Frontiers of Engineering in Health Care

OCTOBER 6-7, 1979

Frontiers of Engineering in Health Care

IEEE/ENGINEERING IN MEDICINE
AND BIOLOGY SOCIETY
FIRST ANNUAL CONFERENCE



OCTOBER 6-7, 1979 DENVER HILTON HOTEL DENVER, COLORADO

F. Dale, D. Alan J.

IEEE Catalog No. 79CH1440-7 EMB Library of Congress Catalog Card No. 79-83926

Copyright and Reprint Permissions: Abstracting is permitted with credit to the source. Libraries are permitted to photocopy beyond the limits of U.S. copyright law for private use of patrons those articles in this volume that carry a code at the bottom of the first page, provided the per-copy fee indicated in the code is paid through the Copyright Clearance Center, P.O. Box 765, Schenectady, NY 12301. Instructors are permitted to photocopy isolated articles for noncommercial classroom use without fee. For other copying, reprint or republication permission, write to Director, Publishing Services, IEEE, 345 E. 47 St., New York, NY 10017. All rights reserved. Copyright © 1979 by The Institute of Electrical and Electronics Engineers. Inc.



ENGINEERING IN MEDICINE AND BIOLOGY SOCIETY

OFFICE OF THE PRESIDENT Eli Fromm, Ph.D.

PLEASE REPLY TO:
Biomedical Engineering & Science Program
Drexel University
Philadelphia, PA 19104
(215) 895-2217

MESSAGE FROM THE PRESIDENT OF THE IEEE ENGINEERING IN MEDICINE AND BIOLOGY SOCIETY

A national and international conference is the highlight of the year's activities of a technical professional society. It is especially so this year for the IEEE Engineering in Medicine and Biology Society since it marks the first of an anticipated annual event. As the organizers and sponsor of this conference we have endeavored to have it serve as a focal point. Our technical committees, publications editors and members of the administrative committee have planned together to bring you presentations at the frontiers of both research and the clinical/industrial applications. Key people have been invited to organize the sessions with both invited and contributed papers. Tutorials and workshops have been included within the regular conference program making it a very full two days. Full papers are published in the Conference Proceedings and preview abstracts of each paper are to appear in the September (pre-conference) issue of the IEEE Transactions on Biomedical Engineering.

Having first expressed the need for our Society to have an annual technical focal point when I first had the priviledge of becoming a member of the executive committee in 1973, it is a gratifying moment to see what we then began as an annual small business meeting evolve into a full technical forum. We owe much gratitude to those who labored to bring this program together in a manner designed to offer the attendee maximum technical benefit and interaction.

Welcome to our conference, enjoy, learn and reap the benefits of interaction with colleagues as a participant in this giant step of technical focus of our Society.

Eli Fromm, Ph.D. President

From the Program Chairman

The primary purpose in organizing the Frontiers of Engineering in Health Care Conference is to better serve the changing needs of the IEEE/Engineering in Medicine and Biology Society. This annual conference offers participants the opportunity to engage actively in a common forum advancing the frontiers of engineering in health care. The opportunity is provided for all groups involved to present the state-of-the-art in biomedical engineering technology and to discuss the safe and effective use and management of medical devices. This interaction will allow all specialty groups and professionals in the health care community to communicate more effectively to advance biomedical research and to improve patient care.

Technical sessions, tutorials and workshops including selected and invited presentations have been obtained, and a special effort has been made to select session chairpersons who will work in developing their sessions so that only the most relevant topics will be presented. Key papers have been invited for all sessions.

All papers presented are supplemented by a published abstract and a full paper. An abstract of each paper will be published in the EMBS Transactions, and the full paper will be published following peer review in the Conference Proceedings for this conference.

Morton D. Schwartz/Program Chairman

Conference Committee

Program Chairman

Morton D. Schwartz California State University, Long Beach, CA

Publicity Chairman

Allen W. Hahn John M. Dalton Research Center University of Missouri-Columbia, MO

Conference Administration

Eli Fromm Drexel University, Philadelphia, PA

Local Arrangements

K. C. Rock University of Colorado Medical Center, Denver, CO

Conference Management

P. Horner Bethesda, MD

General Chairman

Richard J. Gowen South Dakota School of Mines and Technology, Rapid City, SD

Industrial Co-Sponsors

Hewlett-Packard - Medical Products Group

Honeywell - Medical Products for Cardiology and Clinical Laboratories and Instrumentation Service for the Hospital

Physio-Control Corp., Redmond, Washington

Program Committee

John Clark Electrical Engineering Department Rice University, Houston, TX

Al Cook Electrical Engineering Department California State University, Sacramento, CA

Gilbert Devey National Science Foundation Washington, D.C.

Donald Dick Life Instruments Corporation Broomfield, CO

Thelma Estrin Brain Research Institute University of California, Los Angeles, CA

Barry Feinberg Purdue University, West Lafayette, IN

Emanuel Furst Biomedical Engineer University of Arizona Health Science Center Tucson, AZ

Samuel Goldman Picker Corporation, Clinical Laboratory Division Northford, CT

William Jarzembski Biomedical Engineer Texas Tech University Health Science Center Lubbock, TX

Dean Jeutter Electrical Engineering Department Marquette University, Milwaukee, WI

Larry Katz Center for Biomedical Engineering Rensselaer Polytechnic Institute, Troy, NY

J. Knutti Center for Integrated Electronics in Medicine Stanford University, Stanford, CA

Robin Lake University Hospital Cleveland, OH

Chi-ning Liu Hewlett-Packard, CA

Don McNeal Rancho Los Amigos Hospital Downey, CA

Kenneth Mylrea Electrical Engineering Department University of Arizona, Tucson, AZ Lee E. Ostrander Center for Biomedical Engineering Rensselaer Polytechnic Institute, Troy, NY

Robert Plonsey Case-Western Reserve Cleveland, OH

Alfred Potvin Biomedical Engineering University of Texas at Arlington, TX

Richard Randlett Manager, Advanced Product Development Laboratory Harris-Semiconductor Co., FL

Blair A. Rowley Department of Biomedical Engineering Texas Tech University, School of Medicine Lubbock, TX

Louis Sheppard Department of Surgery University of Alabama, Birmingham, AL

Willis Tompkins Department of Electrical and Computer Engineering University of Wisconsin, Madison, WI

George Webb Johns Hopkins Hospital Baltimore, MD

John Webster Department of Electrical and Computer Engineering University of Wisconsin, Madison, WI

Leon Wheeless Rochester University Medical Center Rochester, NY

Myron Youdin New York University Medical Center Institute of Rehabilitation Medicine, NY

IEEE Engineering in Medicine and Biology Society

The Engineering in Medicine and Biology Society of the IEEE (IEEE/EMBS) is an association of 7,000 members concerned with the application of engineering science and methodology to biology, medicine, and health care delivery systems.

EMBS is a Society within the umbrella framework of the Institute of Electrical and Electronics Engineers (IEEE) offering identification with the world's largest professional engineering organization of 180,000 members. Activities of the IEEE/EMBS include:

Publications - The IEEE Transactions on Biomedical Engineering is a monthly publication of reviewed articles reporting original research and application and development, short communications to disclose new ideas, and tutorials and reviews. The EMBS Newsletter is published quarterly and contains news and events of current interest to biomedical engineering professionals.

Conferences - Conference Proceedings are widely distributed and indexed through IEEE and may be purchased at member's prices from IEEE. The Society also cosponsors and/or cooperates in other national and regional biomedical conferences.

Technical and Professional Committees - EMBS

Committees organize conference sessions, workshops and special activities on behalf of the Society.

Technical Committees include: bioelectric phenomena, clinical engineering, medical instrumentation, prosthetic and sensory aids, signal processing and information handling, transducers and devices, and biomaterials. Professional Committees include: awards, biomedical coordination, education, ethics, membership, professional activities, publications, standards, government affairs, and industrial relations. In addition, EMBS participates, through appointed delegates, in other national bodies such as ANSI and NFPA as well as in broad based IEEE Technical Committees addressing such issues as energy, ocean engineering, environmental quality, man and radiation, and social implications of technology.

Regional Councils and Chapters - Society members have the opportunity to exchange technical and professional information with colleagues in their same geographic area through meetings and activities of 7 EMBS Regional Councils and 33 Chapters. Membership in these geographically organized subdivisions is an automatic component of Society Membership.

Membership in IEEE/EMBS is open to all qualified persons in grades designated student, senior member, fellow, and affiliate. Biomedical professionals who wish to join EMBS but not join the IEEE umbrella organization may do so as affiliate members of EMBS. Affiliate members are accorded the opportunities of participation in all EMBS programs and activities as planned and administered by the EMBS elected Administrative Committee (AdCom).

SATURDAY, OCT. 6

		r			1
Futorials 8 Workshops 7:30 AM-9 AM	Morning Technical Session 9 AM-Noon	Lunch Breek Noon-1:30 PM	Afternoon Technical Session 1:30 PM-4:30 PM	Tutorials & Workshops 8 PM—10 PM	Room
	Session 1 Signal Processing and Imaging Part 1		Session 5 Signal Processing and Imaging Part 2 Session 6 Computers in Medicine	Microprocessors and Instrumentation	Silver Room
	Session 2 Biopotential and Bio- chemical Instrumentation		Session 7 Clinical Engineering	Pending Changes in the National Electrical Code and its Impact on Health Care	Denver Room
	Session 3 Non-Invasive Diagnostic Technology Part 1		Session 8 Non-Invasive Diagnostic Technology Part 2	Introduction to I.C. Technology and its Applications	Century Room
	Session 4 Standards				Spruce Room

SUNDAY, OCT. 7

Tutorials & Workshops 7:30 AM–9 AM	Morning Technical Session 9 AM-Noon	Lunch Break Noon-1:30 PM	Afternoon Technical Session 1:30 PM-4:30 PM	Tutorials & Workshops 8 PM-10 PM	Room
Computers in the Practice of Medicine	Session 9 Biomechanical Instrumentation	Keynote Address Dr. Seymour Perry National Center for Health Care Technology	Session 13 Computerized Control of Therapy Session 14 General Principles of Biomed. Engr.	BME Program Directors Meeting	Silver Room
Delivery of Rehabilitation Services	Session 10 Devices for the Disabled Part 1	(See Announcements for Luncheon Room Assignment)	Session 15 Devices for the Disabled Part 2 Session 16 Education	ECG Data Reduction Algorithms for Microprocessors	Denver Room
Health Care Engineering Management	Session 11 Bio Electric Signals Part 1		Session 17 Bio-Electric Signals Part 2		Century Room
	Session 12 Telemetry	* *	Session 18 Totally Implantable Telemetry Systems	eq.	Spruce Room

TABLE OF CONTENTS

manok if religion.

