dean of the College of Engineering at Pennsylvania State University since 1966 and as Professor of Nuclear Engineering at that university since 1959. Prior to his association with Pennsylvania State University, he was employed by Westinghouse Electric Company in several different positions from 1939 to 1959, including manager of the PWR design division where he was involved in the Shippingport reactor as well as the design of naval reactors. He is a graduate of Lehigh University, is a former President of the American Nuclear Society, and is a former member and Chairman of the Advisory Committee on Reactor Safeguards.

Thomas Roberts, a Memphis businessman, was nominated by President Reagan to fill the empty commissioner's seat on the NRC. Congressional sources expect his confirmation by the Senate by late July or early August. Mr. Roberts is expected to bring a business management perspective to the NRC.

NRC Commissioner **Peter Bradford** will resign late next winter, several months before the expiration of his term in order to take a position as public advocate for the State of Maine, according to Maine Governor Joseph E. Brennan. Bradford, 39, was appointed to the NRC in 1977 by President Carter. Prior to the appointment he served on the Maine Public Utilities Commission.

The other NRC Commissioners are **John Ahearne** who was appointed by President Carter in August 1978 and whose current term expires in June 1983 and **Victor Gilinsky** who was appointed by President Ford in 1975, reappointed by President Carter in June 1979 and whose current term expires in June 1984.

Robert L. Schweizer

Mr. Robert L. Schweizer has recently joined NUSAC, Incorporated as a Technical Associate, Security Programs Division. His services are being used by NUSAC's physical security clients to formulate security plans, develop guard training programs, conduct security audits, and perform other security support functions.

Mr. Schweizer comes to NUSAC with extensive experience in nuclear weapons and reactor inspections, training and physical security. Immediately prior to completing over 30 years service with the U.S. Army, Mr. Schweizer served for four years as Chief, Technical Inspections Division, U.S. Army Inspector General Agency. In this capacity he was responsible for developing nuclear weapon and reactor inspection policy and procedures and managing the worldwide systems of inspections for the Army. His major responsibility was to provide a continuous independent assessment of the security provided storage sites and to ensure organizational compliance with security directives. Schweizer also served in a number of senior command staff positions which have provided him the training, security, managerial and organizational experience necessary to complement NUSAC's services.

Mr. Schweizer holds a MS degree from Shippensburg State College, Pennsylvania and a BGE from the University of Omaha. He has also graduated from the U.S. Army War College, U.S. Army Command and General Staff College and the Armed Forces Staff College.

Ralph J. Jones

Dr. Ralph F. Lumb, President of NUSAC, Incoporated, announced the appointment of Ralph J. Jones as Manager of its General Consulting Division. NUSAC is a consulting firm which provides a wide range of services, especially for the nuclear power industry. The General Consulting Division provides these services primarily in the area of nuclear material safeguards, safeguards engineering, and material surveillances and auditing. Mr. Jones will be responsible for the administrative and technical management of the Division projects.

Mr. Jones comes to NUSAC from the Nuclear Regulatory Commission where he was most recently the Assistant Director for Material Safety Standards in the Office of Standards Development. Prior to that he directed the NRC safeguards standards program. Mr. Jones also was employed by Nuclear Fuel Services as their Manager of Material Control and Quality Assurance. He also worked for the Atomic Energy Commission in various programs associated with nuclear material control and management. Mr. Jones retired from federal service in April after 24 years combined military and civilian service.

Mr. Jones holds a B.S. degree in Industrial Chemistry from Kansas State University and an MBA in Business Administration from Rutgers University.

Washington Waste Ban Ruled Unconstitutional

A federal district court judge in Spokane has ruled unconstitutional Washington State's voter-initiated law banning other states from shipping their non-medical nuclear waste there.

Judge Robert McNichols said the law, which was set to go into effect on July 1, "impermissably regulates federal activities, interferes with national defense activities and the use of federal property as well as with interstate commerce."

In the June 26 ruling, McNichols also said the ban would impede national waste-storage efforts. The law would have affected two low-level waste sites on the Hanford Reservation near Richland - one operated by the Department of Energy to dispose of defense wastes; another operated by U.S. Ecology, Inc. for commercial waste.

—AIF Info

NRC Issues Proposed Technical Criteria for Regulating Geologic Disposal of High-Level Radioactive Wastes

The Nuclear Regulatory Commission is issuing proposed regulations that would establish technical criteria for regulating the geologic disposal of high-level radioactive wastes.

The technical criteria, if adopted, would become part of Part 60 of the Commission's regulations and would be used to review any application from the Department of Energy for a license to receive and dispose of high-level waste at a geologic repository. If the application is acted upon favorably, the criteria also would form the basis for monitoring the construction and operation of the facility.

The major topics covered in the proposed rule are performance objectives, siting requirements, requirements for the design and construction fo the repository, design criteria for the packages containing the wastes, and requirements for confirming repository performance.

Containment of the wastes within the waste packages would be required for at least the first thousand years after burial - when radiation and temperature levels are high. For times beyond the expected period for containment, emphasis would be placed on isolation of the wastes by a combination of engineering and geology. Specifically, the release of radioactive materials to the geologic setting must be at most one part in 100,000 per year. In addition, the site must be chosen so that the groundwater travel time from the emplacement area to the environment accessible to humans must be at least 1000 years.

The rule would require that the repository be designed to allow the wastes to be retrieved for up to 50 years after they are placed in the repository in order to permit a program of confirmatory testing to ensure that the major barriers to release of radiation from the repository are performing as expected.

Radiation exposures to workers during operation of the respository would have to be kept within the limits specified in Part 20 of the Commission's regulations for other licensees' employees.

In addition to listing site conditions likely to be favorable for geologic disposal, the proposed regulation would specify potentially adverse conditions that, if present, could compromise the suitability of the site to host a repository.

When operations at the site are to end, the repository could be closed by taking appropriate action such as final backfilling of subsurface facilities, sealing of shafts, and decontanmination and dismantling of surface facilities.

Book Review

Anthony Fainberg
Brookhaven National Laboratory
Upton, New York

The Killing of Karen Silkwood, by Richard Rashke, Houghton Mifflin Company, 1981, Boston, Price: $11.95

Seven years ago, when I read of the death of Karen Silkwood in the *New York Times,* it sounded mighty suspicious to me. Here was a union activist, working at a plant belonging to a conservative big oil company, on the way to meet with a *Times* reporter to show him documents which allegedly proved falsifications of quality control reports concerning the plutonium fuel rods manufactured at the plant. On the way to meet with a journalist, but killed in a mysterious automobile accident before she arrived. Stuff out of a mediocre grade-B movie. The company, Kerr-McGee, was never known to be too partial to unions in the first place. It generally wheeled and dealed in circles far above one poor union organizer/investigator. After all, Senator Robert Kerr, founder of the company, had foisted the rip-off oil depletion allowance on the American public for years, against much popular opposition. Would such an outfit stop at eliminating one small individual who was becoming an unpleasant nuisance? I hardly thought so. I still hardly think so; however, in the case of Karen Silkwood, nothing is as it seems.

Aside from the manner of her death and the questions still surrounding it, there are questions and histories of union strikes, certification elections, charges of shoddy health and safety practices, and above all, a strange case of contamination of Silkwood only a few days before her death. There were also cases of diversion of uranium fuel pellets outside the plant, and bizarre rumors of plutonium smuggling ring among the workers. It is not the easiest thing in the world to make sense of all of this, and although Richard Rashke, a strong partisan of the pro-Silkwood estate, anti-Kerr-McGee, large-conspiracy school has done a good job of laying before the reader all the facts that he has amassed in a coherent and dispassionate way, his book does not make sense of it all either. Rashke is to be complimented for presenting evidence, both pro and con, relative to his point of view, with a minimum of polemics (except for the title of the book and of the first section, which is called "The Killing"). If all anti-nuclear (and, for that matter, pro-nuclear) people maintained similar standards of intellectual honesty in presenting their viewpoints, the Nation would be better served.

That being said, my impression is, after having read the book, that there is:

1. No convincing evidence that Silkwood met with foul play, although the possibility is certainly not excluded; and
2. A weight of evidence, based only on the information in the book, that, for a possible variety of reasons, Silkwood contaminated herself intentionally.

As far as ancillary questions are concerned, they are still a matter for speculation, and I will outline my thoughts on the subject and then sit and wait for a few brickbats to come my way.

There are three fundamental questions to be determined as far as the case is concerned: Was Silkwood killed? Was she carrying documents seriously detrimental to Kerr-McGee when she died, and if so, what happened to them? Did Silkwood contaminate herself with plutonium, was the contamination accidental, or was she somehow contaminated by other parties, possibly acting on behalf of Kerr-McGee.

Regarding the questions of her death, the known facts are these. Silkwood left a meeting with members of the Oil, Chemical and Atomic Workers Union on Thursday, November 13, 1974, at 7 p.m. at the Hub Cafe in Crescent, Oklahoma. She was headed south along Highway 74 to meet with David Burnham of the *Times* in Oklahoma City. Just over seven miles south of Crescent, her car left the road, crossing the center line; the car traveled in a straight line about 80 yards along the grass on the left (east) side of the road, then flew into the culvert which crossed underneath the highway. She was probably killed instantly. How did this chain of events occur?

One version is that of Bill Taylor, a private investigator hired by Dan Sheehan, who appears to be the Silkwood estate lawyer in charge of wild and unfounded speculation. A good deal of the book is unfortunately devoted to Taylor's peregrinations about the country and, allegedly, in the Bahamas (which, contrary to Mr. Rashke's impression, form an independent country, and are no longer a British colony), over matters so far afield from the Silkwood investigation as to be practically ludicrous. However, at one point, Taylor does visit the scene of the supposed crime and develops a theory which fits the facts of the accident. The anti-Silkwood forces have generally held that she fell asleep at the wheel, due to both fatigue (she had just returned from Los Alamos the day before, and had celebrated her low body count by a good amount of drinking) and to methaqualone (Qualudes) which was found in her blood at a moderately high level (0.35 mg plus another 0.50 mg in the stomach which was being absorbed). This was below what is considered a toxic level (0.50 mg in the blood) and rather more than a standard therapeutic dose. Silkwood had used Qualudes rather heavily as tranquilizers, as, indeed, she had used quite a range of drugs. Evidently, this was not unusual for some young employees of the plant. It is questionable whether the dose found in her blood was enough to knock her out only ten minutes after starting on her drive. But it is far from impossible that she could have dozed off, momentarily. The pro-Silkwood group notes quite rightly that the way in which the steering wheel was bent, down on the left and right, indicates that upon impact, Silkwood was grasping the wheel with some force. Her legs, however, were not broken in a way which suggested that they were braced against the impact. One deduces that at the moment of the crash, Silkwood was indeed conscious, but did not have enough warning of the impending culvert to brace her legs. Further, she traveled in a straight line for 80 meters along a rough grass shoulder area, indicating that she was in control of her vehicle at this point. There were no skid marks on the highway.

Taylor's explanation: she was being forced off the road by a chase car, which bumped her slightly first, causing dents in the left rear of the car, and which are otherwise not satisfactorily accounted for. While trying to get back on the highway and avoid the chase car, her attention was distracted enough not to notice the upcoming culvert until too late. This explanation fits the known physical facts. It is, however, not the simplest and most reasonable analysis of the incident.

It is at least as plausible that Silkwood dozed off for a few seconds, drifted off the highway, woke up on the grass, drove along it for 3 or 4 seconds (the time needed to ravel 80 yards at the 45 mph speed at which she is supposed to have crashed), perhaps avoiding other traffic, and crashed into the culvert while checking for oncoming cars. This scenario is considerably less dramatic than the other, but no less credible except for the left rear dents. These, it appears to me, could have been caused practically anywhere, and, in fact, two weeks before, Silkwood had a minor accident in which she damaged the right rear of her Honda. Her boyfriend, Drew Stephens claims that there was no damage to the left from this accident, but under the circumstances, an after-the-fact memory of the damage done to the car, is not the most convincing sort of evidence. Beyond this fact, three days before, while driving to Los Alamos, Silkwood had managed to get hopelessly lost on the way from Albuquerque and to find herself in the middle of the Pecos Wilderness. Given her general emotional instability, which is well-documented and agreed-upon, and her recent extreme agitation over her contamination and perhaps other matters, as reflected in her recent driving record, it is apparent that the verdict of an accident with no foul play is the most reasonable. However, I repeat, Taylor's explanation, or one like it, is not out of the question. Silkwood was not popular at Kerr-McGee, either with the management, or, by Rashke's own admission, with many of the workers. The accident **could** instead have been due to someone trying to harass or scare her, or even prevent her meeting with Burnham, perhaps with undesired results. It could also have been caused by reckless driving on the part of some other person totally unconnected with the company or with Silkwood. It's just that the evidence in the book, with one exception, does not even make a slightly compelling case for homicide. The exception is a totally unsubstantiated report by Taylor that a rather dubious informant of his (called "Echo") in the FBI stole a look at some supersecret files just after the negligence-suit trial, and found there, lo! and behold, exactly the same story that Taylor had been pushing for months. Pity one can't get at those files. It actually is too bad that no one from the outside, neither Congress or anyone else, can get at them without enormous hassle, and even then, it may not be possible. If some outside party could get at relevant files when it became necessary, perhaps unlikely tales such as this one could be checked.

As for the question of documents allegedly on Silkwood's person when she died, the author is on somewhat more solid ground, although he does not go into much detail on this point. There are eyewitness reports of some papers in Silkwood's possession when she left the union meeting and of papers strewn around the car after the accident. It is likely, that all such papers were not returned to her friend, Drew Stephens, after the accident. However, there are also eyewitness reports which are more disturbing. Late at night after the accident, Silkwood's Honda was in a local garage. Rick Fagen, the Oklahoma Highway Patrolman who had responded to the accident, was called back to the garage after midnight to supervise alleged AEC inspectors who wanted to check the car for radiation. The author never pursues the interesting question of whether the men were actually AEC inspectors. However, the man who appeared to be in charge, Wayne Norwood, was not an AEC inspector at all, but was health physics director of the Kerr-McGee plant. According to Fagen, the men not only checked out the car with an alpha monitor, but also read some of Silkwood's papers in the car, which they apparently had no business doing. The following morning, Fagen had occasion to return to the garage where he read a letter to Silkwood from someone in Canada, which apparently dealt with instructions on how to roll cigarettes with a roller, but not with anything concerning Kerr-McGee. Later on, this letter disappeared, along with a dark, thick file folder, and an 8½ × 11 reddish-brown spiral notebook which had been placed in Silkwood's possession by Jean Jung, Silkwood's friend, just before Karen had left the Hub Cafe on her tragic ride. Here, the circumstantial evidence is fairly strong that Kerr-McGee had motive and opportunity to make off with these documents, which, from Silkwood's indications to Jung, contained evidence detrimental to the company. The documents in question have never been recovered. One must remark, of course, that if Kerr-McGee personnel did purloin them, this in no way proves that they were responsible for her death. If they did, it is likely that they would have done the same whether or not the accident came as a complete surprise to them.

The third question, on the contamination of Silkwood shortly before her death, is one on which most discussion about the case has been centered. Yet, here, too, the truth on this point may not be related to her death at all. That is, she may have contaminated hereself and still been killed, or, she may have been contaminated by someone else, and died in a real accident. There could be a relation between the two, but it is not necessary that this be so.

On Tuesday, November 5, 1974, eight days before her dealth, Silkwood discovered at a monitor that she had some radioactive contamination. Upon being check by a health physics technician, it was discovered that she had nasal smears which were significant, but not very high. Left hand, right wrist, arm, and shoulder, and face and hair were hot, as were her clothes. Levels of 10,000-20,000 d/m were the maximum found, and all disappeared after careful showering. It was not found what the source of the contamination was. There were no leaks in lab glove boxes. Silkwood had just been reprimanded that morning by her supervisor for being obviously under the influence of drugs at work a few days before. She was not terribly disturbed at this time.