and possibly presentated they are in the

	SESSION 1		2.3	Experience with a Modular µP Base for Medical Instruments	45
	Signal Processing and Imaging — Part I			S. K. Burns, N. B. Dowling, S. K. Peterson, R. L. Pettyjohn, P. S. Schluter, J. R. Tole,	445
11	Statistical Pattern Recognition of Ballistocardio-				
1.1				J. W. Valvano, and R. G. Mark	
	grams	1	2.4		46
	R. Hanka, University of Cambridge, England			K. R. Nelson, R. J. Morgan, M. K. Wells, and	
1.2	Quantization Studies on Data Compression			M. B. Histand, Colorado State University, Fort	
	Techniques Applied to ECG Data	7		Collins, Colorado	
	M. Shridhar and N. Mohankrishnan, University		2.5	Variation of Cardiac Pacemaker Rate Relative	
	of Windsor, Windsor, Ontario, Canada; M. F.		2,0	to Respiration	-5Ô
				The second secon	
250	Stevens, Bell-Northern Research, Ottawa,			W. A. Getzel and J. M. Orlowski, The Medical	
-	Ontario, Canada			College of Wisconsin, Wauwatosa, Wisconsin;	
1.3	Increased Information and Reduced Dose in			B. C. Bergner, B. A. Cunningham, M. J. Esser,	
	Chest Radiography: The Integrated Radiog-			M. A. Jacob and D. C. Jeutter, Marquette	
	raphy System	12		University, Milwaukee, Wisconsin	
	R. E. Wernikoff, J. S. Ballas and D. Collier,		2.6	An Integrated System for Esophageal pH Moni-	
	Brattle Instrument Corporation, Cambridge,			toring	- 53
	Massachusetts; R. E. Dinsmore, S. W. Miller			R. J. Lee, Jr., R. J. Connelly, M. L. Ramenofsky,	
	and M. S. Potsaid, Massachusetts General			and L. L. Leape	
			22	AND AND A STATE OF THE STATE OF	
	Hospital, Boston, Massachusetts		2.7	An Instrumentation System for the Simulta-	
1.4	A Circuit for Minimizing False Alarms in Com-			neous Measurement of Transcutaneous Oxygen	
	puterized ECG Monitoring	16		and Skin Blood Flow	55
	N. V. Thakor and J. G. Webster, University of			D. W. Piraino, G. L. Zick, and G. A. Holloway,	
	Wisconsin-Madison, Madison, WI			University of Washington, Seattle, Washington	
1.5	Nonstationary EEG Analysis Using the Maxi-		2.8	Electrochemical Removal of UREA: A Basis for	
	mum Entropy Method	20		a Regenerative Dialysis System	59
	C. Pomalaza, J. Aunon and C. McGillem,			R. W. Keller, Jr., S. J. Yao, J. M. Brown and S. K.	
	Purdue University, West Lafayette, Indiana			Wolfson, Jr., University of Pittsburgh, Pitts-	
1.6	Microcomputer Implementation of EEG Wave			burgh, PA	
UNIVI .	Duration Analysis	25			
	J. E. Zicker and W. J. Tompkins, University of			SESSION 3	
	Wisconsin-Madison, Madison, WI			3E331014 3	
1.7	Estimation of Intracranial Pressure by Measure-			New Jersel - Discountie Technology - Death	
	ment of Visual Evoked Potentials	29		Non-Invasive Diagnostic Technology — Part I	
	D. H. York, M. Pulliam, J. Rosenfeld and C.				
			3.1	Improvements in Ultrasonic CT Data Acquisi-	
	Watts, University of Missouri, Columbia,			tion and Pre-Processing	64
	Missouri			P. A. Lambert, P. L. Carson, D. E. Dick, T. V.	
1.8	An EEG Monitoring Using the Walsh Transform			Oughton, and J. E. Kubitschek, University of	
	on a Standard Microprocessor	32		Colorado, Denver, Colorado	
	J. J. Setton and W. D. Smith, California State		22		
	University, Sacramento, CA		3.2	A Data Acquisition System for Ultrasonic	00
	TO THE PROPERTY OF THE PROPERT			Tomography	68
	se "La Valoro Corporation Col-			K. Chan, R. M. Fish, and W. D. O'Brien, Jr.,	
	DATE V L			University of Illinois, Urbana, Illinois	
	The man will be a second service of the service of		3.3	Broadband Ultrasonic Tomography	69
Rei I	Mod - T			R. A. Altes, Orincon Corporation, La Jolla,	
	SESSION 2			California	
			3.4	Investigation of Phase Incoherent and Other	
	mad galactical for dendrate order on an		3.4		
E	Siopotential and Biochemical Instrumentation			Signal Processing with a Simulated Array for	~~
				Ultrasonic CT	73
2.1	A Dry Electrode Monitoring System	36		S. M. Jones, F. L. Kitsen, P. L. Carson, and	
	J. Fraden, M. R. Neuman and R. Rich, Case			E. J. Bayly, University of Colorado, Denver,	
	Western Reserve University, Cleveland, Ohio			Colorado	
2.2	Eye Position Measurement from the Surface-		3.5	A Resource Sharing Computer Hierarchy for	
	Recorded Electroretinogram	40		Three-Dimensional X-Ray Image Reconstruction	
81		70			77
	J. M. Shapiro, J. E. Cantonnet and S. S.			of the Heart, Lungs, and Circulation	11
	Heghinian, Boston University, Boston, Massa-			B. K. Gilbert, A. Chu, R. D. Beistad, and L. M.	
	chusetts			Krueger, Mayo Clinic, Rochester, Minnesota	

SESSION 4 Standards Session 4 Standards Session 4 Standards Session 4 Standards Standards Session 4 Standards Standards Session 4 Standards Standa						
Evaluation of Bhycaerdial Partusion A. D. Nelson, L. T. Andrews, F. J. Kollarits, J. P. Opdycke, and J. P. Windham, Medical College of Ohio, Toledo, Ohio SESSION 4 SESSION 4 SESSION 4 SESSION 4 A Which Standards A Wald, Columbia University, New York, N. Y. Standards for Hospital Electrical Safety: The View price of Hospital Electrical Safety: The View price of Hospital Electrical Safety: The View from the FDA R. J. Cangelosi, Food and Drilg Administration, Department of Heilith, Education, and Welfare L. G. Foxwell, The Hartford Insurance Group, Hartford, Connecticut A An Analysia of Standards System and Medical Device Standards and Codies-View From Education of G. N. Webb, Johns Hopkins School of Medicine, Baltimore, MD SESSION 5 Session 5 Signal Processing and Imaging—Part 2 5.1 A High-Speed Biomedical Data Acquisition Subsystem R. B. Lake, Case Western Reserve University, Cleveland, O. H. Colon, The Views from Comporation, Oak Collinge of Ohio, Toledo, Ohio Subsystem R. D. Andrews, F. J. Kollarits, J. Kollarits, J. C. Landards and Codes—View From Education of Medicine, Baltimore, MD Session 5 Signal Processing and Imaging—Part 2 5.1 A High-Speed Biomedical Data Acquisition Subsystem R. B. Lake, Case Western Reserve University, Cleveland, O. H. Colon, The View From Comporation, Oak Collinge of Ohio, Toledo, Ohio Computarized Control of Medicine, Baltimore, Manual A. R. Kahin, Nicolet Instrument Corporation, Medican, Wisconsin Computarized Interface to Clinical Engineers in Medicine and Structured Programming R. A. Natural Language Interface to Clinical Data Bases M. Woodyard, B. Hamel, J. R. Bourne, and D. V. Foster, Vanderbille University, New York City, Vir. York City, Vir. York, Vir. Y. S. Habit, City College of New York City, Vir. York, New York City, Vir. York City, Vir. York City, Vir. Y. S. Habit, City College of New York City, Vir. York City, Vir. York City, Vir. York City, Vir. Y. S. Safety City College of New York City, Vir. York City, Vir. York City, Vir. York City, Vir. York City, Vi						
J. P. Opdycke, and J. P. Windham, Medical Collage of Ohio, Toledo, Ohio SESSION 4 SESSION 4 Standards 4.1 Which Standards? A Wald, Columbia University, New York, N.Y. 4.2 Standards for Mospital Electrical Safety: The Viewpoint from Alhesthesiology G. Bashein, University of Weshington, Sesttle, WA 4.3 The View from the PDA R. J. Cangelosi, Food and Drüg Administration, Department of Heilath, Education, and Welfare The View From Liability and Safety Inspections L. G. Foxwell, The Hartford Insurance Group, Hartford, Connecticut An Analysia of Standards' System and Medical Device Standards Device Standards Device Standards System and Medical Device Standards and Codes—View From Voluntary Concessus Standards' System and Medical Device Standards Device Standards and Codes—View From Voluntary Concessus Standards System and Medical Device Standards Standards and Codes—View From Voluntary Concessus Standards System and Medical Device Standards Device Standards Session 5 Signal Processing and Imaging—Part 2 5.1 A High-Speed Biomedical Data Acquisition Subsystem* R. B. Lake, Case Western Reserve University, Cleveland, OH R. B. Lake, Case Western Reserve University, Cleveland, OH Subsystem* Concessing and Imaging—Part 2 5.1 A High-Speed Biomedical Data Acquisition Subsystem* R. B. Lake, Case Western Reserve University, Cleveland, OH Subsystem* R. B. Lake, Case Western Reserve University, Cleveland, OH Scott, The View From Optical State University of Arizona March Lake Topic, Indianapolis, Indiana R. M. Satural Language Interface to Clinical Engineers of D. W. N. Folty, Case Membral Data Subsystem* Session 4 Session 5 A Matural Language Interface to Clinical Engineeris	3.6		83		SESSION 6	
College of Ohio, Toledo, Ohio 8. A Natural Language Interface to Clinical Data Bases 8. Bases M. Woodyard, B. Hamel, J. R. Bourne, and D. V. Foster, Vanderbilt University, Neshville, Tennessee 8. Laboratory Microprocessor Applications and Structured Programming 8. L. Schoenfeld, Rockefeller University, New York, IV, W. Standards for Hospital Electrical Sefecy: The Viewpoint from Americal Sefecy: The View from the PDA 8. J. Cangelosi, Food and Drüg Administration, Department of Heilith, Education, and Welfare 8. R. J. Cangelosi, Food and Drüg Administration, Department of Heilith, Education, and Welfare 8. An Analysis of Standards Device Standards System and Medical Device Standards and Codes—View From Voluntary Concensus Standards' System and Medical Device Standards and Codes—View From Voluntary Concensus Standards' System and Medical Device Standards and Codes—View From Education G. N. Webb, Johns Hopkins School of Medicine, Beltimore, MD 8. SESSION 5 Signal Processing and Imaging—Part 2 5.1 A High-Speed Biomedical Data Acquisition Subsystem* 8. B. Lake, Case Western Reserve University, Cleveland, OH 8. Lake, Case Western Reserve University, Cleveland, OH 8. Cook, The Views Trans to Clinical Engineering to Industry St. J. Cook, The View Transition Comporation, Oak 8. Metaporatory Microprocessor Applications and Structured Programming 8. L. Schoenfeld, Rockefeller University, New York City, NY; S. Habib, City College of New York, New York City, NY 8. B. Lake, Cook The Views Trans Automatical Services Center, The Distribution of Critical Engineers and Services Center, Tucson, Arizona; A. M. Cook, California State University, Sacramento, California State University of Arizona Mora Luck Them Management 8. Computer Views Transition: Clinical Engineers to Heilith College of New York, Ny, F. J. Computing Maintenance Consultants, Inc., Lebaron, Weconsin 8. Computer Views Transition: Clinical					Computers in Medicine	
SESSION 4 Standards Session 5 Standards Session 6 Session 6 Session 7 Standards Session 8 Session 9 Session 8 Session 9 Ses				6.1		
SESSION 4 Session 5 Session 6 Session 6 Session 6 Session 7 Session 7 Session 7 Session 7 Session 7 Session 7 Session 6 Session 7 Session 6 Session 6 Session 7 Session 7 Session 6 Session 7 Session 7 Session 7 Session 6 Session 6 Session 6 Session 6 Session 6 Session 6 Session 7 Session 7 Session 6 Session 6 Session 6 Session 6 Session 7 Session 7 Session 6 Session 6 Session 6 Session 6 Session 6 Session 7 Session 7 Session 6 Session 6 Session 6 Session 7 Session 7 Session 7 Session 6 Session 6 Session 6 Session 7 Session 8 Session 6 Session 6 Session 6 Session 6 Session 7 Session 7 Session 7 Session 7 Session 8 Session 7 Session 7 Session 8 Session 7 Session 8 Session 7 Session 8 Session 7 Clinical Engineer: 1 He Prepared? Can He grow? M. O. Brinkman, Hospital Maintenance Consultants, Inc., Lebanon, Wisconsin More Luck Then Melanegament M. M. Foltz, Community Hospital of Indianapola, Inciden Corporation, Oak K. J. Cook, The Velaron Corporation, Oak Session 8 Session 9 Session 6 Session 9 Sessio			e			126
SESSION 4 SESSION 5 Signal Processing and Imaging—Part 2 5.1 A High-Speed Biomedical Data Acquisition Subsystair R. B. Lake, Case Western Reserve University, Cleveland, OH SESSION 5 SESSION 6 SESSION 6 SESSION 6 SESSION 6 SESSION 7 Laboratory Microprocessor Applications and Structured Programming 7. S. Scheenfeld, Rockefeller University, New York, New York City, NY; S. Habib, City, Oly Oliversity of New York, New York City, NY; S. Habib, City, Oly Oliversity of Pitts-burgh, Pattaburgh, Pattaburgh, Pattaburgh, Pattaburgh, Pattaburgh, Pattaburgh, Pittaburgh, Pattaburgh, Pattaburgh, Pattaburgh, Pittaburgh, Pattaburgh, P		อาร์ไรส์ที่สมตัวสองค์ ฟัง นอสสราห์ การกระบางการสิทธิภาพ			D. V. Foster, Vanderbilt University, Nashville,	
SESSION 4 Standards 4.1 Which Standards 4.2 Standards for Hospital Electrical Safety: The Viewpoint from Ansethesiology G. Bashein, University of Weshington, Seattle, WA 4.3 The View from the FDA R. J. Cangelosi, Food and Drilig Administration, Department of Heistih, Education, and Welfare 4.4 The View From Liability and Safety Inspections L. G. Foxwell, The Hartford Insurance Group, Hartford, Connecticut 4.5 An Ansalysia of Satiolary's Development W. B. Jarzembski, FAAAE 4.6 The View From Counteers: The Voluntary Concensus Standards Device Standards L. E. Sloter, III, Dallas, Texas 4.7 Standards and Codes-View From Education G. N. Webb, Johns Hopkins School of Medicine, Baltimore, MD 7.1 New Vistas for Clinical Engineers W. L. Woods and E. Furst, University of Arizona Health Sciences Center, Tucson, Arizona; A. M. Cook, California 7.2 The Clinical Engineer is He Prepared? Can He grow? W. L. Woods and E. Furst, University of Arizona Health Sciences Center, Tucson, Arizona; A. M. Cook, California State University, Secremento, California Clinical Engineers W. L. Woods and Medical Data Acquisition Subsystem R. E. Lake, Case Western Reserve University, Cleveland, OH SESSION 6 Structured Prysical Sate University, New York City, VIX; S. Habib, City College of New York, New York City, NY; S. Habib, City, City, Illand, Rock City, NIX; S. Isabellator of New York City, NY; S. Habib, City College of New York City, NY; S. Habib, City College of New York City, NY; S. Habib, City College of New York City, NY; S. Habib, City City, Illand, The Automatical Physiologic Profile M. Klain and A. Sidend, University of Pitts-burgh, Piece Computative of Heiston, Pittsburgh, Piece Computative of Heiston, New York, New York City, NY; S. Habib, City City, Pittsburgh, Piece City, Visa Hutchard Physiologic Profile M. Klain and A. Sidend, University of University of Pittsburgh, Piece City, Visa Hutchard City, Usa Hutc				6.2		
Standards 4.1 Which Standards? A Wald, Columbia University, New York, N.Y. 4.2 Standards for Hospital Electrical Safety: The Viewpoint from Anesthesiology G. Bashein, University of Weshington, Seattle, WA 4.3 The View from the FDA R. J. Cangelosi, Food and Drug Administration, Department of Health, Education, and Welfare The View Forn Liability and Safety Inspections L. G. Foowell, The Hartfurd Insurance Group, Hartford, Connecticut A.5 An Analysis of Standards believelopment W. B. Jarzembski, PAAAE A.6 The View From Volunteers: The Voluntary Cononsus Standards and Codes—View From Education G. N. Webb, Johns Hopkins School of Medicine, Baltimore, MD 7.1 New Vistas for Clinical Engineers W. L. Woods and E. Furst, University of Arizons Health Sciences Center, Tucson, Arizons, A. M. Cook, California SESSION 5 Signal Processing and Imaging—Part 2 5.1 A High-Speed Biomedical Data Acquisition Subsystem R. B. Lake, Case Western Reserve University, Cleveland, OH Standards, Charles, N.Y. 8.8 Evaluation of Critically Ill Patients by en Automated Physiologic Profile M. Klain and A. Sladen, University of Pitts- burgh, Pittsburgh, Pa. Computarized Aliert System Use in Clinical Medicine, M. Gardner, T. P. Clemmer, K. G. Larsen, and D. S. Johnson, L.D. Shooghtal, Sait Lake City, Utah Instrumentation for Mapping Electrocardiographic Potential Distributions R. F. Wyatt, University of Utah, Sait Lake City, Utah A. Microprocessor-Based Ventricular Function Analyzer K. K. Dhupar, H. Baharestani, D. E. Bahr, and A. R. Kahn, Nicolet Instrument Corporation, Medison, Wisconsin 7.1 New Vistas for Clinical Engineers V. L. Woods and E. Furst, University of Arizons Health Sciences Center, Tucson, Arizona, A. M. Cook, California The Clinical Engineer: Is He Prepared? Can He Grow? N. O. Brinkman, Hospital Maintenance Consultants, Inc., Lebanon, Wisconsin 7.2 The Clinical Engineering to Industry Vork City, Vista		out of a ballot a highly are			Structured Programming	130
4.1 Which Standards A Wald, Columbite University, New York, N.Y. 4.2 Standards for Hospital Electrical Safety: The Viewpoint from Aniesthesiology G. Bashein, University of Weshington, Seattle, WA 4.3 The View from the FDA R. J. Cangelosi, Food and Drilg Administration, Department of Health, Education, and Welfare The View From Liability and Safety Inspections L. G. Foxwell, The Harriford Insurance Group, Hartford, Connecticut An Analysis of Standards W. B. Jarzemback, FAAAE A. Standards and Codes—View From Education G. N. Webb, Johns Hopkins School of Medicine, Baltimore, MD 5. Standards and Codes—View From Education G. N. Webb, Johns Hopkins School of Medicine, Baltimore, MD 5. Signal Processing and Imaging—Part 2 5. A High-Speed Biomedical Data Acquisition Subsystem R. B. Lake, Case Western Reserve University, Cleveland, OH 4. A Which Standards A Wald, Columbate University, Securements A Wald, Columbate University of Pitts- burgh, Pittsburgh, Pa. Computerized Alert System Use in Clinical Engineer R. M. Gardner, T. P. Clemmer, K. G. Larsen, and D. S. Johnson, LDS Hospital, Sait Lake City, Utah Instrumentation for Mapping Electrocardiographic Potential Distributions R. F. Wystt, University of Utah, Sait Lake City, Utah A Microprocessor-Based Ventricular Function Analyzer K. K. Dhupar, H. Baharestani, D. E. Bahr, and A. R. Kahn, Nicolet Instrument Corporation, Madison, Wisconsin 5. SESSION 7 Clinical Engineers 1. New Vistas for Clinical Engineers 1. New Vistas f		SESSION 4	815		York City, NY; S. Habib, City College of New	
4.1 Which Standards? A Wald, Columble University, New York, N.Y. 4.2 Standards for Hospital Electrical Safety: The Viewpoint from Ansethesiology G. Bashein, University of Washington, Seattle, WA 4.3 The View from the PDA R. J. Cangelosi, Food and Drig Administration, Department of Health, Education, and Welfare 4.4 The View From Liability and Safety Inspections L. G. Foxwell, The Hartbird Insurance Group, Hartford, Connecticut W. B. Jarzembiki, FAAAE 4.6 The View From Volunteers: The Voluntary Concensus Standards System and Medical Device Standards L. E. Sloter, II, Dallis, Texas 4.7 Standards and Codes—View From Education G. N. Webb, Johns Hopkins School of Medicine, Baltimore, MD SESSION 5 Signal Processing and Imaging—Part 2 5.1 A High-Speed Biomedical Data Acquisition Subsystem R. B. Lake, Case Western Reserve University, Cleveland, OH Viewpland, OH Viewpland, OH Viewpland A Sladen, University of Pitts- Durgh, Pittaburgh, Pa. 6.4 Computerized Alert System Use in Clinical Medicine Medicine on Computative Medicine Medicine on Computative Alert System Use in Clinical Medicine on Computative Alert System Use in Clinical Instrument Corporation, And D.S. Johnson, LDS Hospital, Salt Lake City, Utah Instrument Use Potential Distributions R. F. Wyst., University of Utah, Salt Lake City, Utah Instrument University Of Utah, Salt Lake City, Utah Instrum		Standards Standards		6.3		
A Wald, Columbia University, New York, N.Y. 4.2 Standards for Hospital Electrical Safety: The Viewpoint from Amesthesiology G. Bashein, University of Washington, Seattle, WA 4.3 The View from the PDA R. J. Cangelosi, Food and Drug Administration, Department of Health, Education, and Welfare L. G. Foxwell, The Hartford Insurance Group, Hartford, Connecticut A.5 An Analysis of Standards Elevelopment W. B. Jarzambski, FAAAE A.6 The View From Volunteers: The Voluntary Concensus Standards System and Medical Device Standards L. E. Sloter, II, Dallas, Texas 4.7 Standards and Codes—View From Education G. N. Webb, Johns Hopkins School of Medicine, Baltimore, MD 5. Signal Processing and Imaging—Part 2 5.1 A High-Speed Biomedical Data Acquisition Subsystem R. B. Lake, Case Western Reserve University, Cleveland, OH Views and E. Frest, University of Indianapolis, Inc., Indianapolis, Inclinana Inc., Indianapolis,	4.1		00	0.0	mated Physiologic Profile	134
4.2 Standards for Hospital Electrical Safety: The Viewpoint from Aniesthesiology G. Bashein, University of Weshington, Seattle, WA 4.3 The View from the PDA R. J. Cangelosi, Food and Drug Administration, Department of Health, Education, and Welfare 4.4 The View From Liability and Safety Inspections L. G. Foxwell, The Hartford Insurance Group, Hartford, Connecticut 4.5 An Analysis of Standards Development W. B. Jarzembiki, FAASE 4.6 Standards Development W. B. Jarzembiki, FAASE 4.7 Standards and Codes—View From Education G. N. Webb, Johns Hopkins School of Medicine, Baltimore, MD 4.8 Session 5 Signal Processing and Imaging—Part 2 5.1 A High-Speed Biomedical Data Acquisition Subsystem R. B. Lake, Case Western Reserve University, Cleveland, OH 4.9 Computarized Alert System Use in Clinical Medicine In Medicial Device Safety Insurance Group, In Medicine Insurance Group, Indiana Insurance Group, Manipulation Subsystem R. M. Gardner, T. P. Clemmer, K. G. Larsen, and D. S. Johnson, LDS Hospital, Sait Lake City, Utah Instrumentation for Mapping Electrocardiographic Potential Distributions R. F. Wyatt, University of Utah, Salt Lake City, Utah A. M. Gardner, T. P. Clemmer, K. G. Larsen, and D. S. Johnson, LDS Hospital, Sait Lake City, Utah Instrumentation for Mapping Electrocardiographic Potential Distributions R. F. Wyatt, University of Utah, Salt Lake City, Utah A. M. Electrocardiographic Potential Distributions R. F. Wyatt, University of Utah, Salt Lake City, Utah A. M. Electrocardiographic Potential Distributions R. F. Wyatt, University of Utah, Salt Lake City, Utah A. M. Electrocardiographic Potential Distributions R. F. Wyatt, University of Utah, Salt Lake City, Utah A. M. Electrocardiographic Potential Distributions R. F. Wyatt, University of Utah, Salt Lake City, Utah A. M. Electrocardiographic Potential Distributions R. F. Wyatt, University of Utah, Salt Lake City, Utah A. M. Electrocardiographic Potential Distributions R. F. Wyatt, University of Utah, Salt Lake City, Utah A. M. Electrocardiographic Potential	4.1	Trillott o consultation				
G. Bashein, University of Washington, Seattle, WA 4.3 The View from the FDA R. J. Cangelosi, Food and Driig Administration, Department of Health, Education, and Welfare 4.4 The View From Liability and Safety Inspections L. G. Foxwell, The Hartford Insurance Group, Hartford, Connecticut 4.5 An Analysis of Staindards Development W. B. Jarzembski, FAAAE 4.6 The View From Voluntary Concessus Standards System and Madical Device Staindards Device Staindards L. E. Sloter, II, Dallas, Texas 4.7 Standards and Codes—View From Education G. N. Webb, Johns Hopkins School of Medicine, Baltimore, MD 7.1 New Vistas for Clinical Engineers W. L. Woods and E. Furst, University of Arizone Health Sciences Center, Tucson, Arizone; A. M. Cook, California 7.2 The Clinical Engineer: Is He Prepared? Can He Grow? M. O. Brinkman, Hospital Maintenance Consultants, Inc., Lebanon, Wisconsin 7.3 Mere Vistas for Clinical Engineer: Is He Prepared? Can He Grow? M. O. Brinkman, Hospital Maintenance Consultants, Inc., Lebanon, Wisconsin 7.3 Mere Luck Then Management M. D. Brinkman, Hospital Maintenance Consultants, Inc., Lebanon, Wisconsin 7.4 High-Speed Biomedical Data Acquisition Subsystem R. M. Gardner, T. P. Clemmer, K. G. Larsen, and D. S. Johnson, LDS Hospital, Salt Lake City, Utah R. F. Wyatt Larke City, Utah R. F. Wyatt Larke City, Utah R. F. F	4.2		01		Computerized Alert System Use in Clinical	
## D. S. Johnson, LDS Hospital, Salt Lake City, Utah R. J. Cangelosi, Food and Drüg Administration, Department of Health, Education, and Welfare 4.4 The View From Liability and Safety Inspections L. G. Foxwell, The Hartbrid Insurance Group, Hartford, Connecticut A. Analysis of Stanidards Development W. B. Jarzembeki, FAAAE 4.6 The View From Voluntary Concessus Standards System and Medical Device Standards L. E. Sloter, II, Dallas, Texas 4.7 Standards and Codes—View From Education G. N. Webb, Johns Hopkins School of Medicine, Baltimore, MD 7.1 New Vistas for Clinical Engineers W. L. Woods and E. Furst, University of Arizone Health Sciences Center, Tucson, Arizona; A. M. Cook, California State University, Secramento, California 7.2 The Clinical Engineer: Is He Prepared? Can He Grove? M. O. Brinkman, Hospital Maintenance Con- subsystem S. B. Lake, Case Western Reserve University, Cleveland, OH 7.4 Transition for Mapping Electrocardiographic Protential Distributions R. F. Wyatt, University of Utah, Salt Lake City, Utah A. Microprocessor-Based Ventricular Function Analyzer K. K. Dhupar, H. Baharestani, D. E. Bahr, and A. R. Kahn, Nicolet Instrument Corporation, Madison, Wisconsin 7.5 New Vistas for Clinical Engineers W. L. Woods and E. Furst, University of Arizone Health Sciences Center, Tucson, Arizona; A. M. Cook, California State University, M. M. Foltz, Community Hospital of Indianap- oils, Inc., Indianapolis, Indiana Transitions City, Utah A. Microprocessor-Based Ventricular Function A. R. Kahn, Nicolet Instrument Corporation, M. R. Kahn, Nicolet Instrument Corporation, M. R. W. L. Woods and E. Furst, University of Arizona Health Sciences Center, Tucson, Arizona W. L. Woods and E. Furst, University of Arizona W. L. Woods and E. Furst, Uni		G. Bashein, University of Washington, Seattle,	91		***************************************	136
R. J. Cangelosi, Food and Drug Administration, Department of Health, Education, and Welfare 4.4. The View From Liability and Sefety Inspections L. G. Foxwell, The Hartford Insurance Group, Hartford, Connecticut 4.5. An Analysis of Standards Development W. B. Jarzembski, FAAAE 4.6. The View From Volunteers: The Voluntary Concessus Standards System and Medical Device Standards L. E. Sloter, II, Dellas, Texas 4.7. Standards and Codes—View From Education G. N. Webb, Johns Hopkins School of Medicine, Baltimore, MD 7.1. New Vistas for Clinical Engineers W. L. Woods and E. Furst, University of Arizone Health Sciences Center, Tucson, Arizona; A. M. Cook, California State University, Sacramento, California 7.2. The Clinical Engineer: Is He Prepared? Can He Grow? M. O. Brinkman, Hospital Maintenance Consultants, Inc., Lebanon, Wisconsin 7.3. More Luck Then Management W. M. Foltz, Community Hospital of Indianapolis, Indiana olis, Inc., Indianapolis, Indiana Transition: Clinical Engineering to Industry K. J. Cook, The Valeron Corporation, Oak	4.3	WA	94	8.5		
4.4 The View From Liability and Safety Inspections L. G. Foxwell, The Harriord Insurance Group, Hartford, Connecticut 4.5 An Analysis of Standards Development W. B. Jarzembski, FAAAE 4.6 The View From Voluntiers: The Voluntary Concensus Standards System and Medical Device Standards L. E. Sloter, II, Dallas, Texas 4.7 Standards and Codes—View From Education G. N. Webb, Johns Hopkins School of Medicine, Baltimore, MD 7.1 New Vistas for Clinical Engineers W. L. Woods and E. Furst, University of Arizona Health Sciences Center, Tucson, Arizona; A. M. Cook, California State University, Sacramento, California 7.2 The Clinical Engineer: Is He Prepared? Can He Grow? M. O. Brinkman, Hospital Maintenance Con- sultants, Inc., Lebanon, Wisconsin W. M. Foltz, Community Hospital of Indianap- olis, Inc., Indianapolis, Indiana Transition: Clinical Engineering to Industry K. J. Cook, The Veleron Corporation, Oak		R. J. Cangelosi, Food and Drug Administration,		0.0	Potential Distributions	141
L. G. Foxwell, The Hartford Insurance Group, Hartford, Connecticut 4.5 An Analysis of Standards Development W. B. Jarzembski, FAAAE 4.6 The View From Volunteers: The Voluntary Concensus Standards System and Medical Device Standards L. E. Sloter, II, Dallas, Texas 4.7 Standards and Codes—View From Education G. N. Webb, Johns Hopkins School of Medicine, Baltimore, MD 7.1 New Vistas for Clinical Engineers W. L. Woods and E. Furst, University of Arizona Health Sciences Center, Tucson, Arizona; A. M. Cook, California 7.2 The Clinical Engineer: Is He Prepared? Can He Grow? M. O. Brinkman, Hospital Maintenance Consultants, Inc., Lebanon, Wisconsin 8. SESSION 5 8. A Microprocessor-Based Ventricular Function Analyzer K. K. Dhupar, H. Baharestani, D. E. Bahr, and A. R. Kahn, Nicolet Instrument Corporation, Madison, Wisconsin 8. SESSION 7 8. SESSION 7 7.1 New Vistas for Clinical Engineers W. L. Woods and E. Furst, University of Arizona Health Sciences Center, Tucson, Arizona; A. M. Cook, California State University, Sacramento, California 7.2 The Clinical Engineer: Is He Prepared? Can He Grow? M. O. Brinkman, Hospital Maintenance Consultants, Inc., Lebanon, Wisconsin	4.4		360			
4.5 An Analysis of Standards Development W. B. Jarzembiki, PAAAE 4.6 The View From Voluntiers: The Voluntary Concensus Standards System and Medical Device Standards L. E. Sloter, II, Dallas, Texas 4.7 Standards and Codes-View From Education G. N. Webb, Johns Hopkins School of Medicine, Baltimore, MD 7.1 New Vistas for Clinical Engineers W. L. Woods and E. Furst, University of Arizona Health Sciences Center, Tucson, Arizona; A. M. Cook, California 7.2 The Clinical Engineer: Is He Prepared? Can He Grow? M. O. Brinkman, Hospital Maintenance Consultants, Inc., Lebanon, Wisconsin 8.1 A High-Speed Biomedical Data Acquisition Subsystem R. B. Lake, Case Western Reserve University, Cleveland, OH 7.2 Transition: Clinical Engineering to Industry K. J. Cook, The Valeron Corporation, Oak		L. G. Foxwell, The Hartford Insurance Group,		6.6	A Microprocessor-Based Ventricular Function	
W. B. Jarzembski, FAAAE The View From Voluntairy Concensus Standards System and Medical Device Standards L. E. Sloter, II, Dallas, Texas 4.7 Standards and Codes—View From Education G. N. Webb, Johns Hopkins School of Medicine, Baltimore, MD 7.1 New Vistas for Clinical Engineers W. L. Woods and E. Furst, University of Arizona Health Sciences Center, Tucson, Arizona; A. M. Cook, California The Clinical Engineer: Is He Prepared? Can He Grow? M. O. Brinkman, Hospital Maintenance Consultants, Inc., Lebanon, Wisconsin 7.3 More Luck Then Management W. M. Foltz, Community Hospital of Indianapolis, Indiana oils, Inc., Indianapolis, Indiana Transition: Clinical Engineering to Industry K. J. Cook, The Valeron Corporation, Oak	4.5	An Analysis of Standards Development	95			145
Concensus Standards System and Medical Device Standards L. E. Sloter, II, Dallas, Texas 4.7 Standards and Codes—View From Education G. N. Webb, Johns Hopkins School of Medicine, Baltimore, MD 7.1 New Vistas for Clinical Engineers W. L. Woods and E. Furst, University of Arizona Health Sciences Center, Tucson, Arizona; A. M. Cook, California State University, Secremento, California 7.2 The Clinical Engineer: Is He Prepared? Can He Grow? M. O. Brinkman, Hospital Maintenance Consultants, Inc., Lebanon, Wisconsin More Luck Then Management W. M. Foltz, Community Hospital of Indianapolis, Indianapoli	AR	W. B. Jarzembski, FAAAE		3.3	A. R. Kahn, Nicolet Instrument Corporation,	
L. E. Sloter, 11, Dallas, Texas 4.7 Standards and Codes—View From Education G. N. Webb, Johns Hopkins School of Medicine, Baltimore, MD 7.1 New Vistas for Clinical Engineers W. L. Woods and E. Furst, University of Arizona Health Sciences Center, Tucson, Arizona; A. M. Cook, California State University, Sacramento, California 7.2 The Clinical Engineer: Is He Prepared? Can He Grow? M. O. Brinkman, Hospital Maintenance Con- sultants, Inc., Lebanon, Wisconsin More Luck Than Management W. M. Foltz, Community Hospital of Indianap- olis, Inc., Indianapolis, Indiana 101 Transition: Clinical Engineering to Industry K. J. Cook, The Valeron Corporation, Oak	4.0	Concensus Standards System and Medical	4		Madison, Wisconsin	
4.7 Standards and Codes—View Front Education G. N. Webb, Johns Hopkins School of Medicine, Baltimore, MD 7.1 New Vistas for Clinical Engineers W. L. Woods and E. Furst, University of Arizona Health Sciences Center, Tucson, Arizona; A. M. Cook, California State University, Sacramento, California 7.2 The Clinical Engineer: Is He Prepared? Can He Grow? M. O. Brinkman, Hospital Maintenance Con- sultants, Inc., Lebanon, Wisconsin 7.3 More Luck Then Management W. M. Foltz, Community Hospital of Indianap- oils, Inc., Indianapolis, Indiana Transition: Clinical Engineering to Industry K. J. Cook, The Valeron Corporation, Oak		Device otericards	98	*	CCOLON T	140
7.1 New Vistas for Clinical Engineers W. L. Woods and E. Furst, University of Arizona Health Sciences Center, Tucson, Arizona; A. M. Cook, California State University, Secremento, California 7.2 The Clinical Engineer: Is He Prepared? Can He Grow? M. O. Brinkman, Hospital Maintenance Con- sultants, Inc., Lebanon, Wisconsin More Luck Than Management W. M. Foltz, Community Hospital of Indianap- olis, Inc., Indianapolis, Indiana R. B. Lake, Case Western Reserve University, Cleveland, OH 7.3 New Vistas for Clinical Engineers W. L. Woods and E. Furst, University of Arizona Health Sciences Center, Tucson, Arizona; A. M. Cook, California 7.2 The Clinical Engineer: Is He Prepared? Can He Grow? M. O. Brinkman, Hospital Maintenance Con- sultants, Inc., Lebanon, Wisconsin W. M. Foltz, Community Hospital of Indianap- olis, Inc., Indianapolis, Indiana 7.4 Transition: Clinical Engineering to Industry K. J. Cook, The Valeron Corporation, Oak	4.7	Standards and Codes-View From Education	99		SESSION /	
W. L. Woods and E. Furst, University of Arizona Health Sciences Center, Tucson, Arizona; A. M. Cook, California State University, Sacramento, California 7.2 The Clinical Engineer: Is He Prepared? Can He Grow? M. O. Brinkman, Hospital Maintenance Consultants, Inc., Lebanon, Wisconsin 7.3 More Luck Than Management W. M. Foltz, Community Hospital of Indianapolis, Inc., Indianapolis, Indiana Subsystem R. B. Lake, Case Western Reserve University, Cleveland, OH W. L. Woods and E. Furst, University of Arizona Health Sciences Center, Tucson, Arizona; A. M. Cook, California 7.2 The Clinical Engineer: Is He Prepared? Can He Grow? M. O. Brinkman, Hospital Maintenance Consultants, Inc., Lebanon, Wisconsin W. M. Foltz, Community Hospital of Indianapolis, Inc., Indianapolis, Indiana 7.4 Transition: Clinical Engineering to Industry K. J. Cook, The Valeron Corporation, Oak					Clinical Engineering .	
Health Sciences Center, Tucson, Arizona; A. M. Cook, California State University, Sacramento, California 7.2 The Clinical Engineer: Is He Prepared? Can He Grow? M. O. Brinkman, Hospital Maintenance Consultants, Inc., Lebanon, Wisconsin 7.3 More Luck Than Management M. M. Foltz, Community Hospital of Indianapolis, Inc., Indianapolis, Indiana Subsystem R. B. Lake, Case Western Reserve University, Cleveland, OH Health Sciences Center, Tucson, Arizona; A. M. Cook, California State University, California State University, M. Cook, The Valeron Corporation, Oak		X		7.1		150
Cook, California State University, Sacramento, California 7.2 The Clinical Engineer: Is He Prepared? Can He Grow? M. O. Brinkman, Hospital Maintenance Consultants, Inc., Lebanon, Wisconsin 7.3 More Luck Than Management M. M. Foltz, Community Hospital of Indianapolis, Inc., Indianapolis, Indiana 8. B. Lake, Case Western Reserve University, Cleveland, OH Cook, California State University, Sacramento, California 7.2 The Clinical Engineer: Is He Prepared? Can He Grow? M. O. Brinkman, Hospital Maintenance Consultants, Inc., Lebanon, Wisconsin W. M. Foltz, Community Hospital of Indianapolis, Indiana 7.4 Transition: Clinical Engineering to Industry K. J. Cook, The Valeron Corporation, Oak		4.35.1923.55				
7.2 The Clinical Engineer: Is He Prepared? Can He Grow? M. O. Brinkman, Hospital Maintenance Consultants, Inc., Lebanon, Wisconsin 7.3 More Luck Than Management W. M. Foltz, Community Hospital of Indianapolis, Indiana 8. B. Lake, Case Western Reserve University, Cleveland, OH 7.2 The Clinical Engineer: Is He Prepared? Can He Grow? M. O. Brinkman, Hospital Maintenance Consultants, Inc., Lebanon, Wisconsin 7.3 More Luck Than Management W. M. Foltz, Community Hospital of Indianapolis, Indiana 7.4 Transition: Clinical Engineering to Industry K. J. Cook, The Valeron Corporation, Oak		Surg - mark of the Year of the Art of the Surger			Cook, California State University, Sacramento,	
SESSION 5 Grow? M. O. Brinkman, Hospital Maintenance Consultants, Inc., Lebanon, Wisconsin 7.3 More Luck Than Management W. M. Foltz, Community Hospital of Indianapolis, Inc., Indianapolis, Inc., Indianapolis, Indiana R. B. Lake, Case Western Reserve University, Cleveland, OH Grow? M. O. Brinkman, Hospital Maintenance Consultants, Inc., Lebanon, Wisconsin W. M. Foltz, Community Hospital of Indianapolis, Indiana 7.4 Transition: Clinical Engineering to Industry K. J. Cook, The Valeron Corporation, Oak		The second secon		7.2		
Signal Processing and Imaging—Part 2 sultants, Inc., Lebanon, Wisconsin 7.3 More Luck Than Management W. M. Foltz, Community Hospital of Indianapolis, Indiana R. B. Lake, Case Western Reserve University, Cleveland, OH Signal Processing and Imaging—Part 2 sultants, Inc., Lebanon, Wisconsin W. M. Foltz, Community Hospital of Indianapolis, Indiana 7.4 Transition: Clinical Engineering to Industry K. J. Cook, The Valeron Corporation, Oak					Grow?	152
5.1 A High-Speed Biomedical Data Acquisition Subsystem R. B. Lake, Case Western Reserve University, Cleveland, OH W. M. Foltz, Community Hospital of Indianapolis, Inc., Indianapolis, In						9.5
Subsystem R. B. Lake, Case Western Reserve University, Cleveland, OH Olis, Inc., Indianapolis, Indiana Transition: Clinical Engineering to Industry K. J. Cook, The Valeron Corporation, Oak	5.1	A High-Speed Riomedical Data Assuriation		7.3		154
Cleveland, OH K. J. Cook, The Valeron Corporation, Oak	0.1	Subsystem 101 marked normal mach at the land	101	-	olis, Inc., Indianapolis, Indiana	
				7.4		156
	5.2	Modern Spectral Analysis	104	7 5	Park, Michigan	
				7.0	and the second contract of the	158
5.3 Recognition of Suspicious Pneumoconiosis with the Aid of Pulmonary Function Measurements 110 J. K. Chung, G. W. Pratt, and P. S. Babyn, Massachusetts Institute of Technology, Cam-	5.3		110			
C. C. Li and M. G. Strintzis, University of bridge, MA; R. Poss, Robert B. Brigham Hospi-					bridge, MA; R. Poss, Robert B. Brigham Hospi-	
Pittsburgh, Pittsburgh, PA; J. W. Stanis, tal, Boston, MA J. Newman, G. A. Kunkel, and B. J. Wadhwani, 7.6 Managing Medical Equipment Acquisition with				7.6		
Centerville Clinics, Inc., Fredericktown, PA Life Cycle Cost Containment 1		Centerville Clinics, Inc., Fredericktown, PA			Life Cycle Cost Containment	161
5.4 Recognition of Behavioral Patterns of Rats Induced by Chlorpromazine-Amphetamine Drug 7.7 Education to Continue the Clinical Engineer's	5.4			7.7		
Interaction of room valid temperature and artists 114 Career the second state of the care		Interaction Popular Vall A length and a second	114		Career Care	162
P. P. Wang and E. H. Ellinwood, Jr., Duke University, Durham, North Carolina L. S. Toth, Hughes Aircraft Company, Los Angeles, CA						
		N AN A COMMISSION AND ASSESSMENT OF STREET	2			