On Wednesday morning, she was checked again by health physics, and it was discovered that her smears were somewhat higher than the day before and that she had some contamination on her forearm which did not come off after a bit of scrubbing. It was still not at a level high enough to cause great concern, and, from the narrative in the book, Silkwood was not inordinately disturbed until that night, when she called up Dr. Dean Abrahamson of the University of Minnesota (he had been brought to Kerr-McGee two weeks earlier by the union to inform the workers of the dangers of radiation, and Silkwood had met him then). The following morning, Thursday, Silkwood reported to health physics and found that her levels of contamination had increased tremendously. Nasal smears were on the order of 40,000 d/m (in both nostrils, including one that had been blocked for years). It was clear that the contamination was not occurring at the plant, and plans were made to check the car and her apartment. The car turned out to be negative. Silkwood called her roommate, informed her of the coming check-out of the apartment and warned her to stay out of the kitchen and bathroom. Did this indicate that she knew something about the places of contamination in the apartment? One might be led to think so. Silkwood had prepared four urine samples and a fecal sample at home the night before. When the health physics people, led by Wayne Norwood, showed up, they found definite patterns of high contamination at the apartment in the kitchen and toilet. Norwood was, of course, highly disturbed. The refrigerator was hot, particularly a wrapper of bologna and cheese. The toilet-seat cover and bathroom floor mat was very hot. Levels were up to 400,000 d/m. Norwood asked Silkwood where all this came from. She replied that she had spilled urine in the bathroom while preparing the samples. This seems to indicate that she realized that either the urine or preparation of the sample was the source of contamination. This, in particular, is extremely damning information. She had placed the bologna and cheese, in the wrapper, on the toilet seat the night before, after the spill, to remind her to take food with her to work the following morning. Further evidence is as follows: her urine samples taken at home were quite hot, but contained plutonium in the form of insoluble plutonium oxides, which would not have passed through the kidneys. This shows that the samples were spiked, and were spiked by someone who did not know in what form plutonium can be excreted through the urine. Someone, probably like Silkwood, who had been largely unaware of the dangers of plutonium before Abrahamson's visit shortly before, but not like the management of Kerr-McGee, who would surely be more careful about playing such games. There is also the possibility that Silkwood had contaminated herself by accident; for example, I have been told that she painted her nails in the lab - an excellent method for trapping some material on your hands. However, isotopic analysis showed that the plutonium came from a lot which had been fabricated over two months earlier. Unless the metal lab, where she worked, was far behind schedule, it is unlikely that the contamination resulted from some accidental contamination in the lab when it did. It is far more probable that a small amount (about 30 ug) was secreted in late August or September, removed from the plant by purposely avoiding monitors (which should have detected a gross unintentional hand contamination), and later was used to spike the urine samples. Incidentally, I have been told that it is not uncommon for people occasionally to spike their own samples in order to get transferred temporarily out of hot areas upon health physics orders, so the idea of someone spiking his/her own sample does not appear to me to be too outrageous, or terribly unusual.

As to motivation, Silkwood was angry at the company for her reprimand, and could possibly have been interested in embarrassing Kerr-McGee just before a certification election. Kerr-McGee's possible motivation? They could have wished to frighten Silkwood, a union activist, in order to chase her out of the company. Both had motivation. The facts, however, weigh clearly on the side of a purposeful contamination by Silkwood.

There are two additional scraps of information. Silkwood went to Los Alamos for a full-body count, with Drew Stephens and her roommate, Sherry Ellis. Her lung burden was 8 nanocuries. This was half the maximum lung burden tolerated by the AEC, and while not too comforting, probably meant that she would never receive ill effects from it. This was a relief to her, as she had been extremely upset and worried that she was going to die because of the high counts she registered in Oklahoma. The other point is, that, during the trip, her friend, Drew Stephens unexpectedly asked her if she had eaten a plutonium pellet. One can conjecture that there had been conversations in the past about purposeful contaminations. She had asked Abrahamson of the effects of eating a fuel pellet two weeks before.

The book describes in great detail the negligence suit, where the jury found for the Silkwood estate for about half a million dollars in injury damages, and $10.5 million in punitive damages. The motivation for the finding centers on repeated testimony of poor health and safety practices at the plant. However, the Silkwood forces look upon the verdict as a vindication. If it is a vindication of Silkwood's investigations of the company's practices, this is true. Howver, the decision does not vindicate her innocence of self-contamination: the judge had instructed the jury that if it found that her contamination was caused by Kerr-McGee plutonium, the burden of proof was **on the company** to show that she had contaminated herself. The jury did not decide that she had not done so, contrary to the book's implications; rather it found that the company had not proved beyond a reasonable doubt that she had.

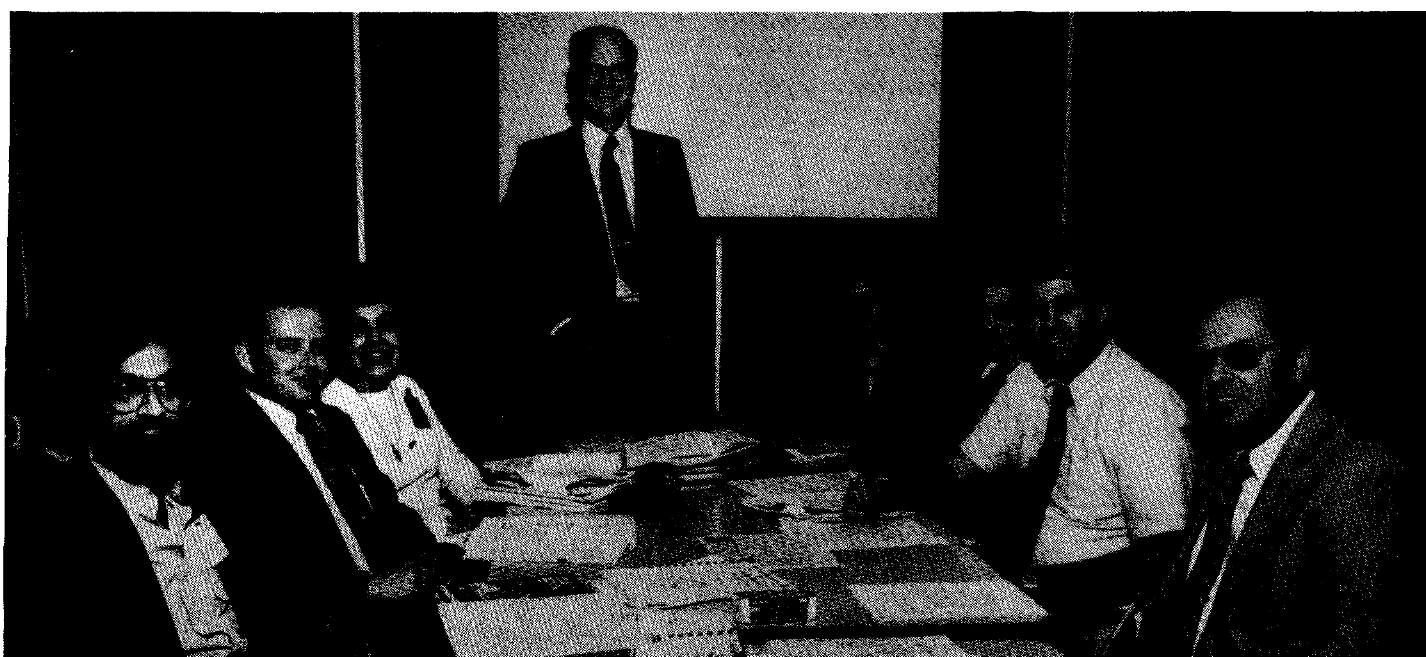
It is interesting that of the six lawyers on the Silkwood team, at least three were unconvinced of conspiracies between the FBI and Kerr-McGee, or of the dark hints of dirty work afoot, to which the author devotes so much totally unconvincing print. They were only trying the case from the negligence point of view. If her own lawyers are unconvinced of deep conspiracies, Rashke must forgive the rest of us for being equally skeptical.

There are allegations of collusion between the FBI and Kerr-McGee, regarding wiretapping of union members. It all may be true, but there is no hard evidence that it is. Even if true, such facts would not affect the essentials of the case. There is considerable discussion of a mysterious figure, Ms. Jacque Srouji, who injected herself into the investigations of the case on the excuse that she was writing a book on nuclear power. She evidently was an FBI informant and a journalist, her publisher was alledgedly a CIA man, and she was personally close to Fred Olson, the FBI agent in charge of the Bureau's Silkwood investigation.

She had, among other things, infiltrated the PLO for the FBI and refused to answer questions at a pre-trial deposition on who had told her to get involved in the subject. Judge Theis, who presided at the negligence trial, allowed her not to answer, after an **in-camera** session with government lawyers, saying that the answer would reveal sinister secrets not connected at all with the Silkwood case. This is most intriguing. What was going on here? A possible plutonium smuggling ring at Kerr-McGee, watched by U. S. intelligence agencies? Maybe links to the PLO? It may not have a bearing on Silkwood, but I would like to know a bit more.

In any case, much of the book and lawyer Sheehan's efforts are devoted to affairs of this sort, resulting in a weakening of the whole. If the author had concentrated more on the Silkwood case itself, and less on unrelated cloak-and-dagger speculation, he would have produced a better work. He could, for instance, have had drawings and photos of the car and the accident site which were more complete and expository, he could have tried to find out why Stephens wondered whether Silkwood had contaminated hereself. Finally, he could have had someone check him technically. Here, Rashke is pretty awful, repeating canards about fuel rod failure being able to cause "a nuclear explosion" in a reactor. Naturally, there is no reference to any scientist or engineer who would make such a stupid remark. He also appears to believe that there are 2.5 pounds to a kilogram, which gives a good measure of his competence in matters scientific.

All this is a pity, because Rashke has worked hard on researching the story and has presented the basic facts very fairly. One day he will be a good investigative reporter. What is interesting is that he has managed to persuade me of the opposite of what he wanted to do. I should remark that what prejudices I had on the case before reading the book tended to be more on his side than not.



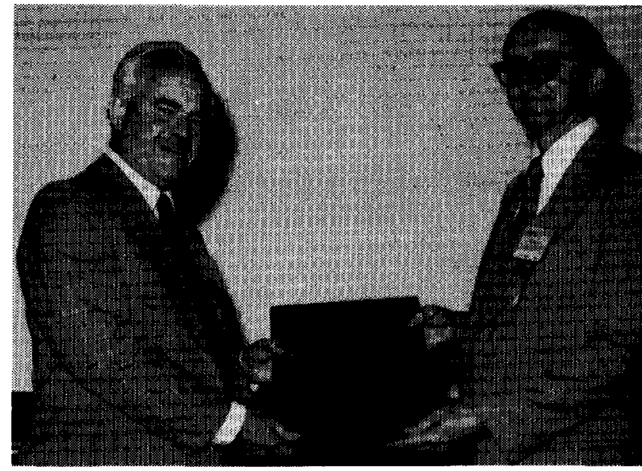
Meeting of the 15.9.3 Committee, February 1981. Left to right: Dr. Junaid Razvi, Dr. John Gramlich, Ms. Nancy Trahey, Dr. Ronald Harlan (chairman), Dr. T. Douglas Reilly, Dr. Sandra Frattali, Mr. Todd Hardt and Mr. Michael Jump.

Writing Group Meets

In February 1981, General Atomic Company hosted a meeting in the INMM 15.9.3 writing group (Physical Standards). The meeting was held to work on a draft guide for calibration materials required for neutron counting methods.

Balloting was recently completed on the 9.3's first standard, N15.35, "American National Standard Guide to Preparing Calibration Material for Nondestructive Assay by Counting Passive Gamma Rays." All societies and organizations were affirmative with some comments to be answered.

Chairman Gary Molen presenting the Annual Student Paper Award to Houng Y. Soo of the University of Washington.



Chairman Gary Molen presenting INMM Distinguished Service Award to R. M. Smith of AECL at the 22nd Annual Meeting.

Chairman's Report

Gary Molen

As noted in Bob Keepin's report last year, the decade of the 80's promises to be a decade of continued growth for the Institute both in increased membership and in greater and more diversified activities. During this last year we have reached several very important milestones:

Our Certification Program has been officially launched and the Certification Board has examined and awarded certificates to several individuals.

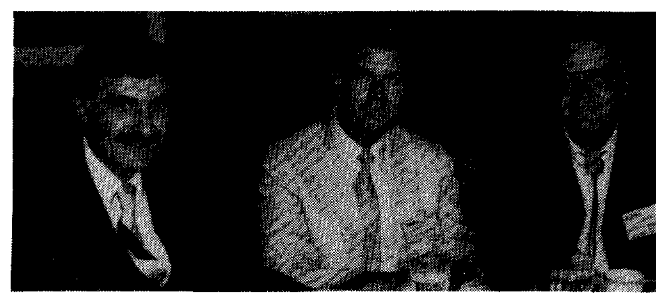
We obtained liability insurance for the Officers, other members of the Executive Committee, and Standing Committee Chairmen.

Our Safeguards Committee established formal liaison with the NRC Division of Safeguards thus enabling the Institute to lend its expertise to the regulatory process.

Our Safeguards Committee established formal liaison with the State Department thus enabling the Institute to lend its expertise, particularly from the U.S. private sector, to the negotiations on and the implementation of, IAEA inspections in the U.S.

And, last but not least, our Executive Committee voted unanimously to retain the services of an association management firm, and to that end we have hired John Messervey (Messervey & Company) as Executive Director of the Institute effective October 1, 1981.

Indeed it has been an active and productive year. The members of the Executive Committee and the Standing Committees have served us all well. I think we owe a particular debt of gratitude to Sam McDowell and his Long Range Plans Committee, to Fred Tingey and the Certification Board, and to Bob Sorenson and his Safeguards Committee. All of these members have served far "above and beyond the call of duty."



Don Davis of Bechtel, Dick Tyler and Bill Yates of Sandia at the 22nd Annual Meeting Luncheon.

Vice Chairman's Report

John L. Jaech

The major activities of the Vice Chairman's Office during the past year were:

(1) Continued oversight of the Physical Protection Technical Working Group and Implementation of the Statistics Technical Working Group

(2) Planning, arranging, and executing the 1981 Annual Meeting

(3) Coordination and planning of future meeting sites and dates.

Technical Working Groups

The Technical Working Group on Physical Protection under the able leadership of T. A. Sellers of Sandia was very active during the past INMM year. Two very successful workshops were conducted, one on Guard Training held in Gatlinburg, Tennessee on August 27-29, 1980, and one on Physical Protec-

Mr. C. Joseph of AGNS presenting his paper at the 22nd Annual Meeting in San Francisco.

tion held in Charleston, South Carolina on March 9-11, 1981. Because of Mr. Sellers' appointment as Meeting Arrangements Chairman, he resigned as Chairman of the Technical Working Group in May of this year. The newly appointed Chairman is J. D. Williams, also of Sandia. Our appreciation for an excellent performance as Chairman of our first Technical Working Group is extended to Tommy Sellers.

A new Technical Working Group, this one on Statistics, was formed during the year under the leadership of C. A. Bennett of Battelle. The initial meeting of this Group was held in San Francisco, concurrent with the annual meeting of the INMM. INMM.

Annual Meeting Committee

The overall responsibility for the 1981 Annual Meeting was vested in the Vice Chairman, who also serves as Chairman of the Annual Meeting Committee. In this capacity, he coordinates all aspects of the annual meeting, including close coordination as necessary with appropriate standing committees of the Institute.