	SESSION 8		9.5	Esophageal Acceleration and the Cardiovascular	-
N	on-Invasive Diagnostic Technology—Part 2			System A. C. Pinchak, Case Western Reserve University— CMGH, Cleveland, Ohio	369
8.1	Fourier Transform Reconstruction in Cat by Exact Interpolation H. Stark, I. N. Paul, and C. S. Sarna, Rensselaer	165	9.6	Extraocular Eye Muscle Force Duction Tests After Administration of Succinylcholine or Pancuronium	203
0.0	Polytechnic Institute, Troy, NY			J. D. Woodburn, Jr., D. P. Burbank, N. K.	203
8.2	A New Rebinning Algorithm for Fan-Beam X-Ray Scanners	169		France, and T. D. France, University of Wisconsin-Madison, Madison, WI	
	W. C. Lin, University of California, Davis, California		9.7	A Modern Shadowgraph for the Measurement of Finger Clubbing	206
8.3	Optimization of System Design Parameters for Emission Computed Tomography	363		J. P. Salsgiver, United Technical Corporation, Concord. MA	
	E. J. Hoffman, M. E. Phelps, A. R. Ricci, S. Huang and D. E. Kuhl, University of Califor-		9.8	Pulse Rete Monitor C. J. Savant, Jr., California State University,	208
0.4	nia, Los Angeles, California			Long Beach, CA; J. Labelle, T. Bonnaud,	
8.4	Noninvasive Flowmetry in Upper Limbs of Patients With Arteriovenous Dialysis Fistulas	175		and M. Wsol, Tek-Aid, Inc., Long Beach, CA	
	S. X. Salles-Cunha, R. E. Halbach, J. H. Battocletti, H. M. Kauffman, M. B. Adams, and		×		
	A. Sances, Jr., The Medical College of Wisconsin, Milwaukee, Wisconsin				
8.5	A Linear Measurement of the Water Content of the Stratum Corneum of Human Skin Using a			SESSION 10	
	Microwave Probe S. L. Jacques, University of California, Berkeley,	180		Devices for the Disabled—Part 1	
8.6	California		10.1		
0.0	Particle Concentration and Clearance in the	183	10.1	An Implantable Cochlear Prosthesis for the Pro- foundly Desf; Principles and Performance Re-	
	S. E. Robinson and A. P. Freedman, Hahne-	103		quirements R. L. White, R. G. Mathews, and G. A. May,	211
04.65	mann Medical College and Hospital, Philadelphia, PA			Stanford University, Stanford, CA; F. B. Simmons, Stanford University Medical Center, Stanford, CA	
	And the second of the second		10.2	Microelectrode Arrays for an Implantable Auditory Prosthesis	211
11	A COLOR SAND BOOK A STORY OF THE SAND SAND SAND SAND SAND SAND SAND SAND			G. A. May, S. Shamma and R. L. White, Stanford University, Stanford, CA	-
	encode o in colle emany and the first of		10.3	The STIMULISS Series Implantable Multi- channel Receiver-Stimulator Units for an Audi-	
	Account with the property of the country of a			tory Prosthesis	211
	SESSION 9			G. A. May, M. Soma, R. G. Mathews, and R. L. White, Stanford University, Stanford, CA	
	Biomechanical Instrumentation	9	10.4	tablishing the Stimulus-Percept Data Base for	
9.1	Monolithic Capacitance Pressure Transducer-IC			an Auditory Prosthesis R. G. Mathews, M. G. Walker, and M. K.	211
	With Pulse Period Output C. S. Sander, J. W. Knutti, and J. D. Meindl,	189		Herndon, Stanford University, Stanford, CA; F. B. Simmons, Stanford University Medical	
9.2	Stanford University; Stanford, California A Measurement System for Monitoring Brain		10.5	Center, Stanford, CA A Portable Speech Processing System for an	
	J. E. Nicholson, R. F. Gatturna, L. Milesky,	193		Auditory Prosthesis M. G. Walker, R. G. Mathews, M. K. Herndon	212
9.3	L. Bunegin and M. S. Albin A Messurement of the In Vivo Human Tissue.			and L. E. Atlas, Stanford University, Stanford, CA	*
	Response to Retraction During Open-Heart Surgery	196	10.6	Electric Field Control Electrode for Stimula- tion of Peripheral Nerve	213
200	A. I. West, Codman & Shurtleff, Inc., Randolph,			J. A. Foster, Brentwood VA Medical Center, Los Angeles, California	
	Massachusetts; D. D. Payne, Tufts New England Medical Center, Boston, Massachusetts		10.7	An Externally Programmable and Rechargeable	245
9.4	A Method to Monitor the Healing of Human Long Bones H. H. Doemland and B. H. Stanley, Kansas	198		Generator for Cerebellar Stimulation S. V. Pantulu, D. C. Jeutter, and A. Sances, Jr., Marquette University, Milwaukee, WI; E. Millar,	215
	University, Lawrence, Kansas			Shriners Hospital, Chicago, IL	

	the contract of the latter of the post of the party.				
10.8	P. N. Sawyer, B. M. Stanczewski, D. O'Connor, W. Wrezlewicz, S. Polaniecki, and N. Ramasamy,	219	12.5	A Telemetry Pulse-Frequency Demodulation System Employing Microprocessor Controlled Noise Rejection	267
	State University of New York, Brooklyn, New York		. 5.	F. J. Zelina, S. Vamvakas, W. C. Lin, and M. R. Neuman, Case Western Reserve University,	
1. 14.				Cleveland, Ohio	
	SESSION 11		12.6	Extending Implanted Electronic Device Life- time by External Switching and Battery Re-	270
	Bio-Electric Signals—Part 2	'n.		charging D. C. Jeutter, Marquette University, Milwaukee, Wisconsin	270
11.1	Signal Analysis by Hopf Bifurcation in Cochlear Fluid Mechanics	224	12.7	An Eight Channel Surgical Patient Monitoring Telemetry System Utilizing Infrared Light as	
	T. W. Barrett, University of Tennessee Center			the Transmitting Medium	273
11.2	for the Health Sciences, Memphis, Tennessee Theoretical Investigations and Clinical Appli-			F. F. Klein, D. A. Davis, L. A. Dowell, and L. W.	
11.5	cation of the Evoked Potential	228		Burton, Duke University Medical Center, Dur- ham, North Carolina; W. E. Thornton, National	
	A. Sances, Jr., J. Myklebust, S. J. Larson, J. F. Cusick, and P. R. Walsh, <i>The Medical College of Wisconsin Wood</i> , W.			Aeronautics and Space Administration, Manned Spacecraft Center, Houston, Texas	
11.3	Wisconsin, Wood, WI Finding the Extended Sources of Evoked Cere-				
1110	bral Potentials: An Application to the N55				
	Component of the Somatosensory Evoked			The rounce of the late toward over 14	
	Potential R. D. Sidman, University of Southwestern	233		SESSION 13	
	Louisiana, Lafayette, Louisiana			Computerized Control of Therapy	
11.4	Dipole Localization of Potentials Elicited by	220		a contract of the contract of	
	Visual Pattern Stimulation R. Sencaj and J. Aunon, Purdue University,	236	13.1	Computer Control of Cardiac Arrhythmia	276
	West Lafayette, Indiana			S. M. Collins and R. C. Arzbaecher, The Univer- sity of Iowa, Iowa City, Iowa .	
11.5	Brain Stimulation in Different Sites and Thala-		13.2	Computer Controlled Infusion of Vasoactive	
	mocortical Excitability: Definition of an Index	241		Drugs in Post Cardiac Surgical Patients	280
	of Anticonvulsant Effect W. J. Nowack, R. N. Englander, R. N. Johnson,	241		L. C. Sheppard, J. F. Shotts, N. F. Roberson, F. D. Wallace, and N. T. Kouchoukos, <i>Univer-</i>	
	and G. R. Hanna, University of Virginia School of Medicine, Charlottesville, Virginia			sity of Alabama in Birmingham, Birmingham, Alabama	
11.6	Syntactic EEG Analysis: Artifact and Drowsi-		13.3	A Model for Design of a Blood Pressure Con-	
	ness Detection	244		troller for Hypertensive Patients	285
	V. Jagannathan, J. R. Bourne, D. A. Giese, B. Hamel, and J. W. Ward, Vanderbilt University, Nashville, Tennessee			J. B. Slate, L. C. Sheppard and E. H. Blackstone, University of Alabama in Birmingham, Birming-	
11.7	Quantification of Time-Connectivity Patterns in			ham, Alabama; J. B. Slate and V. C. Rideout, University of Wisconsin-Madison, Madison,	
	Point Processes P. Y. Ktonas and J. F. Bonilla, University of	246		Wisconsin	
	Houston, Houston, Texas				
	Tradacti, Tradacti, Tonas			de the party and the similar profession	
	SESSION 12			The state of the s	
	A DESCRIPTION OF THE PROPERTY			SESSION 14	
	Telemetry			Consent Principles of Pierrodical Engineering	
10.1	Madical Talamater From Laborators Navalta			General Principles of Biomedical Engineering	
12.1	Medical Telemetry—From Laboratory Novelty to Clinical Instrument W. H. Ko, Case Western Reserve University,	250	14.1	Studies of V _{DS} Fringe Field Effect on ISFET	290
	Cleveland			J. Lee, W. Ko, P. Cheung, A. Wong, and C. Fung,	200
12.2	Chronically Implantable Instrumentation for	054		Case Western Reserve University, Cleveland,	
	Medical Research Animals J. W. Knutti, H. V. Allen, and J. D. Meindl,	251	14.2	Ohio . Muscle Geometry and the Spectrum of Motor	
	Stanford University, Stanford, California		1-7-6	Unit Surface Potentials	292
12.3	Wildlife Biotelemetry	256		V. Pollak, University of Saskatchewan, Saska-	
	F. M. Long and R. W. Weeks, University of			toon, Saskatchewan, Canada	
12 /	Wyoming, Laramie, Wyoming A Portable Multi-Sensor Telemetry System for		14.3	On the Theory of Fuzzy Sets and Medical Diagnosis	294
12.4	a Rural Health Network	260		M. M. Gupta and P. N. Nikiforuk, University	204
	M. E. Silverstein and J. Worman, University of			of Saskatchewan, Saskatoon, Saskatchewan,	
	Arizona, Tucson, Arizona			Canada	