Three committees are identified within the Annual Meeting Committee: the Meeting Arrangements Committee, the Program Committee, and the Site Selection and Advanced Arrangements Committee. The Chairman of the Meeting Arrangements Committee for the San Francisco meeting was T. A. Sellers of Sandia (Joe Stiegler, also of Sandia, was the former chairman and was active in the early planning for this meeting; he resigned earily in the INMM year because of a change in work assignments). Tommy's Subcommittee includes the following:

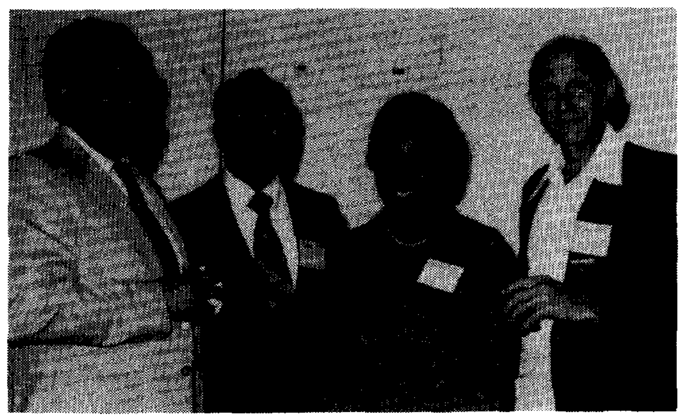
(1) Herman Miller of INET Corporation as the Local Arrangements Chairman, assisted by Dennis Bitz of Bechtel

(2) Duane Dunn, Rockwell International, as the Registration Chairman

(3) Mary Dodgen of duPont, Savannah River, as Communications and Publicity Chairperson

(4) Tom McDaniel, SAI, as the Exhibits and Displays Chairman

(5) Anton Kraft, Exxon Nuclear, as the Photographics Chairman



Mr. Chris Kinard, Monsanto; Mr. and Mrs. B. L. Brock, USNRC; and Mr. Carleton Bingham of New Brunswick Laboratory at the Chairman's Reception in San Francisco.

The Program Chairman for the 1981 Meeting was Dick Chanda of Rockwell International. He was assisted by John Glancy of SAI as Contributed Papers Chairman, and by George Huff of Allied-General Nuclear Services as Invited Papers Chairman. Also, Bob Keepin of LANL provided assistance in arranging for the Monday morning Plenary Session speakers.

The Site Selection and Advanced Arrangements Committee continues to be chaired by Ray Lang of the U. S. DOE. He has served as Chairman for a number of years, and we members of the Institute owe him a debt of gratitude for his excellent professional service in this capacity.

Future Meeting Sites

Future meeting sites and Local Arrangements chairmen are:

Year	Location	Local Arrangements Chairman
1982	Washington, D.C. Hyatt Regency	J. Mark Elliott
1983	Denver, Colorado Marriott	(to be selected)

Certification Board and Safeguards Committee

G. Robert Keepin
Executive Committee Oversight

Certification Board

F. H. Tingey
Chairman

The Certification Board is proceeding with the INMM program for certification of safeguards experts at two levels. The indemnity problem that caused a delay in the program has been resolved with insurance having been purchased from Lloyds of London. The Lloyds policy indemnifies the INMM, its officers, directors, and employees, whether salaried or not, while acting in the course of duties directed by the Executive Committee or Board of Directors for and on behalf of the INMM in its professional capacity as an association, in the amount of $1,000,000 annual aggregate with a $2,500 deductible per claim.

A revised application form consistent with the recommendations of the INMM legal counsel was developed and appeared in the Winter 1980 issue of the INMM Journal and in a separate mailing to all the membership of the Institute. The INMM Certification Program rules and procedures accompanied both publications.

The INMM Certification Board has met quarterly in conjunction with the meetings of the Executive Committee and has deliberated at length over such matters as the certification examination library, certification standards, bylaws, etc. It is believed that most of the problems incidental to the implementation of a program such as this are behind us and hence we are looking forward to an aggressive administration of the INMM Certification Program. Certification Plaques and Certificates were awarded to successful candidates at the INMM annual business meeting on Tuesday, July 14, at San Francisco.

A concerted effort must now be made to gain the support of DOE, NRC, and the nuclear industry in general with respect to encouraging participation in the INMM certification program.

Certification Board and Safeguards Committee

G. Robert Keepin
Executive Committee Oversight

Safeguards Committee

R. J. Sorenson
Chairman

The Safeguards Committee has been very active during the past year. Highlights of the Committee's activities and results in FY 1981, as reported by Safeguards Committee Chairman Bob Sorenson, are summarized below:

- The charter or scope of the Safeguards Committee has been discussed and it was concluded that we should "provide technical policy input, but leave political policy input to organizations such as AIF." Reacting to short-term items is difficult to do, and obtaining long-term commitments is equally difficult but more achievable. It was felt that we need to walk the narrow line between technical and political issues. Our charter includes reacting to and providing input to new government regulations (thus influencing), and developing technical positions as a resource on certain issues. We have established interface/coordination activities between the Safeguards Committee and AIF.
- We have recommended that the Executive Committee adopt the skills directory as reported by Joe Steigler at the Palm Beach Annual Meeting. The Committee believes that it should be integrated with the membership listing that Ed Johnson is preparing. Having more than one data base within the INMM would weaken all the Institute's data bases. Also, some of the key information in the skills directory could be included in the membership directory. Incidentally, the Committee felt that phone numbers should be included in any membership directory.
- The Committee has also recommended that the emergency response activities should be consolidated with the skills directory. The Committee could not conceive of a situation where an immediate response would be needed for safeguards purposes. Rather, any emergency response by the INMM would be a delayed response for evaluating and analyzing a problem using a variety of technical experts. Also, it was believed that the frequency would be very low. It was felt that some licensees would seek outside help from their own consultants rather than from the INMM. Thus, the skills directory and response planning functions

should be combined by the INMM, using such resources as the Secretariat.

- Howard Menke held a meeting on February 26 in Washington, D.C. to review some proposed changes to the federal regulations that impact materials safeguards. His working group has developed substantive comments and recommendations for the NRC on three proposed rule changes.

  1. "Proposed General Statement of Policy and Procedures for Enforcement Actions"
  2. "Protection of Unclassified Safeguards Information"
  3. "Periodic and Systematic Review of Regulations"

- A subcommittee has been established to provide industry input to the U. S. government regarding international safeguards and non-proliferation issues. Dick Duda is chairing the group called "Government/Industry Liaision Subcommittee." On June 18, 1981 they had their first meeting with representatives from the State Department and Arms Control and Disarmament Agency. Dick will be reporting on that meeting at the Safeguards Committee's next meeting on July 16 in San Francisco.

- The Safeguards Committee met on April 15, 1981 with Robert F. Burnett and some of his staff from NRC's Division of Safeguards. It was a productive meeting where a number of ideas were exchanged and a healthy dialog ensued. During the meeting, the Committee presented its recommendations to the NRC for changing some of the regulations for low enriched uranium at bulk-handling facilities. We were pleased with the presentation and its reception by the NRC and are optimistic that some beneficial changes in the requirements will be forthcoming. Bob Burnett has agreed to have further meetings with the INMM on a regular basis, starting as quarterly meetings. The next meeting is tentatively scheduled for August.

- One of the suggested rule changes for low enriched uranium involves the Limit of Error on Inventory Difference (LEID). Because of the controversial nature of any discussion on LEID, a small Ad Hoc Group has been established to review this proposal including two recognized statisticians in the safeguards field. Fred Tingey and John Jaech have agreed to perform such a review, and Charlie Vaughan has agreed to present the proposal to them. The meeting will be held on July 12 in San Francisco.

- The Safeguards Committee has recently written two letters to the editor - Redbook magazine and Science. We have received essentially no feedback from the members of the INMM or Executive Committee. Both letters have been published in the Journal. It would be helpful to the Committee if we could get some "feedback" so we now if what we are writing is what the members are thinking.

- The next meeting of the Safeguards Committee will be held in conjunction with the annual meeting of the INMM in San Francisco on Thursday, July 16, 1981. The following is a tentative agenda for the meeting:

- Government/Industry Liaison Subcommittee - Duda
- Regulations for LEU Fuel Fabrication - Vaughan
- Congressional Oversight Committee/GAO - Lumb
- Response to Proposed Rule Changes - Menke
- Policy Statements in Safeguards - de Montmollin
- Policy Guidance - Weinstock
- Next Meeting with the NRC - Sorenson/Evans

Comments from INMM members would be greatly appreciated and certainly would serve to guide the Committees' future efforts. We have lots of ideas to work on, but would welcome additional recommended areas for future consideration.

Awards Board and Standards Committee

Carleton D. Bingham
Executive Committee Oversight

Awards

Oversight activity in this area has been minimal, due largely to effective committee work chaired by Dr. Ralph Lumb. In response to publicity, both printed and word-of-mouth, nominations and papers have been submitted, respectively, for the INMM Distinguished Service Award and the Student Paper Award. Selections have been made and awardees will be recognized at appropriate ceremonies at the July National Meeting.

Standards

A. **N-15:** The ANSI N15 Standards Committee, chaired by Dennis Bishop, has continued to exert positive influence within the nuclear community in the development of consensus standards of practice. A new subcommittee on measurement quality assurance will be adding to the productivity of an already productive committee.

The impact of Dennis' transfer within his company on the ongoing work of N15 at this time is unknown. The absence of a vice-chairman tends to compound the uncertainty.

B. **N-14:** The Institute has proposed ANSI to assume the Secretariat for the N14 Transportation Committee. Jim Clark has agreed to serve as chairman and has assembled individuals willing to work with him in moving forward. As of the date of this submission, no official response has been received by the Institute from ANSI. Mr. Clark has represented INMM in some preliminary discussions with ANSI staff representatives. The ANSI Nuclear Standards Board is to meet in late June at which time a decision regarding the Secretariat is to be made.

INMM Journal and Secretariat

Yvonne M. Ferris
Executive Committee Oversight

The responsibility for *Nuclear Materials Management,* the Journal of the Institute of Nuclear Materials Management, was transferred at E. R. Johnson Associates, Inc. as Secretariat in July 1980. To date, the summer, fall, and winter 1980 and spring 1981 issues have been published by the Secretariat.

In order to expedite the publication of the Journal and to exercise greater control over its scheduling, the printing function was moved from Manhattan, Kansas to northern Virginia. The format was changed to two columns, right and left justified for both the business and technical portions of the Journal. Also, various designs and size of type are now employed routinely within a given article for ease of reading and researching.

The cover of the Journal was redesigned to enhance the name of the Journal. This has improved its appearance and increased its identity.

Advertising is both a scientific service to the membership and an economic benefit. The Journal is an excellent medium for safeguards related advertisements because of its international circulation and informed readership. The Secretariat continues to expand this service by soliciting appropriate and related advertisements for each issue.

Nuclear Materials Management continues to improve with each publication. The dedication and challenge with which E. R. Johnson's staff prepares each copy has led to the competitive Journal we are privileged to receive today. A publication can not long survive, however, without printed matter. It needs timely, informative, and even controversial articles to provoke discussion and research. Recipients of the Journal should consider its "care and feeding" as their personal responsibility. Only with constant up-to-date, provacative input can the highly sophisticated, scientifically advanced readership of *Nuclear Materials Management* remain enthusiastic about its existence.

Long Range Plans Committee

S. C. T. McDowell
Executive Committee Oversight

Since its organization and first meeting in May 1980, the Long Range Plans Committee (LRP) has been and is continuing to look at the INMM today and its interests/activities in the long term. Owing to the Institute's growth in number as well as its involvement in new areas of interest, two subcommittees of the LRP were formed; (1) a Short Term Subcommittee to define and develop a plan of operation over the next two-three years, and (2) a Long Term Subcommittee to look at the role and scope of the INMM over the long term. The two subcommittees have worked very hard this past year making contacts (via phone and correspondence) within the INMM membership, participating in scheduled meetings, study groups and performing cost-benefit analyses. From this, we feel a plan of operation has been developed that will, among many things, enhance INMM recognition as a certified professional organization of experts in the field of safeguards and materials management; promote additional growth in the INMM; and expand its ability to better service industry, government and its members. In order to accomplish and carry out this plan in a most advantageous, economical way, it was decided that an Executive Director/Professional Manager would be needed to manage the business and other affairs of the Institute, as delegated by the Chairman of the Executive Committee; and for long term planning a decade would be an appropriate period of time to consider.

At the April 1981 meeting the Executive Committee approved proceeding with the proposed plan of operation. The following recent actions/accomplishments have taken place within each Subcommittee.

Short Term Subcommittee

1. Have written an approved job description for an Executive Director.
2. As approved by the Executive Committee, will seek to hire an executive Director on a trial (one year) basis to manage the affairs on the INMM.
3. Have scheduled interviews during the latter part of June for those companies already expressing an interest in managing the INMM. (At the writing of this report, six companies so far have expressed an interest and the actual interviews have not yet begun.)

Long Term Subcommittee

1. In planning for a decade, this Subcommittee agreed that there were three considerations to be addressed: what will the nuclear environment be a decade hence; what should the scope of the INMM activities be within that environment; and how should the Institute

organize so as to make effective contributions during this 10 year period of time.

2. A ten year plan was formulated to include the following four areas for study:
   - Industry
   - International
   - Military Application
   - Government

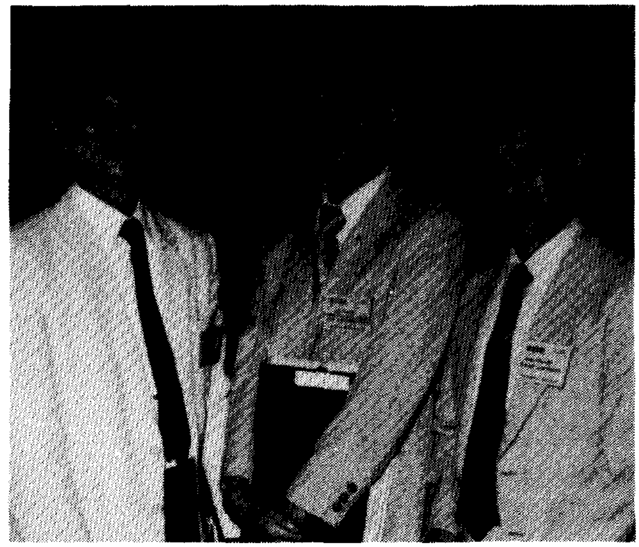
   Study groups were established to address each area and suggestions and recommendations have been made to the Executive Committee for consideration.

Through the activities of these two Subcommittees to date, the Long Range Plans Committee believes that there need to be no radical change in the organization of the Institute to effectively contribute in the next decade; however, to harness the capabilities to deal with expansion in the areas identified by the Long Term Subcommittee, a full time management staff is needed.

The Long Range Plans Committee will continue review of the INMM operation under professional management, and in the best interest and with the help and support of the full membership, make suggestions and recommendations for improvement and/or change to the Executive Committee for consideration. Progress reports from the Long Range Plans Committee will continue to be made available to the Executive Committee and the membership.

As a special part of this report and as Chairman of the Long Range Plans Committee, I would like to express my sincere appreciation to V. J. DeVito, Yvonne Ferris, T. J. Haycock, W. Hendry, E. R. Johnson, R. Lumb, W. Myre, and E. Owings for serving with me on this Committee. Because of their individual interest and dedication to the work of the INMM, we have been able to set in place a plan which we hope will improve the overall operation and status of the INMM.

Members of Long Range Planning Committee meeting at 22nd Annual Meeting in San Francisco.



Mr. Sadao Tsurumi, NMCC, Tokyo; Mr. Akira Kobe, PNC, Japan; and Mr. Kaku Sugiura of Nippon Electric, Japan at Chairman's Reception at San Francisco meeting.