14.4	Comparative Sensitivity of Frequency Dependence of Compliance and Differential Bronchial		17.2	Atrial Electrical Activity: The View from the Esophagus	314
	Pressure in Detecting Peripheral Asynchronous Time Constants	374		R. Arzbaecher, S. Collins, and E. Berbari, The University of Iowa, Iowa City, IA; J.	
	P. Bhansali, J. Dempsey, T. Musch, L. Chosy, J. Webster, C. Iber, <i>University of Wisconsin</i> ,		17.3	Jenkins, Northwestern University, Chicago, IL Parasympathetic Control of Nodal Activity	210
	Madison, Wisconsin		17.3	J. W. Clark, K. K. Dittert, and J. R. Ellis, Rice	319
	madiadri, Priaconalii			University, Houston, Texas	
			17.4	Relating Epicardial and Torso Potentials with	
				Multipoles	320
				T. C. Pilkington and M. N. Morrow, Duke	020
	SESSION 15			University, Durham, North Carolina	
			17.5	Electrocardiographic Body Surface Potential	
	Devices for the Disabled—Part 2			Mapping: A Non-Invasive Technique for Im-	
	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1			proved Diagnosis	322
15.1	A New Concept in the Design and Utilization of			R. L. Lux, University of Utah College of Medi-	
	Environmental Control Instruments for the			cine, Salt Lake City, Utah	
	Severely Disabled	295	17.6	Nonlinear Analysis of the Electrocardiogram in	
	M. Youdin, G. H. Sell, T. Reich, M. Clagnaz,			the Early Detection of Coronary Artery Disease	325
	R. Dickey, H. Louie, and R. Kolwicz, New			J. R. Lundy, M. B. Jaffe, and J. G. Mills, The	020
	York University Medical Center, New York,			Cooper Union School of Engineering, New	
	New York			York, New York	
15.2	EMG Activated Spatial Morse Code General		17.7	Mathematical Investigation of Bio-Electric	
	Purpose Communication Device	298		Rhythms Represented by Populations of	
	C. B. Friedlander and M. A. Rahimi, Michigan			Coupled Synthesized Relaxation Oscillators	329
	State University, East Lansing, Michigan			B. L. Bardakjian and S. K. Sarna, McMaster	020
				University , Hamilton , Ontario , Canada	
				omvordity, riamiton, ontario, danada	
	CECCION 16				
	SESSION 16				
	Education			SESSION 18	
	Education				
16.1	Professional Society Emphasis Areas in Dia			Totally Implantable Telemetry Systems	
10.1	Professional Society Emphasis Areas in Bio- medical Engineering Education	300			
		300	18.1	A Chronically Instrumented Animal Model	
	A. R. Potvin, University of Texas at Arlington, Arlington, Texas			For Electrophysiologic Research	334
16.2				J. P. Claude, J. R. Griffin, S. J. Gschwend, J. W.	
10.2	Accreditation of Biomedical Engineering Pro-	302		Knutti, H. V. Allen, and J. D. Meindl, Stanford	
	A. M. Cook, California State University, Sacra-	302		University, Stanford, California	
	mento, Ca.		18.2	An Implantable Radio Telemetry Dimension	
16.3	BME Graduate and Undergraduate Program Up-			Sensor	337
10.3	date	303		J. D. Marshall, J. W. Knutti, H. V. Allen, and	
	J. L. Katz, Rensselaer Polytechnic Institute			J. D. Meindl, Stanford University, Stanford,	
16.4	Perspectives on Rehabilitation Engineering			California	
10.4	Education	304	18.3	Implant Assembly Technology for High Reli-	
	R. J. Jendrucko, University of Tennessee at	30-4		ability Telemetry Systems	341
	Knoxville			S. J. Gschwend, J. W. Knutti, H. V. Allen, and	
16.5	The Emergence of Biomedical Engineering as a			J. D. Meindl, Stanford University, Stanford,	
10.0	Discipline	305		California	
	D. J. Schneck, Virginia Polytechnic Institute	000	18.4	A Digital Data Link for Totally Implantable	
	and State University, Blacksburg, Virginia			Continuous Wave Doppler Ultrasonic Blood	
	and due officially, Didologially, Virginia			Flowmeters	344
				T. R. Harrison, J. W. Knutti, H. V. Allen and	
				J. D. Meindl, Stanford University, Stanford,	
				California	
	SESSION 17	5	18.5	Myocardial Dimension Measurement System	348
				E. Wildi, J. W. Knutti, H. V. Allen, and J. D.	
	Bio-Electric Signals—Part 2			Meindl, Stanford University, Stanford, Califor-	
				nia	
17.1	A New Test for EEG Gausian Amplitude Dis-			No. of the second	
	tribution	309	8		
	M. S. Weiss, Naval Aerospace Medical Research				
	Laboratory Detachment, New Orleans, Loui-			d3. p	