OFFICE OF THE MAYOR
SAN FRANCISCO

DIANNE FEINSTEIN

Proclamation

WHEREAS, The Institute of Nuclear Materials Management is an international organization of over 700 professionals working in governmental, industrial, and academic institutions; and

WHEREAS, INMM members apply the principles of several technical disciplines as well as accounting for safeguarding of nuclear facilities including power reactors and nuclear materials in fuel cycle facilities and in transportation; and

WHEREAS, INMM promotes research in the field of nuclear safeguards including nuclear materials accounting, nuclear materials control and physical protection; and

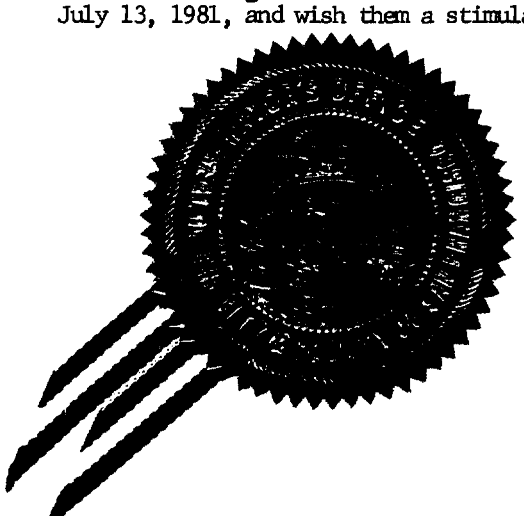
WHEREAS, INMM members encourage, develop and prepare American National Standards Institute standards consistent with professionals and regulatory requirements; and

WHEREAS, INMM promotes continual development of the qualifications and usefulness of those individuals engaged in nuclear materials management as a profession; and

WHEREAS, The INMM is conducting its 22nd annual meeting from July 13-15, 1981 at the Sheraton-Palace Hotel in San Francisco, California; and

WHEREAS, The meeting will attract nearly 400 of the world's leading experts in nuclear materials management in its many aspects;

NOW, THEREFORE, BE IT RESOLVED THAT I, DIANNE FEINSTEIN, Mayor of the City and County of San Francisco, do hereby welcome attendees at the official opening of the 1981 meeting of the INSTITUTE OF NUCLEAR MATERIALS MANAGEMENT on this Monday, July 13, 1981, and wish them a stimulating and rewarding time in our City.



IN WITNESS WHEREOF, I have hereunto set my hand and caused the Seal of the City and County of San Francisco to be affixed this ninth day of July, nineteen hundred and eighty-one.

Dianne Feinstein
Mayor

Factors Which Affect Sensor Selection for Intrusion Detection Systems*

James D. Williams
Supervisor, Intrusion Detection Systems Technology Division
Sandia Laboratories

ABSTRACT

Areas which require physical protection systems are usually those in which very valuable material, potentially dangerous material, or strategic information is stored. The primary purpose of the physical protection systems for such areas is to prevent theft or sabotage of the protected items. Intrusion detection is one of the essential elements of a physical protection system. It is essential that any new or to-be-improved intrusion detection system be carefully planned and analyzed to ensure that it will reliably perform its intended function in the specified environment and that the system's strengths and weaknesses be identified and understood. Details about particular types of sensors and how they operate are given in the references listed and are not repeated here. The performance of intrusion detection sensors is influenced by a complex interrelationship of a large number of factors. Some of these factors for exterior and interior sensors to be used in intrusion detection systems are identified and discussed.

*This work was supported by the U.S. Department of Energy under DOE Contract DE-AC04-76DP0089.

Introduction

The selection of sensors for intrusion detection systems involves a complex interrelationship of a large number of factors. Because of this complexity, one is tempted to try to simplify the relationships by organizing the sensors into preferred order lists or tables. Such lists and tables are potentially dangerous because they can lull facility designers and operators into thinking they have performed an adequate sensor system design and/or they can provide excuses for poor system design by virtue of the fact that the system designer has chosen an item (or items) high on the preference list.

Physical protection systems for fixed facilities (usually referred to in the nuclear industry as safeguards systems) are designed to provide protection against acts of sabotage and theft of special material or other items being protected. Four elements must react in a timely manner to form an effective physical protection system: (1) detection and assessment systems must expose and verify any intrusion attempt from outside (e.g., intruders may pose as a person authorized to enter or they may try to enter at a point not normally used for entry), or any malevolent act by insiders or outsiders; (2) communications systems must bring all pertinent information to the point or points where appropriate action may be taken; (3) delay systems must impede continued efforts to penetrate into -- or exit from -- the protected area; (4) response systems (or forces) must counteract adversary activity and neutralize the threat.

These elements are of equal importance; none can be eliminated or compromised if the systems are to remain effective. Detection, which encompasses not only intrusion detection but also entry control, is basic to protection: Any delay scheme can eventually be overcome, and without detection the response force cannot be alerted. System considerations related to the selection of intrusion detection sensors is the subject of this article.

System Planning

If a sensor system is to perform reliably, with strengths as well as weaknesses clearly identified and understood, a new system -- or one that is being improved -- must be carefully planned and analyzed. Included in this planning and analysis are the development of system philosophy and site-related evaluation, followed by iterative design finalization, then cost analysis, scheduling, equipment procurement, and construction and installation.

System objectives, which also define the purposes of the detection equipment and the types of threats assumed, should include the specifications desired in three primary areas: (1) probability of detecting the intruder, P_d; (2) vulnerability to defeat of the equipment; and (3) the allowable alarm rates* and the manner in which these rates are calculated. These parameters cannot be represented by single-valued numbers, however, because they are influenced by many variables -- the physical environment, weather, threat, maintenance, regulations, installation procedures and operating personnel. Therefore, the conditions that apply to each number specified must also be listed. Additionally, no single sensor presently exists or is expected to exist that will reliably detect all intruders and still have an acceptably low alarm rate for all natural and manmade environments. Therefore, when a high P_d and a low alarm rate are required over a wide range of operating conditions, it will be necessary to use combinations of sensors. The combinations of sensors and the way in which the sensors provide overlapping detection volumes not only contribute to enhanced detection and reduced alarm rate, but also contribute to the safeguards concept known as "protection-in-depth." (Protection-in-depth means simply providing a

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*The alarm rates are the number of non-intruder generated alarms which occur in a given time period. The non-intruder generated alarms are the sum of the alarms due to system idiosyncrasies (false alarms) and the alarms due to nuisance sources (nuisance alarms). In modern solid state equipment which operates at low voltages, true system idiosyncrasies such as microphonics, shot noise, etc., are almost nonexistent, therefore the alarm rate is mostly due to nuisance sources.

number of protective measures in series such that an intruder must successfully circumvent or defeat each of the protective measures in sequence or simultaneously before access to the protected material or facility can be achieved.) Consideration of these combinations must be given at the time of sensor selection to assure that each is compatible with the site characteristics, that one complements the other in detection capabilities, and that threat defeat vulnerabilities are reduced rather than enhanced. This consideration requires detailed evaluation and becomes a function of site peculiarities rather than site similarities.

A detailed consideration of the interaction among the items mentioned is integral to the selection and location of the "best" technological types of equipment necessary to ensure the desired intrusion detection functions.

Hardware for intrusion detection comprises sensors, alarm-assessment and alarm-reporting systems -- the latter including alarm communications and information-display equipment. The performance of the first two groups is heavily influenced by the physical environment in which it must operate, as well as by installation and maintenance considerations.

Unfortunately, we lack full knowledge of the limitations imposed by the environment on sensor operation. Additional on-site evaluation will therefore be required during and after sensor installation. Moreover, facility type, regulations, procedures, and personnel impact on the system's operational effectiveness, along with the material to be safeguarded and the most probable threat anticipated, all influence final system design.

Selection of intrusion-detection systems involves identifying the components and installation methods that best meet the overall system objectives. A key system component, of course, is the sensor. Sensors may be categorized as either exterior or interior. Exterior sensors include fence-associated sensors, free-standing line sensors, buried-line sensors and point sensors. Interior sensors include boundary-penetration sensors, motion (volume) sensors, and proximity sensors.

Tables I and II have been prepared to illustrate the complexity and interaction of these components and the site characteristics. The tables should not be used for sensor selection without studying additional explanatory material. In Table I it is important to realize that if an intruder can pass entirely above or below the detection zone of a sensor the intruder will go undetected. Therefore elaborate tunnels or bridges will defeat all of the sensors listed. The terminology "low bridge" could be as simple as a 2x4 longer than the detection zone is wide and supported at its ends by several short sections of 2x4's. Such a structure could allow a careful intruder to cross the detection zone of a seismic sensor just a few inches above the ground without imparting enough seismic energy into the sensor to activate it. A "high bridge" also implies a simple structure, but one which would allow the intruder to pass a few feet above the ground. The inclusion or exclusion of an "X" in the tables is a general indication. Particular situations can alter these general indications. A number of sources of additional information about sensors are listed in the references.

Physical and Environmental Conditions Affecting Exterior Sensors

The physical and environmental conditions that can affect exterior detection systems include topography, vegetation, wildlife, background noise, meteorological conditions, and soil surface and volumetric properties (moisture content, conductivity, compactness, etc.). It is important to recognize that there is no "typical" site since combinations of conditions are site specific. Topographical concerns include slopes and hills, gullies and ditches, lakes, rivers and streams, swamps and temporary surface water, perimeter access points and manmade structures. Vegetation includes all plant life such as trees, weeds, grass, bushes, and crop foliage. The vibration of the root systems of this vegetation as well as aboveground motion of foliage can affect sensor performance. Wildlife of concern includes large and small animals, burrowing animals, and birds and insects. Background noise such as traffic, wind, natural and manmade (water and sewer lines, drainage culverts, buried power and communication lines, etc.) seismic sources, and electromagnetic interference all must be taken into account. The specific type of meteorological information which may prove useful in the design and operation of sensor systems includes wind, temperature, rain, snow, hail, visibility, airborne corrosives, moisture content of the soil, and electrical storms. Soil volumetric properties primarily affect buried sensors.

Physical and Environmental Conditions Affecting Interior Sensors

The environmental conditions which can affect interior sensors are electromagnetic, radioactive, acoustical, thermal, optical, seismic, and meteorological in nature. Two general physical conditions of importance are building or room construction and the various equipment or objects that occupy the area or room to be monitored. Certain physical features are unalterable, while others may be changed.

A careful review or survey of the area to be monitored, coupled with other detailed information about the area, will provide the user with guidance to choose a particular technological type of sensor or a combination of types of interior detection systems.

Equipment Identification

Considerations leading to the initial equipment identification for either exterior or interior applications include: (a) the compatibility of the sensors with the alarm signal transmission media and display equipment (signal levels, impedances, no-alarm condition of relays, etc.); (b) the compatibility of the assessment equipment (usually CCTV) with the overall system layout, lighting, and personnel procedures; (c) the assurance that the system is adequate but not unnecessarily complex, (d) the assurance that a proper balance between security and safety exists; (e) the assurance that the individual subsystems can be installed with a minimum of duplicated construction and that the signal cables and power lines for lights, cameras, sensors, etc., can be installed, to avoid interference, at a reasonable cost, (f) the assurance that procedures for operation during emergency conditions are established and that the equipment and personnel are compatible with these procedures, (g) the assurance that tamper-indicating circuitry is available on all critical assemblies, (h) the assurance that full end-to-end self-test circuitry is available on critical sensors or subsystems, (i) the assurance that the system also provides protection for intraplant movement of critical material, (j) the assurance that adequate emergency power is provided and that it is properly protected, (k) the determination that adequate protection-in-depth has been designed into the overall system, (l) the assurance that the display and control equipment is human-engineered, and (m) discussion of the entire system with the personnel who will operate it to ensure their acceptance of the system.

In summary, a major design goal is to obtain an intrusion detection system which exhibits a low alarm rate and an acceptable P_d in the environment in which it must operate and is not susceptible to defeat. This goal can be achieved in a cost effective manner if the complex interrelationships of a very large number of variables are well understood and considered during the system design. No single sensor presently exists or is expected to exist that will reliably detect all intruders and still have an acceptably low alarm rate for all expected natural and manmade environments. To simplify the procedure with shortcut attempts is to court disaster.

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Table 1

EXTERIOR SENSORS SUITABLE FOR FIXED-SITE APPLICATIONS

Application	Operating Principle	Detection: Nonmagnetic	Detection: Walk, Run and Crawl	Detection: Shallow Tunnel	Detection: Climb Fence	Detection: Cut Fence	Common Conditions for Unreliable Detection (All sensors are adversely affected by improper installation)	Common Simple Defeat Methods	Typical Causes of Nuisance Alarms: High Wind	Heavy Rain	Heavy Snow	Heavy Fog	Birds	Small Animals	Large Animals	Seismic Activity	Thunder and Lightning	RFI (including electrical transients)	High Grass	Surface Water
Buried	Seismic-Magnetic	x	x		NA	NA	Frozen ground, deep and/or crusted snow	Bridge and carry no ferromagnetic material	x						x	x	x	x		x
	Seismic	x	x		NA	NA		Low bridge	x						x	x	x			
	Magnetic		x		NA	NA		Carry no ferromagnetic material									x	x		
	Balanced Pressure	x	x	x	NA	NA		Low bridge							x	x				
	Ported Coax	x	x	x	NA	NA	Conductive Soil	Medium bridge							x		x	x		x
Fence Disturbance	Electromechanical (Electret, Tribo-electric, geo-phone, piezo-electric, etc.)	x	NA		x	x	Flexible posts loose fabric, improper mounting positions	Ladder or short tunnel	x	x					x		x	x		
	Mechanical* (Mercury and inertia switches)	x	NA		x			Ladder or short tunnel	x	x					x					
	Taut-Wire	x	NA		x	x		Ladder or short tunnel							x					
Free-Standing	Electric-Field (can be fence-mounted)	x	x		x	x	High grass and/or deep and crusted snow	Tunnel High Bridge	x	x			x	x	x		x	x	x	x
	Microwave (Bistatic)	x	x		NA	NA	High grass, irregular terrain, deep and/or crusted snow	Tunnel High Bridge						x	x				x	x
	Infrared	x	x		NA	NA		Ladder, short tunnel, or redirect low beam			x	x		x	x				x	x
Point	Seismic or Electromagnetic	x	x		NA	NA	Same as Buried	Tunnel					x	x	x		x		x	x

NA Not Applicable

*Some of the inertia type switches will detect cutting.

Table 2
INTERIOR SENSORS SUITABLE FOR FIXED-SITE APPLICATIONS

Application	Operating Principle	Detection: Portal Opening	Breaking Through Wall/Floor/Ceiling	Radial Motion	Transverse Motion	Touching Object	Conditions for Unreliable Detection	Typical Defeat Methods	Major Causes of Nuisance Alarms: Air Humidity/Temp/Velocity	Localized Heating	Movement Less Than 0.025 metre/sec	Movement Greater Than 0.025 metre/sec	Movement Outside Area	Fluorescent Lights	Loose Fitting Doors	Mount Vibration	Ambient Acoustic Noise	Rodents/Animals	RFI
Boundary-Penetration	Balanced Magnetic	X		NA	NA	NA	Improper Installation	Stay Behind Intruder or Entry Through Unprotected Area							X				
	Vibration		X	NA	NA	NA							X			X			
	Continuity		X	NA	NA	NA													
Motion	Sonic	X		X	X	NA	Acoustic Background	Disenable Electronics	X			X				X	X	X	
	Ultrasonic	X		X		NA	Air Movement	Cover When Sensor Is In Access	X			X				X	X	X	
	Microwave	X		X		NA	RFI					X	X	X		X		X	X
	Infrared				X	NA	Unstable Thermal Background		X	X		X				X		X	
Proximity	Capacitance	NA	NA	NA	NA	X	Gross Changes in Relative Humidity, Temperature or Pressure	Disenable Electronics	X									X	
	Strain	NA	NA	NA	NA	X												X	
	Pressure Pad	NA	NA	NA	NA	X												X	

NA } Not Applicable

Constrained Expected Likelihood Estimates of Precisions Using Grubbs' Technique for Two Measurement Methods

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1. Introduction

The data under consideration consist of measurements performed on each of n items by two measurement methods. The problem is to obtain estimates of the measurement random error variance for each method. This problem has common application in nuclear materials safeguards, as is discussed in [1].

Grubbs [2] proposed a method of estimating these parameters. The estimators are given in Section 2. Unfortunately, when the product variance, (variance of true values of items being measured), is large relative to the measurement error variances, the estimate of one of these error variances is negative with high probability [3]-[6].

In the event that one of the estimates in question is negative, altered estimates of the parameters have been proposed by Thompson [7]. These estimators are given in Section 3. The estimate of one of the parameters is zero. Since some workers are hesitant to report zero values for variance components, the purpose of this paper is to present other estimators of the parameters that will always provide positive non-zero estimates. These estimators, and the basis for them, are given in Section 4. In Section 5, examples are given, and in Section 6, it is suggested that the estimation principle involved may be applied in general, even when Grubbs' related estimates are all positive. A few summarizing comments are given in Section 7.