Workshops & Tutorials

352

siana

at the set of providing a first			
	LIST OF	ECG diagnosis ECG-gated radiography ECG monitoring ECPD Education Educational preparation EEG amplitude distribution EEG arallysis EEG artifact EEG drowsiness EEG power spectrum estimation EEG processing Electric field control electrodes Electrical safety standards Electrically stimulated osteogenesis Electrocardiogram Electrocardiogram analysis	
A/D conversion	5.1	ECG diagnosis	17.5
Alveolar bone regeneration	10.8	ECG-gated radiography	1.3
American Society for Testing and Materials	4.6	ECG monitoring	13.1
A/D conversion Alveolar bone regeneration American Society for Testing and Materials Animal biotelemetry Arrhythmia management	12.3	ECPD	16.2
Arrhythmia management	13.1	Education	4.7
Arrhythmia management Artifacts Artificjal kidney Atrium Auditory prosthesis 10. Automated patient treatment	1.4	Educational preparation	7.2
Artificial kidney	2.8	EEG amplitude distribution	17.1
Atrium	17.2	EEG analysis	1.6
Auditory prosthesis 10.	1, 10.2	EEG artifact	11.6
10.	3, 10.4	EEG drowsiness	11.6
10.	5	EEG power spectrum estimation :	1.5
Automated patient treatment	13.3	EEG processing	1.8
		Electric field control electrodes	10.6
Ballistocardiogram	1.1	Electrical safety standards	4.2
Bandwidth reduction	18.2	Electrically stimulated osteogenesis	10.8
Bedside monitoring	6.3	Electrocardiogram 1.2, 1.4	, 2.4
Benavioral patterns	5.4	Electrocardiogram 1.2, 1.4 Electrocardiogram analysis Electrocardiographic lead field Electrocardiography 17.4, Electrochemical oxidation Electromyography Electromyography Electrophysiology Electroretinogram Environment design Epilepsy Equipment planning process Esophageal accelerometry Esophageal electrocardiogram Evoked cerebral potentials	17.6
Bio-electric rhythm	1.7.7	Electrocardiographic lead field	17.2
Blomagnerism	8.6	Electrocardiography 17.4,	17.5
Biomedical engineering accreditation	16.2	Electrochemical oxidation	2.8
Biomedical engineering education 16.	1, 16.5	Electromyography	15.2
Blomedical engineering profession	16.5	Electrophysiology	18.1
Biomedical engineering subjects	16.5	Electroretinogram	2.2
Biomedical pattern recognition	5,3	Environment design	15.1
Biopotentials	.4, 2.2	Epilepsy	11.5
Plandingsource	12.4	Equipment planning process	0.5
Blood pressure	13.2	Esophageal accelerometry	17.0
Plood surface natential manning	17.5	Esophageal electrocardiogram	17.2
Bono trauma	0.4	Evoked petentials	11.3
Automated patient treatment Ballistocardiogram Bandwidth reduction Bedside monitoring Behavioral patterns Bio-electric rhythm Biomagnetism Biomedical engineering accreditation Biomedical engineering education Biomedical engineering profession Biomedical engineering subjects Biomedical pattern recognition Biopotentials Biotelemetry Blood pressure Blood pressure control Blood surface potential mapping Bone trauma Bone union Brain retraction monitor Broadband ultrasonic tomography	0.4	Evoked cerebral potentials Evoked potentials Eye position measurement	2 2
Reain retraction monitor	1 2		2.2
Recarded ultraconte tomography	3 3	Fan-beam Finger clubbing Flexural vibrations Fluid mechanics	8.2
broadband dicrasonic comography	3.3	Finger clubbing	9.7
Capacitive pressure transducer	9.1	Flevural vibrations	7.5
Cardiac dimension estimation using ultrasound		Fluid mechanics	2.2 2
Cardiopulmonary evaluation	6.3	Food and Drug Administration: Bureau of Medical Devices Forced duction tests Fourier-transform reconstruction Frequency response of long bones Fuzzy set theory Gastroesophageal reflex	
Cardiovascular function	6.3 9.5	Medical Devices	4.6
Cardiovascular function Cardiovascular pulsations radiography Cardiovasuclar screening X-ray CAT Cerebellar stimulator Clinical EKG monitor	1.3	Forced duction tests	9.6
Cardiovasuclar screening X-ray	1.3	Fourier-transform reconstruction	8.1
CAT	8.2	Frequency response of long bones	9.4
Cerebellar stimulator	10.7	Fuzzy set theory	14.3
Clinical EKG monitor Clinical engineer Clinical engineering Clinical engineering to industry Coal workers' pneumoconiosis	2.4	a billion by a consol of a consol of	
Clinical engineer	7.2	Gastroesophageal reflex	2.6
Clinical engineering	4.7	Graduate BME program	16.3
Clinical engineering to industry	7.4	Growth opportunities	7.2
Coal workers' pneumoconiosis	5.3	Gastroesophageal reflex Graduate BME program Growth opportunities Guidelines for accreditation in biomedical	
Cochlea	11.1	engineering	16.2
Coded aperture	3.6		
Communication prostheses	15.2	Heart	2.5
Computed tomography 3	.1, 3.5	High reliability implants	12.2
Computed tomography - ultrasonic	3.4	Udeb wasaluttan D com and C com ulturante	
Computer-aided tomography	8.1	imaging	3.2
Computer control 13.	1, 13.2	High-speed A/D conversion	5.1
Computer controlled experiments	10.5	High-speed A/D conversion Hopf bifurcation Hospital computer system Hospital electrical safety	11.1
Computer interpretation of patient data	6.4	Hospital computer system	6.4
Computer simulation	17.1	Hospital electrical safety	4.2
Computerized classification	1.1		
Computerized medical decision making	6.4	Implantable cardiac dimension system	18.5
Coronary artery disease	17.6	Implantable cochlear prosthesis	10.1
Correlogram	11.7	Implantable electro-stimulation system	18.1
Coal workers' pneumoconiosis Cochlea Coded aperture Communication prostheses Computed tomography 3 Computed tomography - ultrasonic Computer-aided tomography Computer control 13. Computer controlled experiments Computer interpretation of patient data Computer simulation Computerized classification Computerized medical decision making Coronary artery disease Correlogram Coupled relaxation oscillators Custom integrated circuits Data acquisition Data compression	17.7	Implantable hybrid assembly	18.3
Custom integrated circuits	12.2	Implantable telemetry	18.2
		Implanted telemetry	12.6
Data acquisition	5.1	Independent living	15.1
Data compression	1.2	Infrared telemetry	12.7
DC powered endosteal implants	10.8	Instrumentation	2.3
Decision making	14.3	Interactive computer systems	5.4
Diagnostic ultrasound	3.4	Intracranial pressure	1.7
Dialysis fistulas blood flow	8.4	Intraocular pressure	9.6
Data acquisition Data compression DC powered endosteal implants Decision making Diagnostic ultrasound Dialysis fistulas blood flow Dipole localization	11.4	ISFET	14.1
Dopprer Flowinecer	18.4	Implantable cardiac dimension system Implantable cochlear prosthesis Implantable electro-stimulation system Implantable hybrid assembly Implantable telemetry Implanted telemetry Independent living Infrared telemetry Instrumentation Interactive computer systems Intracranial pressure Intraocular pressure ISFET Kolmogorov-Smirnov test	
Dry electrode	2.1	Kolmogorov-Smirnov test	17.1