2. Grubbs' Estimates (Maximum Likelihood)

The notation of [6] is used with slight modification. Let $x_1, x_2, \ldots, x_n$ denote the true values of the items to be measured. Let $y_{11}, y_{21}, \ldots, y_{n1}$ be the measured values for measurement method 1, and $y_{12}, y_{22}, \ldots, y_{n2}$ be the measured values for method 2. The model is

$$y_{ij} = x_i + \varepsilon_{ij} \qquad (2.1)$$

$$(i=1, 2, \ldots, n \; ; j=1, 2)$$

It is assumed that $x_1, x_2, \ldots, x_n$ constitute a random sample of size n selected from a population having a mean μ and variance of σ^2. Further, for j=1,2:

$$E(\varepsilon_{ij}) = \beta_j \qquad (2.2)$$

$$E(\varepsilon_{ij}-\beta_j) = \sigma_j^2 \qquad (2.3)$$

and

$$E[(\varepsilon_{i1}-\beta_1)(\varepsilon_{i2}-\beta_2)] = 0 \qquad (2.4)$$

The quantity σ^2 is called the product or process variance, while σ_j^2 is the measurement error variance for method j and β_j is the bias for method j.

The Grubbs' estimates of σ^2, σ_1^2, and σ_2^2 involve the following sample variances and covariance:

$$s_{jj} = \frac{\sum_{i=1}^{n} y_{ij}^2 - \left(\sum_{i=1}^{n} y_{ij}\right)^2/n}{(n-1)} \quad ; j=1,2 \qquad (2.5)$$

$$s_{12} = \frac{\sum_{i=1}^{n} y_{i1} y_{i2} - \sum_{i=1}^{n} y_{i1} \sum_{i=1}^{n} y_{i2}/n}{(n-1)} \qquad (2.6)$$

The Grubbs' estimates are, from [2]:

$$\sigma^2 \sim s_{12} \qquad (2.7)$$

$$\sigma_1^2 \sim s_{11} - s_{12} \qquad (2.8)$$

$$\sigma_2^2 \sim s_{22} - s_{12} \qquad (2.9)$$

where $\sim$ is read "is estimated by".

Thompson states that if x_i and ε_{ij} are normally distributed, then Grubbs' estimates "have a maximum likelihood property" [6]. In fact, the Grubbs' estimates when multiplied by (n-1)/n are maximum likelihood.

3. Thompson's Estimates (Constrained Maximum Likelihood)

As pointed out in the Introduction, Grubbs' estimates frequently assume negative values. To avoid negative estimates of variance components, Thompson proposed the following altered estimates of the parameters [7]. (Say that σ_2^2 of (2.9) is negative; similar results hold if σ_1^2 of (2.8) is negative).

$$\tilde{\sigma}^2 = S_{22} \quad (3.1)$$

$$\tilde{\sigma}_1^2 = S_{11} + S_{22} - 2S_{12} \quad (3.2)$$

$$\tilde{\sigma}_2^2 = 0$$

It can be shown that if x_i and ε_{ij} are normally distributed, then Thompson's estimates are related to maximum likelihood in the constrained space that does not permit negative estimates. (Note: We are not concerned in this paper with negative values of s_{12}; Thompson also addresses this case in his paper [7]). In fact, as for Grubbs' estimates, if Thompson's estimates are multiplied by (n-1)/n, they are exactly constrained maximum likelihood estimates.

It is also noted that Thompson provides joint 95% and 99% confidence regions for the parameters σ^2, σ_1^2, and σ_2^2 [7]. The construction of the joint confidence region is a simple exercise using tables provided in [7] and is a meaningful calculation to perform for it provides valuable insight into the quality of the Grubbs' estimates for a given set of data. This will be illustrated in the examples considered later.

4. Constrained Expected Likelihood Estimates

Although reporting a zero estimate for one of the variance components is an improvement over reporting a negative estimate, there is additional room for improvement in an applied sense since zero estimates of variance components still lack something in acceptability. The concept of a constrained expected likelihood estimate (CELE) is introduced to meet the objection of zero estimates.

A simple schematic sketch will illustrate the CELE as it relates to the maximum likelihood estimate (MLE) and the constrained maximum likelihood estimate (CMLE). The key idea is that whereas the separate estimates of σ_1^2 and of σ_2^2 may be of poor quality when σ^2 is large relative to σ_1^2 and σ_2^2, yet their sum may be estimated quite well, independent of σ^2. The maximum likelihood estimate of $(\sigma_1^2 + \sigma_2^2)$ is

$$(\widehat{\sigma_1^2 + \sigma_2^2}) = (n-1)(s_{11} + s_{22} - 2s_{12})/n \quad (4.1)$$

The line in the schematic, Figure 1, consists of points that satisfy (4.1). All the estimates under discussion: the MLE, CMLE, and CELE fall on that line.

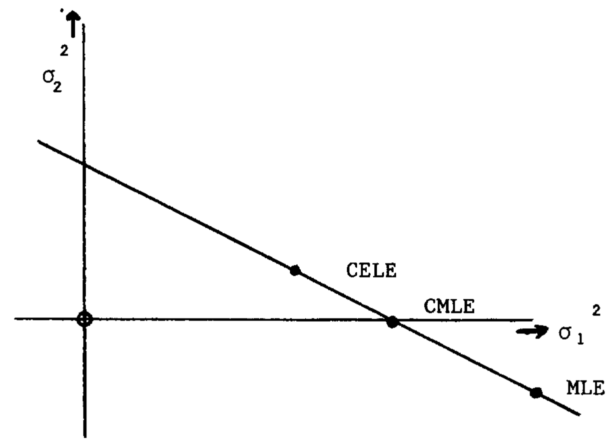

Figure 1
SCHEMATIC SHOWING THE ESTIMATES OF σ^1 and σ^2

Given the likelihood of the sample data, assuming that x_i and ε_{ij} are normally distributed,

- The MLE maximizes the likelihood over the entire space
- The CMLE maximizes the likelihood in the first quadrant
- The CELE determines the likelihood at each of several points on the line in the first quadrant, multiplies the likelihood by the value of σ_1^2 (or σ_2^2) at that point, sums these products over the several points, and divides by the sum of the likelihoods at these points.

It is noted that the CMLE is relevant only if the MLE lies in quadrant 2 or 4. On the other hand, the CELE may also be calculated if the MLE falls in quadrant 1. This will be discussed in Section 6.

Examples have demonstrated that the calculations indicated for the CELE may be performed at eleven points to give reasonable estimates in the sense that further calculations tend to yield about the same estimates. The eleven points correspond to $\sigma_1^2=0$, to $\sigma_2^2=0$, and to nine equally spaced points along the line indicated in Figure (1). The step by step instructions for calculating the CELE are as follows for σ_2^2 of (2.9) being negative. (The procedural changes for negative σ_1^2 are obvious).

(1) Calculate

$$\dot{\sigma}_{11}^{2} = (n-1)\,(S_{11} + S_{22} - 2s_{12})/n \qquad (4.2)$$

(2) For $m = \dot{\sigma}_{11}^{2}/10$, calculate the ten quantities $\dot{\sigma}_{1k}^{2}$ by the recursive relationship:

$$\dot{\sigma}_{1k}^{2} = \dot{\sigma}_{1,k-1}^{2} - m \qquad (4.3)$$

for k=2,3,..., 11,

noting that $\dot{\sigma}_{1,11}^{2} = 0$

(3) For each k=1,2,...,11, calculate

$$L_k = 0.5\, n\, \ell n\, (\dot{\sigma}_k^{2}\ \dot{\sigma}_{1k}^{2} + \dot{q}_k^{2} + \dot{\sigma}_{2k}^{2} + \dot{\sigma}_{1k}^{2}\ \dot{\sigma}_{2k}^{2}) - n \qquad (4.4)$$

$$\text{where } \dot{\sigma}_{2k}^{2} = \dot{\sigma}_{11}^{2} - \dot{\sigma}_{1k}^{2} \qquad (4.5)$$

$$\text{and } \dot{q}_k^{2} = \frac{(n-1)(\dot{\sigma}_{1k}^{4}\, s_{22} + 2\dot{\sigma}_{1k}^{2}\ \dot{\sigma}_{2k}^{2}\, s_{12} + \dot{\sigma}_{2k}^{4}\, s_{11})}{n\,(\dot{\sigma}_{1k}^{2} + \dot{\sigma}_{2k}^{2})^{2}} - \frac{\dot{\sigma}_{1k}^{2}\ \dot{\sigma}_{2k}^{2}}{(\dot{\sigma}_{1k}^{2} + \dot{\sigma}_{2k}^{2})} \qquad (4.6)$$

(4) For each k, calculate the weighting factor

$$w_k = \exp\,(L_k - L_1) \qquad (4.7)$$

(5) Calculate the CELE of σ_1^2:

$$\overset{*}{\sigma}_1^{2} = \sum_k w_k\, \dot{\sigma}_{1k}^{2} \Big/ \sum_k w_k \qquad (4.8)$$

The CELE of σ_2^2 is

$$\overset{*}{\sigma}_2^{2} = \sigma_{11}^{2} - \overset{*}{\sigma}_1^{2} \qquad (4.9)$$

And the CELE of σ^2 is found from (4.6) evaluated at $\overset{*}{\sigma}_1^{2}$ and $\overset{*}{\sigma}_2^{2}$.

The calculation of the CELE's is performed very simply with a programmable pocket calculator and is readily amenable to being programmed for routine calculation on a computer.

5. Examples

Example 1. The example on fuze burning time data given by Thompson [7] and originally reported by Grubbs is considered. The input statistics are:

$n = 30$

$s_{11} = 0.047141$

$s_{22} = 0.045610$

$s_{12} = 0.045931$

From equations (2.7)-(2.9), upon multiplication by (n-1)/n, the MLE's are

$\hat{\sigma}_1^{2} = 0.001170$

$\hat{\sigma}_2^{2} = 0.000310$, (negative estimate)

$\hat{\sigma}^{2} = 0.045931$

From equations (3.1) and (3.2), and again multiplying by (n-1)/n, the CMLE's are

$\tilde{\sigma}_1^{2} = 0.000859$, $\tilde{\sigma}_1 = 0.029$

$\tilde{\sigma}_2^{2} = 0$, $\tilde{\sigma}_2 = 0$

$\tilde{\sigma}^{2} = 0.044090$, $\tilde{\sigma} = 0.210$

Before calculating tahe CELE's, it is noted that in finding the joint 95% confidence region for σ_1, σ_2, and σ using methods provided by Thompson [7], the region boundaries are found to be

$0 \le \sigma_1 \le 0.085$

$0 \le \sigma_2 \le 0.071$

$0.159 \le \sigma \le 0.323$

The confidence limits for σ_1 and σ_2 are in much closer agreement than are the CMLE's. This disagreement leads one to question the usefulness of the CMLE's and motivated the development of the CELE's. To calculate the CELE's, follow the steps of Section 4.

(1) $\dot{\sigma}_{11}^{2} = 0.000859$, (same as $\tilde{\sigma}_1^{2}$)

(2) $m = 0.0000859$

$\dot{\sigma}_{12}^{2} = 0.000773$ $\qquad$ $\dot{\sigma}_{17}^{2} = 0.000344$

$\dot{\sigma}_{13}^{2} = 0.000687$ $\qquad$ $\dot{\sigma}_{18}^{2} = 0.000258$

$\dot{\sigma}_{14}^{2} = 0.000601$ $\qquad$ $\dot{\sigma}_{19}^{2} = 0.000172$

$\dot{\sigma}^2_{15} = 0.000515$ $\quad \dot{\sigma}^2_{1,10} = 0.00086$

$\dot{\sigma}^2_{16} = 0.000430$ $\quad \dot{\sigma}^2_{1,11} = 0$

(3) $L_1 = 122.7191$ (4) $w_1 = 1$

$L_2 = 122.6950$ $\quad w_2 = 0.9762$

$L_3 = 122.6652$ $\quad w_3 = 0.9475$

$L_4 = 122.6296$ $\quad w_4 = 0.9144$

$L_5 = 122.5882$ $\quad w_5 = 0.8773$

$L_6 = 122.5418$ $\quad w_6 = 0.8375$

$L_7 = 122.4892$ $\quad w_7 = 0.7946$

$L_8 = 122.4310$ $\quad w_8 = 0.7497$

$L_9 = 122.3674$ $\quad w_9 = 0.7035$

$L_{10} = 122.2983$ $\quad w_{10} = 0.6565$

$L_{11} = 122.2238$ $\quad w_{11} = 0.6094$

(5) $\overset{*}{\sigma}{}^2_1 = 0.000471$; $\overset{*}{\sigma}_1 = 0.022$

$\overset{*}{\sigma}{}^2_2 = 0.000388$; $\overset{*}{\sigma}_2 = 0.020$

$\overset{*}{\sigma}{}^2_2 = 0.044333$; $\overset{*}{\sigma} = 0.211$

The CELE's of σ_1 and σ_2 appear to be more consistent (non-statistical usage of this term) with the confidence limits for the two parameters than do the CMLE's.

Example 2.

Shipper-receiver data for the measurement of percent plutonium in PuO_2 powder are given on page 307 of [1]. For shipment 3, with the 1 subscript referring to the receiver and the 2 subscript to the shipper, the relevant data are:

$n = 10$

$s_{11} = 0.013207$

$s_{22} = 0.006740$

$s_{12} = 0.007375$

The MLE's and the CMLE's are respectively:

MLE	CMLE
$\hat{\sigma}^2_1 = 0.005249$	$\tilde{\sigma}^2_1 = 0.004677$; $\tilde{\sigma}_1 = 0.068$
$\hat{\sigma}^2_2 = -0.000572$	$\tilde{\sigma}^2_2 = 0$
$\hat{\sigma}^2 = 0.007375$	$\tilde{\sigma}^2 = 0.006066$; $\tilde{\sigma} = 0.078$

The 95% joint confidence region boundaries on the standard deviations are:

$0 \leq \sigma_1 \leq 0.202$

$0 \leq \sigma_2 \leq 0.119$

$0 \leq \sigma \leq 0.220$

In this example, the limits on σ_1 and σ_2 differ by a considerable amount. We would expect the CELE's to differ by a comparable degree. This situation is in contrast to Example 1 where the CELE's were more nearly equal, as were the confidence limits.

To find the CELE's, follow the steps of Section 4.

(1) $\dot{\sigma}^2_{11} = 0.004677$

(2) $m = 0.0004677$

$\dot{\sigma}^2_{12} = 0.004209$ $\quad \dot{\sigma}^2_{17} = 0.001871$

$\dot{\sigma}^2_{13} = 0.003742$ $\quad \dot{\sigma}^2_{18} = 0.001403$

$\dot{\sigma}^2_{14} = 0.003274$ $\quad \dot{\sigma}^2_{19} = 0.000935$

$\dot{\sigma}^2_{15} = 0.002806$ $\quad \dot{\sigma}^2_{1,10} = 0.000468$

$\dot{\sigma}^2_{16} = 0.002339$ $\quad \dot{\sigma}^2_{1,11} = 0$

(3) $L_1 = 42.3508$ (4) $w_1 = 1$

$L_2 = 42.2196$ $\quad w_2 = 0.8770$

$L_3 = 42.0196$ $\quad w_3 = 0.7181$

$L_4 = 41.7578$ $\quad w_4 = 0.5527$

$L_5 = 41.4443$ $\quad w_5 = 0.4039$

$L_6 = 41.0897$ $\quad w_6 = 0.2833$

$L_7 = 40.7021$ $\quad w_7 = 0.1923$

$L_8 = 40.2911$ $\quad w_8 = 0.1275$

$L_9 = 39.8641$ $\quad w_9 = 0.0832$

$L_{10} = 39.4284$ $\quad w_{10} = 0.0538$

$L_{11} = 38.9873$ $\quad w_{11} = 0.0346$

Note: It is interesting to compare these weights with those of Example 1.

The w values decrease much more sharply as one moves away from the CMLE's in Example 2. To continue,

(5) $\overset{*}{\sigma}{}^2_1 = 0.003537$; $\overset{*}{\sigma}_1 = 0.059$

$\overset{*}{\sigma}{}^2_2 = 0.001140$; $\overset{*}{\sigma}_2 = 0.034$

$\overset{*}{\sigma}{}^2 = 0.005760$; $\overset{*}{\sigma} = 0.076$

As was true for Example 1, the CELE's of σ_1 and σ_2 appear to be more consistent with the similar sets of confidence limits for the two parameters than do the CMLE's.

6. CELE as a General Method of Estimation

Although the CELE was developed to provide a solution to the problem of negative estimates of variance components, it may also be applied as an estimation technique when the MLE is positive for both measurement error parameters. An example will illustrate its usage.

On page 277 and following of [1], inspection data consisting of two measurements of the amount of U-235 in containers of UO_2 powder are given. The pertinent statistics are:

$$n = 22$$

$$S_{11} = 329.19$$

$$S_{22} = 271.96$$

$$S_{12} = 265.58$$

The MLE's are identical with the CMLE's and are as follows:

$\hat{\sigma}_1^2 = 60.72$; $\hat{\sigma}_1 = 7.79$

$\sigma_2^2 = 6.09$; $\hat{\sigma}_2 = 2.47$

$\hat{\sigma}^2 = 253.51$; $\hat{\sigma} = 15.92$

The 95% joint confidence region boundaries on the standard deviations are:

$$0 \leq \sigma_1 \leq 16.44$$

$$0 \leq \sigma_2 \leq 12.75$$

$$9.95 \leq \sigma \leq 27.56$$

The limits on σ_1 and σ_2 do not differ drastically; the MLE's do. The CELE's are now found and compared with the confidence limit bounds. The steps of Section 4 are followed.

(1) $\dot{\sigma}_{11}^2 = 66.81$

$m = 6.681$

$\dot{\sigma}_{12}^2 = 60.13$	$\dot{\sigma}_{17}^2 = 26.72$
$\dot{\sigma}_{13}^2 = 53.45$	$\dot{\sigma}_{18}^2 = 20.04$
$\dot{\sigma}_{14}^2 = 46.77$	$\dot{\sigma}_{19}^2 = 13.36$
$\dot{\sigma}_{15}^2 = 40.09$	$\dot{\sigma}_{1,10}^2 = 6.68$
$\dot{\sigma}_{16}^2 = 33.41$	$\dot{\sigma}_{1,11}^2 = 0$

(3)		(4)	
	$L_1 = -129.3709$		$w_1 = 1$
	$L_2 = -129.3475$		$w_2 = 1.0237$
	$L_3 = -129.3809$		$w_3 = 0.9900$
	$L_4 = -129.4703$		$w_4 = 0.9054$
	$L_5 = -129.6145$		$w_5 = 0.7838$
	$L_6 = -129.8114$		$w_6 = 0.6437$
	$L_7 = -130.0585$		$w_7 = 0.5028$
	$L_8 = -130.3518$		$w_8 = 0.3750$
	$L_9 = -130.6878$		$w_9 = 0.2680$
	$L_{10} = -131.0625$		$w_{10} = 0.1842$
	$L_{11} = -131.4716$		$w_{11} = 0.1224$

(5) $\overset{*}{\sigma}_1^2 = 44.46$; $\overset{*}{\sigma}_1 = 6.67$

$\overset{*}{\sigma}_2^2 = 22.35$; $\overset{*}{\sigma}_2 = 4.73$

$\overset{*}{\sigma}^2 = 248.13$; $\overset{*}{\sigma} = 15.75$

These estimates of σ_1 and σ_2 appear to be in better agreement with the confidence limits than do the MLE's.

A sketch of the weights, w_k, versus $\dot{\sigma}_{1k}^2$ is helpful in showing the relationship between the CELE and the MLE for this parameter. This sketch is given as Figure (2).

7. Comments on CELE Method

The method proposed will yield biased estimates of the parameters. However, the estimates of the parameters will always be positive and this was the notivation for developing the estimators. The estimates appear to be in good qualitative agreement with confidence regions. Simulation studies would be helpful in more fully evaluating the properties of the proposed estimators.

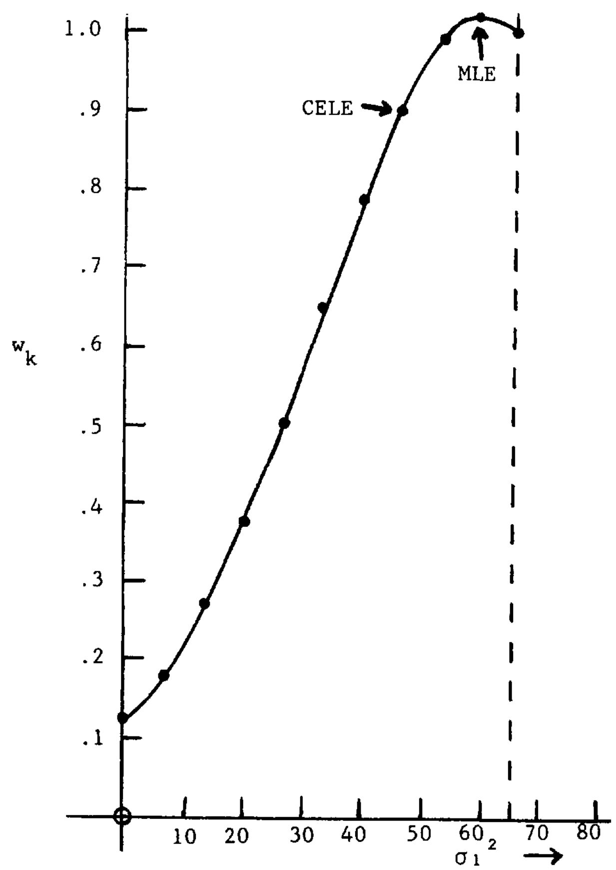

Figure 2

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Video Disc Recording for CCTV Alarm Assessment Systems

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ABSTRACT

Closed circuit television (CCTV) systems are being used in increasingly sophisticated ways in safeguards and security applications. This paper first reviews some of the current uses of CCTV in these appliations and then presents a recent advance in recording video for "instant replay" in alarm assessment systems.

The paper begins by noting that although the use of live CCTV permits one guard to maintain constant surveillance over a number of geographically separated and possibly hazardous areas, it is also possible to have more cameras and/or monitors than the guard can effectively handle in real time.

Techniques for recording video information for delayed and/or repeated viewing are then discussed. It is observed that although video tape recorders are the most common and least expensive type of recording equipment, these units lack the operational features and video resolution that are desirable in many security applications. It is then pointed out that video disc recorders do not have the limitations found in video tape recorders; however, video disc recorders are typically too costly to use in a one-video-disc-recorder-per-scene manner.

The paper then describes a video multiplexing technique that permits a large number of scenes to be concurrently recorded and replayed on one video disc recorder, thereby mitigating the relatively high cost of this equipment. Several possible applications of the multiplexing technique on different types of video disc recorders are presented.

PART I - BACKGROUND

Live Assessment Systems

In the simplest use of CCTV in security systems, a television camera is placed in a remote area and directly connected to a television monitor located in a control room where security personnel can maintain visual surveillance over the remote area without having to be physically present at the area. In addition to permitting one guard to maintain a constant vigil over several areas that are geographically separated, this use of CCTV also permits the visual inspection of areas that are normally restricted to personnel entry for safety reasons such as radiation hazards.

This use of CCTV in security systems is often so valuable that there is frequently a strong incentive to continue to add more cameras and monitors to cover increasingly greater portions of the facility. Unfortunately there is a point of diminishing returns as to the number of monitors that an operator can effectively watch -- additional monitors may only increase the amount of equipment at the operator's console without significantly increasing the operator's ability to detect unauthorized activity.

Live Assessment with Video Switching

In cases where the one-camera-one-monitor approach would result in too many monitors, video switching equipment can be used to present the video from a few selected cameras on a limited number of monitors. However this immediately presents the problem of selecting the scenes that will be displayed. Three commonly used camera selection techniques are manual selection, scanning, and alarm-driven selection.

Manual Selection -- In manual selection, the operator simply selects the cameras he wishes to view by pushing a button or operating a switch. Although this approach gives the operator total control over the system, the mechanics of operating the switching equipment may distract him from his primary function of assessing the video that is being presented. In fact, this approach may be totally ineffective in overload or panic situations.

Scanning -- A scanner is a relatively simple device that automatically cycles through a series of cameras and sequentially displays the video from each camera for a short period of time (e.g., a few seconds per scene) on one monitor. Although a scanner relieves the operator from the manual switching task and presents sufficient video from each camera for gross surveillance of the activity in each area, events of short duration are likely to be missed since the video from any given camera is only switched to the monitor for a small fraction of the total time.

Alarm-driven Selection -- The alarm-driven approach utilizes incoming alarm signals from sensors in the remote areas to drive the video switcher and thereby select the scenes that will be viewed. This approach ensures that the most important scenes are presented to the operator at all times. However, this approach is also the most complicated in terms of the equipment required to perform the switching.

One additional problem that is common to all live CCTV systems is the fact that the "action" happens in real time and cannot be repeated for a second look. Consequently, any assessments must be performed by monitoring the video from the appropriate area as the action of interest is taking place. In the case of alarm assessment systems, this means that the operator must begin viewing an incoming alarm scene quickly since the cause of the alarm may only remain in the camera's field of view for a brief period of time. This implies that the operator's duties must be structured to permit him to direct his attention immediately to the assessment function as soon as an alarm occurs. In cases of multiple alarms, some alarms may not be properly assessed at all; instead, a false sense of security may be created by viewing an apparently normal scene after an intruder has passed out of the field of view.

Recorded Assessment Systems

Recording video can greatly enhance the effectiveness and reliability of an assessment system by allowing the operator to concentrate on one alarm at a time while saving any concurrent alarm scenes for later review. Recording can further enhance an assessment system by allowing repeated review of an alarm scene or a particular portion of the scene. In addition, recorded assessment creates less interference with the operator's other duties than does live assessment because the assessment of recorded scenes can be delayed.

Three types of video recording devices are presently available; video tape recorders, video disc recorders, and digital memory. Each of these device types has a particular range of cost and capability which distinguishes it from the others.

Video Tape Recorders

Video tape recorders, or VTRs, are the most commonly available and least expensive video recording devices. For these reasons, VTRs are usually the first type of device to be considered for use in any video recording application. However, there are several significant limitations to the use of VTRs in recorded assessment systems:

Start-up Delay -- VTRs require several seconds to engage and synchronize the record head before recording can begin. Consequently in alarm-driven assessment systems some initial video information that might be useful for assessment purposes will be lost since recording cannot begin as soon as an alarm occurs.

(One solution to this problem is to keep the VTR running even when no recording is required so that the recording of a particular scene can be initiated immediately by automatically switching the appropriate video source to the recorder input when an alarm occurs. However, since a recorded scene might begin near the end of the tape, a second VTR must be available to automatically continue recording if the first VTR runs out of tape.)

Rewind Delay -- Another problem in using VTRs in assessment systems is repositioning the tape to the beginning of a scene for replay. Although automatic indexing is available on a number of VTRs, a considerable delay may still be encountered while waiting for the tape to be rewound to the desired position. Furthermore, if the scene is replayed repeatedly, the same delay will be incurred before each repetition.

Depending on the specific situation, this delay may seriously interfere with the rapid assessment of alarms.

Interruption of Recording -- Although VTRs can record for as long as two hours on one tape, they cannot record indefinitely without interruption. This is a significant problem in recorded assessment systems in which continuous recording is used so that the video that was present just before an alarm occurred is always available for replay. (This type of recording is especially desirable if the assessment of an alarm might depend upon activity that preceded the activation of a sensor or if the delay between sensor activation and the initiation of recording could be significant due to delays in the alarm reporting system.) Again, this problem could be overcome by using a second VTR to continue recording while the first VTR was being rewound.

Number of Units -- Another consideration in the use of VTRs in a recorded assessment system is that at least one VTR must be available for each scene that is to be recorded and/or replayed simultaneously. For example, recording four scenes while a fifth scene is being replayed requires a minimum of five VTRs. The need for multiple VTRs may significantly offset the low per unit cost of a single VTR.

Limited Video Resolution -- One final drawback to the use of VTRs in recorded assessment systems is that the bandwidth of video tape is limited to approximately 300 vertical lines of video resolution which is considerably less than the 500 to 550 lines of resolution that can be provided by other components of CCTV systems. Consequently it may more difficult to assess nuisance alarms such as those caused by small animals or, alternatively, it may be necessary to use additional cameras with shorter assessment zones in order to maintain the same degree of object definition.

Video Disc Recorders

Video disc recorders, or VDRs have none of the limitations of VTRs that were discussed above, however VDRs are considerably more expensive than VTRs. Several important characteristics of VDRs are discussed below:

Flexible vs. Rigid Discs -- Two basic types of VDRs are available; flexible disc recorders and rigid disc recorders.

Flexible disc recorders utilize cartridges that can be removed from the VDR, thus permitting the recorded scenes to be stored off-line. However, the disc heads come into direct contact with the disc during recording and replay operations with the result that maintenance is required approximately every 300 hours of actual record/replay operation. Although the heads can be lifted away from the disc when the VDR is idle to reduce wear, this introduces an access delay of about one second while the heads are lowered before recording can begin. Consequently, it is generally necessary to keep the heads in position to record at all times so that the recording of any scene can begin immediately.

Rigid disc VDRs use heads which float on an air bearing above an integral disc that cannot be removed from the VDR except for repair. As a result of this design, the mean time between maintenance is approximately 10,000 hours and there is no access delay. For these reasons, rigid disc VDRs are preferable for use in recorded assessment systems.

Recording Format -- As depicted in Figure 1, the recording surfaces of video discs are divided into concentric rings called tracks on which individual video frames or fields are recorded.

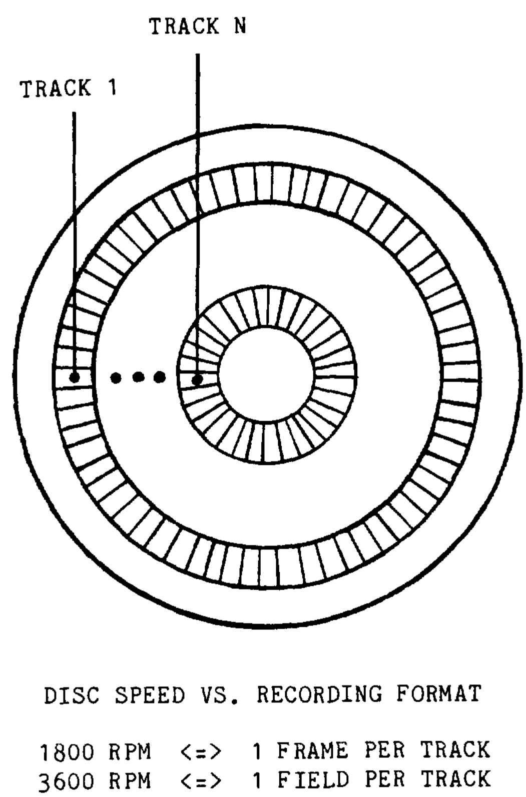

Figure 1
VIDEO DISC GEOMETRY

Conceptually, there is little difference between discs which record one frame per track and discs which record one field per track. However, there are some practical differences. For example, the field-per-track discs must spin twice as fast as the frame-per-track discs which requires more frequent mechanical maintenance. On the other hand, there are some instances in which the ability to repetitively display a single field is preferable to a repetitive display of a single frame due to "interfield flicker" which occurs in "freeze frame" displays. However, for the sake of simplicity all references to video discs in the remainder of this paper will assume a frame-per-track organization.

Recording Capacity -- The recording capacity of a video disc can be stated as either a number of frames or as a number of seconds of continuous video at the normal rate of 30 frames per second. For example, a 600 frame disc may also be called a 20 second disc because it can retain 20 seconds of recorded video at the normal rate. Most commonly available VDRs have recording capacities of 10 or 20 seconds. Although this is considerably less than the capacity of video tapes, it is generally adequate for alarm assessment purposes.

Continuous Recording -- In order to record or replay at the normal real time video rate of 30 frames per second, two independent heads are required so that one head can be moved into position while the other head is recording. A typical head configuration for real time recording is shown in Figure 2 in which one head accesses the odd numbered tracks on the upper disc surface and the other head accesses the even numbered tracks on the lower surface.

Unlike VTRs, VDRs can be used in a continuous loop recording mode where the last logical track is recorded next to the first logical track. This eliminates the rewind delay and end-of-tape problem associated with VTRs. However, disc heads can be moved only a limited distance during the time required to record one frame, so consecutive logical tracks must be in close physical proximity to avoid the loss of incoming video during extreme head movements. For this reason the configuration shown in Figure 2 does not support continuous loop recording due to the large distance from tracks n-1 and n to tracks 1 and 2. However, the track arrangement shown in Figure 3 where the first logical track is adjacent to the last logical track and no pair of consecutive logical tracks is separated by more than two physical tracks can be used for continuous recording.

Solid State Digital Memory

The third type of video recording device presently available is solid state digital memory. Solid state memory is extremely reliable because it has no moving parts. In addition, it can be read or written in a random access fashion with no access delay. This provides instant recording and the use of a circular memory scheme permits continuous recording. Furthermore, the capacity and video resolution of digital memory are effectively limited only by the amount of memory available.

The single drawback to the use of solid state memory for video recording is that it is very expensive in comparison with video tapes and discs; cost considerations usually limit the amount of digital memory to a few frames per

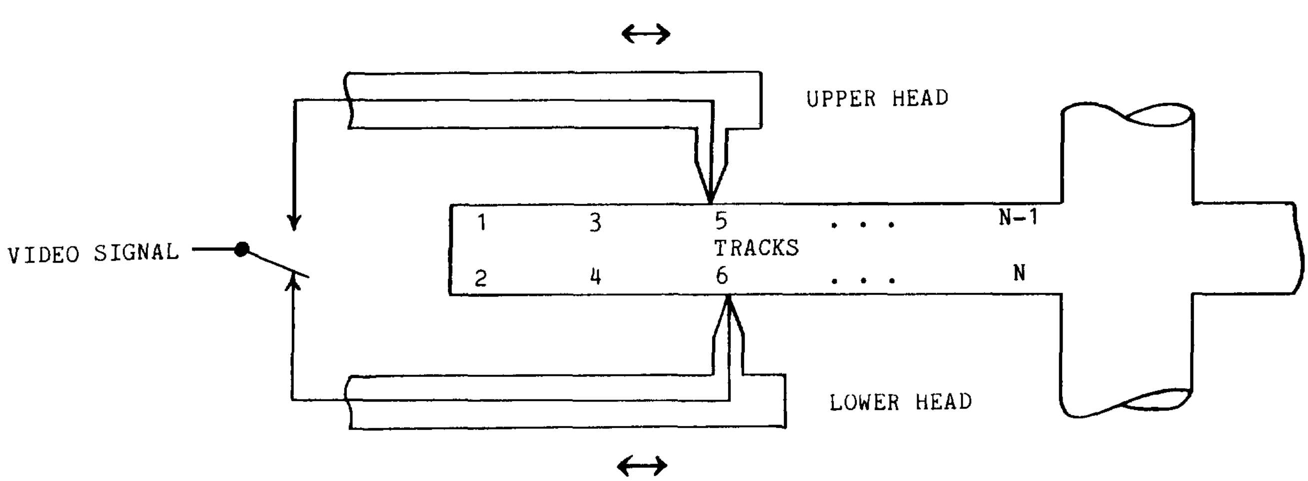

Figure 2
LOGICAL TRACK ARRANGEMENT FOR REAL TIME RECORDING

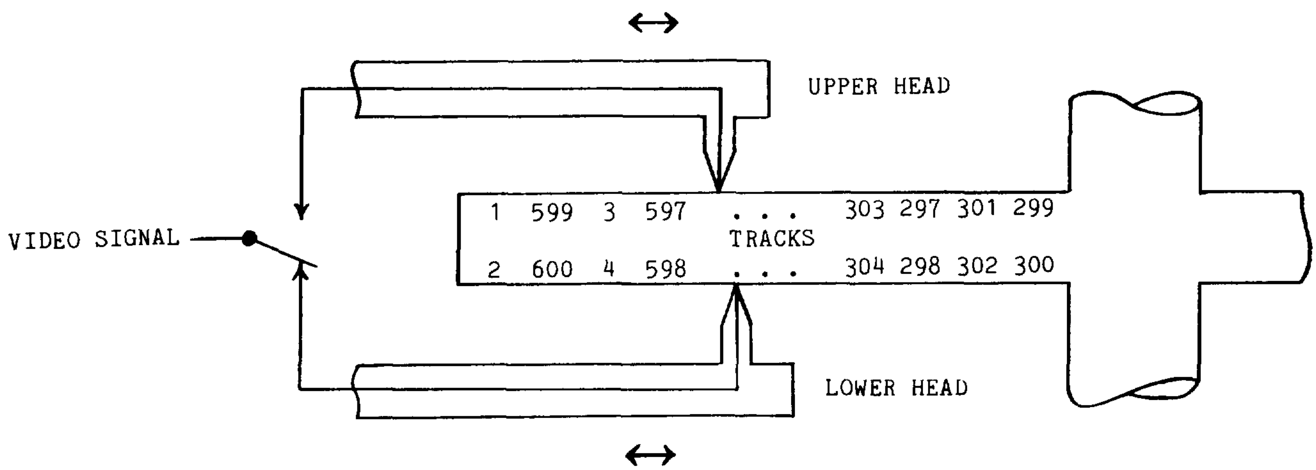

Figure 3
LOGICAL TRACK ARRANGEMENT FOR CONTINUOUS LOOP RECORDING

scene. The use of digital processing algorithms presently under development may eventually alleviate this problem by allowing many intermediate frames of video data to be interpolated from a few recorded frames. However, until these algorithms are fully developed, video disc and tape recorders will remain much more practical alternatives for retaining many recorded frames of video data.

PART II
Multiplexed Video Disc Recording

As discussed in the first half of this paper, video disc recorders have a number of advantages over video tape recorders for use in alarm assessment systems. The main disadvantage of VDRs is cost since a single VDR costs significantly more than a single VTR. This section of the paper describes a recently developed video multiplexing technique which enables one VDR to be used to simultaneously record a potentially large number of alarm scenes and can thereby significantly offset the cost of using multiple VDRs or multiple VTRs in a one-recorder-per-scene manner.

Hardware Considerations

The particular multiplexing technique that will be described is a form of time division multiplexing in which multiple scenes are multiplexed onto a single disc by interleaving frames from each scene at the input to the VDR. In other words, instead of recording one scene at the normal rate of 30 frames per second, N scenes can be recorded at the reduced rate of 30/N frames per second each by recording the first frame of the first scene, the second frame of the second scene, etc.

A block diagram of the hardware that is required to perform this multiplexing is shown in Figure 4. A high speed video switcher is required to (1) route either live or recorded video to the monitor for display to the operator and (2) to route the proper video sources on a frame-by-frame basis to the input of the VDR in accordance with the multiplexing pattern.

The output of the VDR is fed to a video storage device which can acquire and repetitively display a single frame or field of video information. This device is needed to provide a continuous video signal even though the frames that are being replayed from the VDR may be occurring at widely separated intervals. (This frame storage device may be a separate unit or separate set of non-movable heads which are an integral part of the disc.) The output of the frame storage unit is then fed to one of the inputs of the video switcher so that it is available for routing to the monitor or other locations.

Finally, a controller is required that will accept commands from other parts of the security system to initiate the recording or replay of various scenes, incorporate these scenes into the multiplexing pattern, operate the routing switcher, position the disc heads, control the record and replay electronics, and handle the video storage unit.

Visual Quality of Multiplexed Video

It is significant to note that the reduced recording rates that are used for multiplexing video scenes on the disc do not adversely affect the ability to assess the action in the scene. In fact, the reduced recording rate

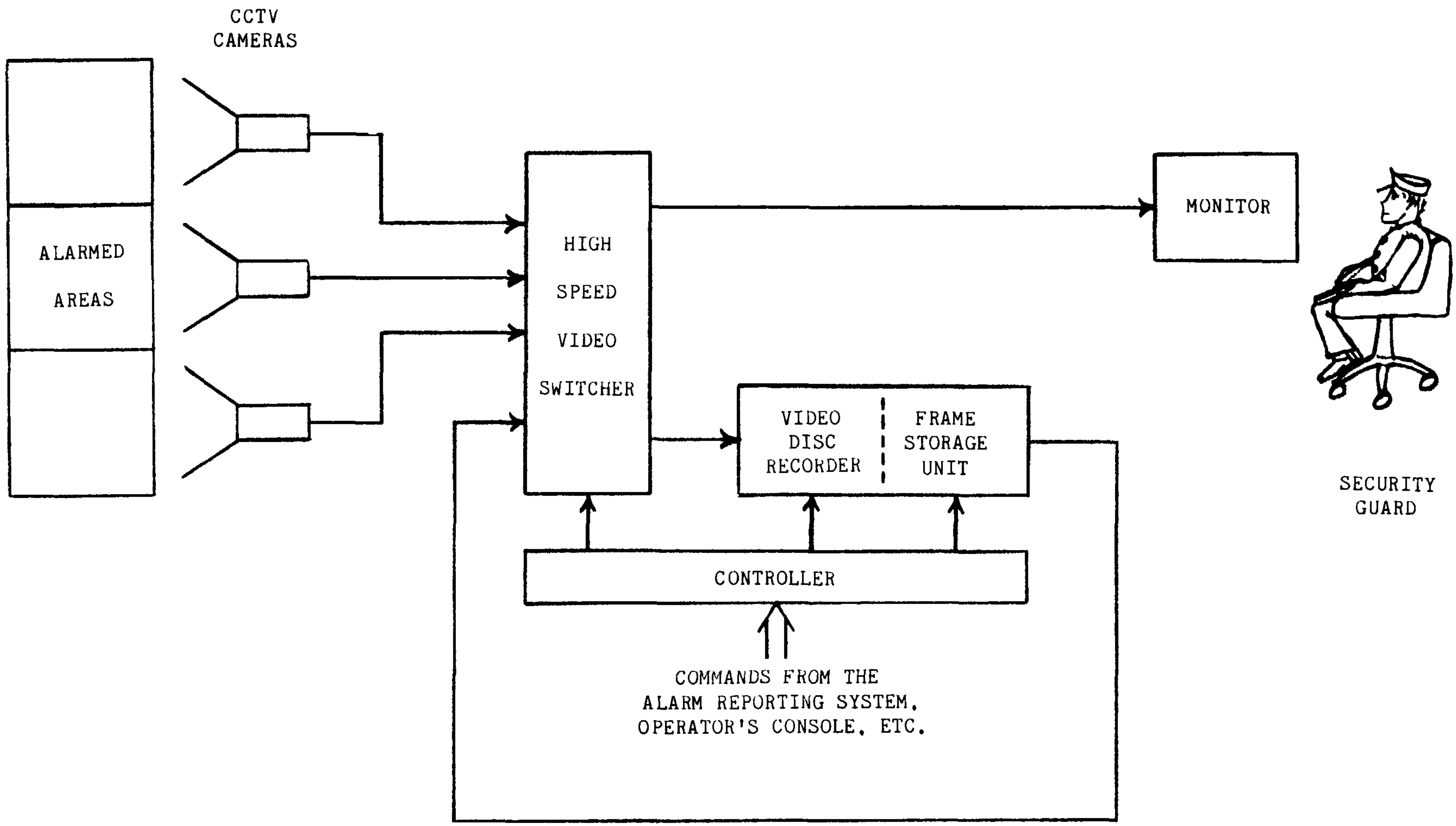

Figure 4
BLOCK DIAGRAM OF MULTIPLEXED VIDEO DISC RECORDING HARDWARE

actually accentuates motion in many cases. In particular, scenes which were recorded at rates of one-half to one-quarter normal speed (i.e., at 15 or 7.5 frames per second) are practically indistinguishable from scenes that were recorded at normal speed unless there is extremely rapid motion in the scene. When rapid motion is present, it is accentuated by the reduced recording rate. Also, it would appear that rates as low as 1/16 speed (i.e., 2 frames per second) or lower may be quite acceptable for assessment purposes. Thus, for a given level of coverage, multiplexing can reduce the cost of using video discs by a factor of 16 or more with no appreciable degradation in assessment capability.

Fixed Versus Variable Number of Scenes

The multiplexing technique that was described above can be used to record either a fixed number of scenes or a variable number of scenes. These two alternatives represent significantly different cases from both the operational and technical viewpoints and are discussed further in the following sections.

Recording a Fixed Number of Scenes

One application of the multiplexing technique is to decide a priori how many scenes will be recorded and develop a multiplexing pattern that will accommodate exactly that number of scenes. For example, if four scenes are to be multiplexed, an interleaved pattern of the form ABCD...ABCD can be used to assign each scene to every fourth track across the entire disc; that is, tracks 1, 5, 9, etc. would be permanently allocated to scene A, tracks 2, 6, 10, etc. would be permanently allocated to scene B, and so on. In this pattern, the first frame is recorded from scene A, the second from scene B, etc. After a frame is recorded from scene D, the pattern is repeated from the beginning again.

One advantage of the fixed number of scenes approach is that it is possible to record all of the scenes at all times. In particular, after each scene has been recorded on its designated tracks for one complete pass across the disc, the record heads "wrap around" from the last track to the first track again. That is, the frames that were recorded on the previous pass are overwritten on each subsequent pass. The time required to record one pass is called the disc duration and is equal to the disc's frame storage capacity divided by 30 since 30 frames are recorded each second. For example, a 600 frame disc has a duration of 20 seconds and its record heads wrap around every 20 seconds during continuous loop recording.

The recording of a particular scene can be terminated at any time to allow the recorded video to be replayed rather than being overwritten. The scene continues to occupy its usual position in the multiplexing pattern but no new frames of that scene are recorded. Since each scene is recorded in a circular fashion with each new frame overwriting the oldest recorded frame of the same scene, the beginning of the recorded scene is located at the next track of that scene after the point of termination. Also, when this type of circular recording is used, the duration of a scene is always equal to the disc duration, D, regardless of the specific point at which recording is terminated. If the recording of a particular scene is terminated upon the receipt of an alarm, then the recorded scene consists entirely of pre-alarm video. If post-alarm video is also required, recording can be continued for some time $T < D$ after alarm detection to capture T seconds of post-alarm video at the expense of overwriting the earliest T seconds of pre-alarm video. After the alarm has been assessed, the circular recording that is used in the absence of alarms can be resumed for the scene that was just replayed.

This mode of operation may be especially desirable if the assessment of an alarm might depend upon activity that preceded the activation of a sensor or if the delay between sensor activation and the initiation of recording could be significant due to delays in the alarm reporting system.

Another advantage of the fixed number of scenes approach from the viewpoint of the controller is that the multiplexing pattern and disc track allocation can be permanently established at the time that the system is designed rather than being computed while the system is in operation.

However, this approach also has several potential disadvantages. For one, the permanent establishment of a multiplexing pattern not only predefines the maximum number of scenes that can be recorded, but it also rigidly fixes the rate at which the scenes will be recorded. As a consequence, this approach can not dynamically adapt to changing requirements such as the need to record an unusually large number of scenes. Furthermore, this approach may also fail to fully utilize the capability that is available such as recording one scene at normal speed to the exclusion of all other scenes in those cases in which only one sensor from one area is alarming.

Recording a Variable Number of Scenes

The principal advantage of being able to record a variable number of scenes is that the multiplexing technique can dynamically adapt to always provide the best possible performance. In particular, if there is only one scene to be recorded, this approach can utilize all of the tracks on the disc to record the one scene at the normal rate of 30 frames per second. On the other hand, if a number of alarms subsequently occur, this approach can dynamically adjust the track allocation to record each of the scenes at a reduced rate. Consequently this approach does not have the disadvantages of the fixed number of scenes approach of "wasting" recording capability on scenes that do not need to be recorded or of not being able to extend the multiplexing pattern to include a larger number of scenes if the need arises.

This multiplexing technique also uses a multiplexing pattern that determines both the time sequence in which the various video sources are recorded and the spacial pattern of disc track allocation. However, this multiplexing technique is complicated by the need to insert scenes into the multiplexing pattern as alarms occur and subsequently delete scenes from the multiplexing pattern as scenes are assessed. The following discussion describes an efficient and manageable multiplexing pattern that can be maintained in a dynamic recording environment.

Scene Insertion -- Conceptually, multiplexing a variable number of scenes is accomplished by recording the first scene at full speed on all of the tracks of the disc and then subsequently reducing the rate and number of tracks allocated to one or more recorded scenes as each new scene is added to the multiplexing pattern. (However, it should be emphasized that the recording rate should not be reduced below the minimum rate which is acceptable for assessment purposes and therefore there is an upper limit on the number of scenes that can be multiplexed.) For example, in the multiplexing pattern AAAA..., scene A is assigned to every track on the disc and is being recorded at full speed.

To accommodate a second scene B in a new multiplexing pattern ABAB..., the tracks can be reallocated so that the original scene A continues to use the odd-numbered tracks and the new scene B is given the even-numbered tracks. This reallocation must be done in a specific way if a uniform rate and corresponding pattern of tracks is to be maintained for each scene. This point can be illustrated by considering the insertion of a third scene C into an established pattern of the form ABAB... It is not sufficient merely to reallocate every third track of the original pattern to obtain the new pattern ABCBACABCBAC... because the original scenes A and B would no longer have uniform rates. Instead, their rates would vary from 1/4 speed to 1/2 speed on a frame by frame basis. Furthermore, the rates would become more irregular and the multiplexing pattern would become more complex with each subsequent insertion.

The only way to reallocate some previously recorded tracks of one scene (while maintaining a uniform rate and corresponding pattern of tracks for that scene as well as the new scene that is to be inserted) is to reallocate exactly every other track of the scene that is to be subdivided. Thus, the insertion of a third scene into the pattern ABAB... would result in either the pattern ABCB... or the pattern ABAC..., depending on whether the new scene's tracks were reallocated from scene A or scene B.

The insertion procedure described above is called binary multiplexing because it is accomplished by "splitting" one of the original scenes into two halves to obtain space for the new scene. In order to equalize the rates of the different scenes as much as possible, it is generally desirable to split the scene with the highest rate each time a new scene is inserted. In practice, binary multiplexing is very easy to implement because it only involves changing the allocation of the one original scene and creating the new scene's allocation.

Scene Duration -- In this dynamic multiplexing technique, after new scene has been inserted into the multiplexing pattern, its first frame is recorded on the first of its newly allocated tracks that is encountered by the record heads. Therefore the location of the first track of the scene depends on the position of the heads at the time that the recording was initiated. After the scene has been recorded for one pass across the disc, the heads return to the first track of the scene again. In the simplest form of this multiplexing technique, the recording of the scene is terminated at that point to yield a scene duration equal to the disc duration. However, it is possible to extend the duration of a scene beyond one pass around the disc at the cost of a corresponding reduction in the recording rate. For example, a duration of two passes can be achieved by halving the recording rate speed and recording half of the allocated tracks on the first pass and the other half on the second pass. In general, P passes can be recorded in a similar way by reducing the rate by 1/P, etc. However, it must be emphasized that any lower limit which assessment requirements impose on the recording rate will, in turn, impose an upper limit on the duration of any scene. Therefore, very long scene durations must be avoided unless correspondingly slow recording rates are acceptable for assessment.

Scene Deletion -- Ideally, the deletion of a scene following its assessment would result in an increase in the rate of another scene. Unfortunately, while the rate of a recorded scene can be reduced at any time by reallocating some of its tracks to another scene, it is not possible to retroactively increase the rate of a scene because unrecorded video cannot be recaptured at a later time. Consequently, it is only possible to simply designate the deleted scene's position in the multiplexing and track allocation patterns as "available" so that the next scene to be inserted can assume that position instead of splitting another scene.

Adjusting the Number of Tracks -- As discussed earlier, the record heads "wrap around" at the end of the disc. As a consequence, the total number of tracks on the disc must be carefully chosen if discontinuities in the multiplexing pattern are to be avoided. (The number of tracks on the disc is "chosen" by restricting the number of tracks that the controller actually uses to be some number that is less that the maximum number of tracks that are physically available.) In the fixed number of scenes multiplexing technique, proper wrap around can be ensured by adjusting the number of disc tracks to be a multiple of the constant pattern length. In the variable number of scenes approach, the solution is not quite so straightforward because the length of the multiplexing pattern varies depending on the number of scenes that are being multiplexed. However, proper wrap around can be ensured for binary multiplexing by adjusting the number of tracks to be a multiple of a power of 2 of the form $M*2^k$, where 2^k is the upper limit on the number of scenes (i.e., $30/2^k$ frames per second is the slowest recording rate permitted) and M is the minimum number of tracks per scene. For example, if the maximum number of scenes is 32 (2^5) resulting in a minimum recording rate of approximately 1 frame per second, a 300 track disc can be reduced to 288 ($9*2^5$) usable tracks to ensure proper wrap around for all scenes with a minimum of 9 tracks per scene and a duration of approximately 9 seconds per pass.

Replay Considerations

Initiation and Termination of Replay -- The replay of a recorded scene can be initiated and terminated automatically by the assessment system or in response to explicit requests from the operator. However, if replay is initiated automatically, the operator's attention may be directed elsewhere when the replay begins. Furthermore, if replay is terminated automatically (e.g., after one review of the entire scene), the replay may continue for longer than necessary or, worse yet, terminate before an assessment can be made. Therefore, it is generally desirable to initiate replay only at the operator's request, thereby assuring that he is ready to begin assessment, and to allow continuous or repeated review of the scene until the operator indicates that the assessment has been completed.

Scene Selection -- In cases of multiple alarms, some mechanism is needed to determine which scene is to be replayed. As with the initiation and termination of replay, scene selection can be automatic or operator controlled. Automatic scene selection frees the operator from the distraction of specifying the particular scene for each assessment. It is best accomplished by queueing, which may be based entirely on the time of alarm occurrence or may be prioritized if alarm priorities are defined. However, regardless of the specific automatic selection algorithm that is used, manual selection of scenes may be essential for the timely assessment of unusual or unforeseen situations. Therefore, it is often most effective to provide automatic scene selection as a default mechanism while allowing manual selection to be used as an override procedure.

Concurrent Recording and Replay -- The multiplexing techniques require that recording and replay occur concurrently on the disc in order to avoid terminating all recording simply because one of the scenes is being replayed. However, the controlled head movements that are required for multiplexed recording impose certain restrictions on the replay if the same pair of disc heads is used for both functions.

Specifically, the recording function requires that a pair of record heads maintain a continuous loop sweep across the disc in order to record the incoming frames on their designated tracks. Thus, when a replay is requested, those heads cannot be moved directly to the start of the scene to be replayed unless recording is terminated. If recording is to continue, the replay of the first frame of the scene must be delayed until the heads reach the proper position through their usual motion.

The magnitude of this delay depends on the particular position of the heads when the replay is requested. In the worst case, the delay is equal to the disc duration while, on the average, the expected delay is half of that amount. Therefore, if concurrent recording and replay are to be performed with a single pair of heads, a relatively short disc duration may be desirable to reduce the delay before replay. Even so, some noticeable delay will usually be encountered. However, it is possible to begin the assessment before the heads return to the start of the scene by replaying any frames from the "middle" of the scene that the heads encounter or by switching live video onto the monitor until the replay begins.

Concurrent recording and replay with a single pair of heads also restricts the rate of the replay. Since the heads must maintain their usual continuous loop motion to continue recording, each scene must be replayed at the same rate at which it was recorded. In addition, it is impossible to replay an arbitrary segment of a scene repeatedly without a delay between repetitions.

Independent Sets of Record and Replay Heads -- The replay restrictions described above can be eliminated if the disc is equipped with one pair of record heads and a second, independent pair of replay heads which access the same set of tracks. In this configuration, the record heads can maintain the recording function while the replay heads are dedicated entirely to the replay function. Thus, a replay can begin without waiting for the record heads to reach the start of the scene because the replay heads can be moved directly to the desired track. Similarly, an arbitrary segment of a scene can be repeated without a significant delay between repetitions because the replay heads can be moved directly from the last track of the segment to the first track. In addition, the replay rate can be faster or slower than the recording rate. In fact, the replay rate can be placed under operator control, allowing the use of a fast scan to locate the segment of interest and a slower scan for the actual assessment. Finally, the replay can proceed either forward or backward in time or be stopped on any frame.

State of the Art

The concept of multiplexing video information onto a VDR for alarm assessment purposes has been under investigation in the ECADS facility at Sandia National Laboratories since the fall of 1979. Currently the multiplexing technique is being implemented on both a standard VDR with a single pair of record/replay heads and a prototype VDR of commercial manufacture with two independent pairs of record/replay heads. Both systems produce high resolution video signals with the general characteristics that were described earlier under the heading "Visual Quality of Multiplexed Video".

A block diagram of the standard VDR system is shown in Figure 5. In this system, the output signals which are produced by the moving heads during replay operations can be switched directly to the output of the VDR system or to a fixed head that is associated with one dedicated track on the disc. This fixed head track is used to buffer video information for repetitive display while the moving heads are in transit to the next track which contains recorded video for the scene which is being replayed.

A block diagram of the prototype VDR system is shown in Figure 6. This system uses an electronic frame synchronizer to buffer video information for repetitive display since the frame synchronizer unit is also needed in this system to resynchronize the video signals which are reproduced by the second pair of heads with the remainder of the television equipment.

Current hardware costs for the VDRs are:

Standard two-headed VDR -- $30,700

Prototype four-headed VDR -- $55,900

Follow-on four-headed VDR (estimate) -- $43,700

Approximately one man year of software development effort has been required to produce microprocessor-based controllers for these systems.

Conclusions

It is believed that the video multiplexing techniques presented in this paper represent a significant advance in the evolution of CCTV technology in security applications. The basic concepts have been thoroughly examined and refined and system testing of both hardware and software is well underway. The initial results in terms of the visual quality of the multiplexed video signals are most satisfactory. The most outstanding questions that remain concern the long-term reliability and maintainabiltiy of this relatively sophisticated equipment. The answers to these questions can only be gained from further operational testing and evaluation.

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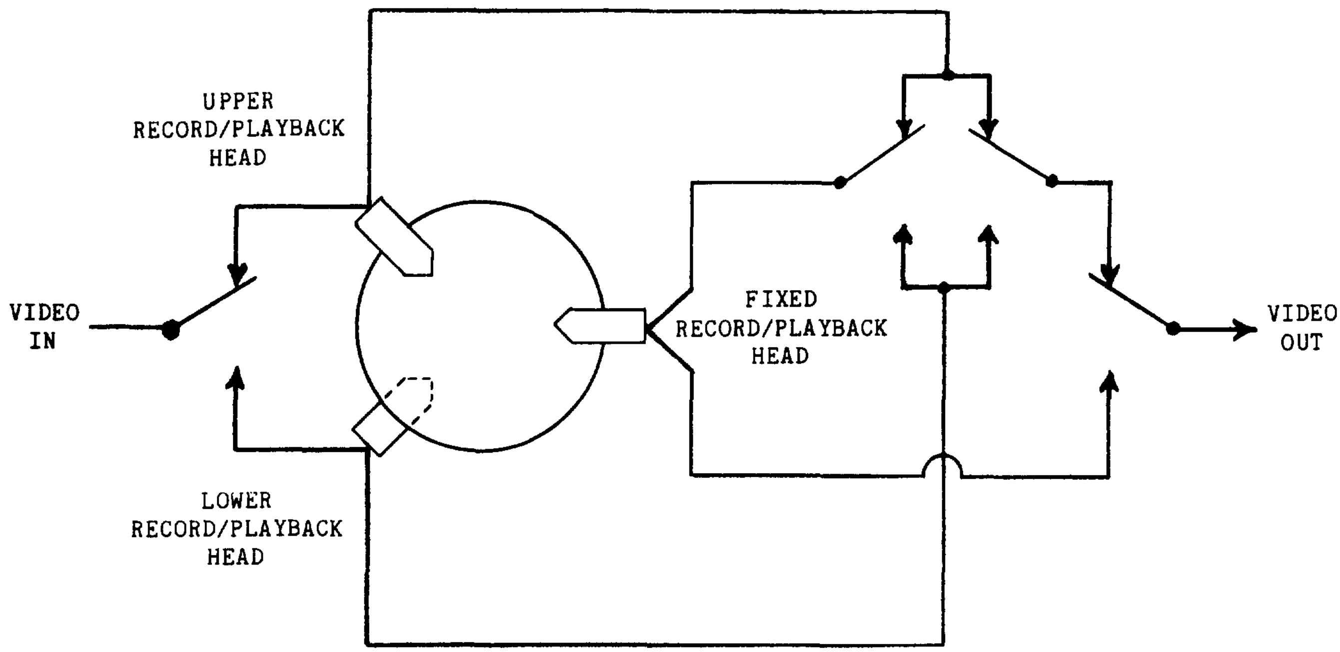

Figure 5
BLOCK DIAGRAM OF STANDARD VDR WITH SINGLE PAIR OF HEADS

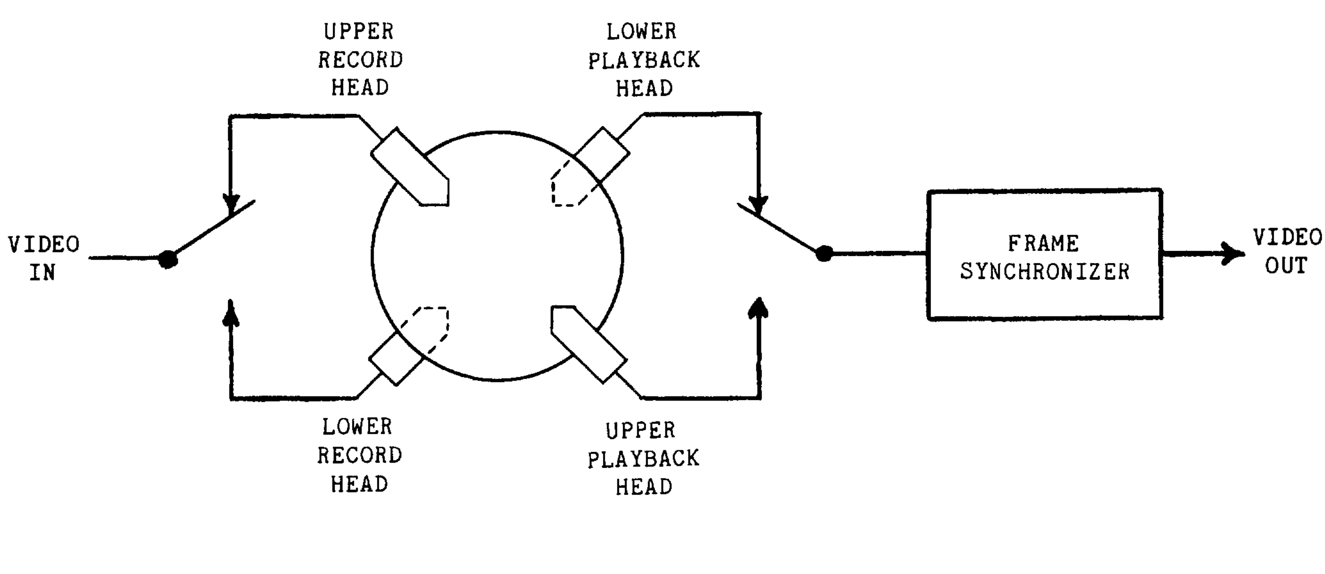

Figure 6
BLOCK DIAGRAM OF PROTOTYPE VDR WITH TWO PAIRS OF HEADS