Laser Doppler velecimetry Life cycle cost analysis Linguistic analysis Lung dust measurement Magnetopneumography Markov point process Mathematical modeling Measurement Measurement circuit Measurement of pulse rate Medical data bases Medical Device Amendments of 1976 Medical diagnosis Microcomputer-based instrumentation Microprocessor Microprocessor control Microprocessor implementation Microprocessors Microprocessor Microprocesor Microprocessor Microprocessor Microprocesor	2.7 7.6 6.1 8.6	Resonance spectra Retraction Retraction pressure measurement Rural health telemetry system		7.5 9.3 9.2 12.4	
Magnetonneumography	8.6	Severe physically disabled		15 1	
Markov noint process	11.7	Shadowaranh		0.7	
Mathematical modeling	11.3	Signal processing	3 4	5.7	
Meacurement	9.7	Skin blood flow	3.4	2.7	
Measurement circuit	14.1	Spatial ion density modulation		10.6	
Measurement of pulse rate	9.8	Special purpose processors		3.5	
Medical data bases	6.1	Spectrum analysis		5.2	
Medical Device Amendments of 1976	4.6	Speech processing		10.2	
Medical diagnosis	14.3	Standards		4.1	
Microcomputer-based instrumentation	1.6	Standards and codes.		4.7	
Microelectrode arrays	10.3	Standards development		4.5	
Microprocessor	1.7	Standards quality		4.5	
Microprocessor control	12.5	Standards writers		4.5	
Microprocessor implementation	10.2	Statistical pattern recognition		1.1	
Microprocessors	2.3	Stratum corneum		8.5	
Microwaves Medicitude measurement	9.5	Sunden intant death syndrome		2.0	
Monttoring	2.1	Surgical instrument		9.2	
More Tuck than management	7.3	Syntactic FEG analysis		11 6	
Morse code	15.2	Synthesized relayation oscillator		17.7	
Multichannel neural stimulation	10.4	Systematic management process		7.6	
Multipoles	17.4	ogs come or o marragement process		7.0	
Multitasking	3.1	Technical solutions for handicapped	1	7.1	
Muscle relaxants	9,6	Telemetry		18.4	
Myocardial wall thickness measurement	18.5	Thalamocortical		11.5	
	100	Thallium-201 scintigraphy		3.6	
Natural languages	6.1	Time-connectivity		11:17	
Needed extension of clinical engineering	7.1	Tissue model		9.3	
Neurosurgery and evaluation	11.5	Tomography	* 5	3.6	
Noise rejection	12.5	Totally implantable telemetry	12.2,	18.1	
Non-invasive cardiac monitor	9.5	Traditional engineering programs		16.3	
Non-invasive electromagnetic flowmetry	8.4	Transcutaneous activation		12.6	
Non-stationary ELG	0.4	Transdormal stimulation electroics		10.4	
Nuclear magnetic resonance flowinetry	0.4	Transducer		0.7	
Ovugen-demand	2.5	Transducer		3.1	
oxygen-deliand		Ultrasonic attenuation		3.2	
Pacemaker	2.5	Ultrasonic computer-assisted tomography		3.2	
Pattern recognition	5.4, 17.6	Ultrasonic data acquisition system		3.2	
Performance standards	4.6	Ultrasonic dimension sensor		18.2	
Peripheral nerve trunk stimulation	10.6	Ultrasound Santa		3.1	
pH monitoring	2.6	Undergraduate BME programs		16.3	
pH sensor	14.1	Urea removal		2.8	
Physiologic profile	6.3				
Physiological models	13.3	Vasodilating agents		13.2	
Polar-sampling theorem	8.1	Ventricular function analyzer	1	6.6	
Portable, multi-sensor telemetry system	12.4	Visual evoked potential		1.7	
Prediction Pressure transducer	9.1	Voluntary consensus standards		4.6	
Products liability	4.6	Walsh transform		1.8	
Professional development	16.1	Wave duration histogram display		1.6	
Programmable	10.7	Wildlife biotelemetry		12.3	
Programming systems	2.3	With the blood of the off		1200	
Prosthetic fixation	7.5	Zero crossing counting		18.4	
Psychophysical auditory stimulation data	10.5				
Pulmonary function indices	5.3				
Pulse frequency demodulation	12.5				
Pulse rate alarm	9.8				
Pulse rate monitor	9.8	. *	*		
	1.0				
Quantization	1.2		à .		
Range/cross-range ambiguity function for	0.0				
diagnostic ultrasound	3.3 2.4				
Read only memory	1.8				
Real time spectrum analyzer	8,2				
Rebinning Rechargeable	10.7	4			
Rechargeable transcutaneously	12.6				
Rehabilitation engineering	7.1				
Reopneumography	2.1				

100

-

LIST OF PRESENTING AUTHORS

Arzbaecher, R. Altes, R. A.		17.2	Robinson, S. E.	8.6
Aunon, J.		1.5, 11.4	Salles-Cunha, S. X. Salsgiver, J. P.	8.4 9.7 9.1
Bardakjian, B. L.		17.7	Sander, C. S. Savant, C. J.	9.8
Barrett, T. W.		11.1	Sawyer, P. N.	10.8
Bashein, G. Brinkman, M. O.		4.2 7.2	Schneck, D. J. Schoenfeld, R. L.	6.2
Burns, S. K.		2.3	Setton, J. J.	1.8
Childers, D. G.		5.2	Shapiro, J. M. Sheppard, L. C.	2.2
Chung, J. K.		7.5	Shridhar, M.	1,2
Claude, J. P.		18.1	Sidman, R. D.	11.3
Collins, S. M. Cook, A. M.		13.1	Silverstein, M. E. Slate, J. B.	12.4 13.3
Cook, K. J.		7.4	Sloter, L. E.	4.6
Dhupar, K. K.		6.6	Stark, H.	8.1
Doemland, H. H.		9.4	Trimble, R. L.	7.6
		3.2	Wald, A.	4.1
Fish, R. M. Foltz, W. M.	1 1964 10 10 1	7.3	Wang, P. P.	5.4
Foster, J. A.		10.6	Webb, G. N.	4.7
Fraden, J. Friedlander, C. B.		2.1	Webster, J. G. Weiss, M. S.	1.4
			Wernikoff, R. E.	1.3
Gardner, R. M. Getzel, W. A.		6.4	West, A. I. White, R. L.	9.3
Gilbert, B. K.		3.5	Wildi, E.	18.5
Gschwend, S. J.		18.3	Woodburn, J. D.	9.6
Gupta, M. M.		14.3	Woods, W. L. Woodyard, M.	7.1 6.1
Hanka, R.		1.1		
Harrison, T. R.		18.4	York, D. H. Youdin, M.	1.7
Jacques, S. L.		8.5	roudin, in	10.1
		0.0		
Jagannathan, V.		11.6	Zelina, F. J.	12.5
Jagannathan, V. Jarzembski, W.		11.6	Zelina, F. J. Zicker, J. E.	12.5
Jagannathan, V. Jarzembski, W. Jendrucko, R. J. Jeutter, D. C.		11.6 4.5 16.4 12.6		
Jagannathan, V. Jarzembski, W. Jendrucko, R. J.		11.6 4.5 16.4 12.6 3.4	Zicker, J. E.	1.6
Jagannathan, V. Jarzembski, W. Jendrucko, R. J. Jeutter, D. C. Jones, S. M. Katz, J. L.		11.6 4.5 16.4 12.6 3.4	Zicker, J. E.	
Jagannathan, V. Jarzembski, W. Jendrucko, R. J. Jeutter, D. C. Jones, S. M. Katz, J. L. Keller, R. W.		11.6 4.5 16.4 12.6 3.4	Zicker, J. E.	ALS/WORKSHOPS
Jagannathan, V. Jarzembski, W. Jendrucko, R. J. Jeutter, D. C. Jones, S. M. Katz, J. L.		11.6 4.5 16.4 12.6 3.4	Zicker, J. E. TUTORI Workshops and Tutorial	ALS/WORKSHOPS s are summarized at the end of
Jagannathan, V. Jarzembski, W. Jendrucko, R. J. Jeutter, D. C. Jones, S. M. Katz, J. L. Keller, R. W. Klain, M. Klein, F. F. Knutti, J. W.		11.6 4.5 16.4 12.6 3.4 16.3 2.8 6.3 12.7 12.2	Zicker, J. E.	ALS/WORKSHOPS s are summarized at the end of
Jagannathan, V. Jarzembski, W. Jendrucko, R. J. Jeutter, D. C. Jones, S. M. Katz, J. L. Keller, R. W. Klain, M. Klein, F. F.		11.6 4.5 16.4 12.6 3.4 16.3 2.8 6.3 12.7	Zicker, J. E. TUTORI Workshops and Tutorial	ALS/WORKSHOPS s are summarized at the end of
Jagannathan, V. Jarzembski, W. Jendrucko, R. J. Jeutter, D. C. Jones, S. M. Katz, J. L. Keller, R. W. Klain, M. Klein, F. F. Knutti, J. W. Ktonas, P. Y. Lake, R. B.		11.6 4.5 16.4 12.6 3.4 16.3 2.8 6.3 12.7 12.2 11.7	Zicker, J. E. TUTORI Workshops and Tutorial	ALS/WORKSHOPS s are summarized at the end of
Jagannathan, V. Jarzembski, W. Jendrucko, R. J. Jeutter, D. C. Jones, S. M. Katz, J. L. Keller, R. W. Klain, M. Klein, F. F. Knutti, J. W. Ktonas, P. Y. Lake, R. B. Lambert, P. L.		11.6 4.5 16.4 12.6 3.4 16.3 2.8 6.3 12.7 12.2 11.7	Zicker, J. E. TUTORI Workshops and Tutorial the Conference Proceed	ALS/WORKSHOPS s are summarized at the end of
Jagannathan, V. Jarzembski, W. Jendrucko, R. J. Jeutter, D. C. Jones, S. M. Katz, J. L. Keller, R. W. Klain, M. Klein, F. F. Knutti, J. W. Ktonas, P. Y. Lake, R. B. Lambert, P. L. Li, C. C. Long, F. M.		11.6 4.5 16.4 12.6 3.4 16.3 2.8 6.3 12.7 12.2 11.7	Zicker, J. E. TUTORI Workshops and Tutorial	ALS/WORKSHOPS s are summarized at the end of
Jagannathan, V. Jarzembski, W. Jendrucko, R. J. Jeutter, D. C. Jones, S. M. Katz, J. L. Keller, R. W. Klain, M. Klein, F. F. Knutti, J. W. Ktonas, P. Y. Lake, R. B. Lambert, P. L. Ling, F. M. Lundy, J. R.		11.6 4.5 16.4 12.6 3.4 16.3 2.8 6.3 12.7 12.2 11.7	Zicker, J. E. TUTORI Workshops and Tutorial the Conference Proceed	ALS/WORKSHOPS s are summarized at the end of ings.
Jagannathan, V. Jarzembski, W. Jendrucko, R. J. Jeutter, D. C. Jones, S. M. Katz, J. L. Keller, R. W. Klain, M. Klein, F. F. Knutti, J. W. Ktonas, P. Y. Lake, R. B. Lambert, P. L. Li, C. C. Long, F. M. Lundy, J. R. Lux, R. L.		11.6 4.5 16.4 12.6 3.4 16.3 2.8 6.3 12.7 12.2 11.7	Zicker, J. E. TUTORI Workshops and Tutorial the Conference Proceed	ALS/WORKSHOPS s are summarized at the end of ings.
Jagannathan, V. Jarzembski, W. Jendrucko, R. J. Jeutter, D. C. Jones, S. M. Katz, J. L. Keller, R. W. Klain, M. Klein, F. F. Knutti, J. W. Ktonas, P. Y. Lake, R. B. Lambert, P. L. Li, C. C. Long, F. M. Lundy, J. R. Lux, R. L. Marshall, J. D.		11.6 4.5 16.4 12.6 3.4 16.3 2.8 6.3 12.7 12.2 11.7 5.1 3.1 5.3 12.3 17.6 17.5	Zicker, J. E. TUTORI Workshops and Tutorial the Conference Proceed	ALS/WORKSHOPS s are summarized at the end of lings.
Jagannathan, V. Jarzembski, W. Jendrucko, R. J. Jeutter, D. C. Jones, S. M. Katz, J. L. Keller, R. W. Klain, M. Klein, F. F. Knutti, J. W. Ktonas, P. Y. Lake, R. B. Lambert, P. L. Li, C. C. Long, F. M. Lundy, J. R. Lux, R. L. Marshall, J. D. Mathews, R. G.		11.6 4.5 16.4 12.6 3.4 16.3 2.8 6.3 12.7 12.2 11.7 5.1 3.1 5.3 12.3 17.6 17.5	Zicker, J. E. TUTORI Workshops and Tutorial the Conference Proceed	ALS/WORKSHOPS s are summarized at the end of lings.
Jagannathan, V. Jarzembski, W. Jendrucko, R. J. Jeutter, D. C. Jones, S. M. Katz, J. L. Keller, R. W. Klain, M. Klein, F. F. Knutti, J. W. Ktonas, P. Y. Lake, R. B. Lambert, P. L. Li, C. C. Long, F. M. Lundy, J. R. Lux, R. L. Marshall, J. D. Mathews, R. G. May, G. A.		11.6 4.5 16.4 12.6 3.4 16.3 2.8 6.3 12.7 12.2 11.7 5.1 3.1 5.3 17.6 17.5	Zicker, J. E. TUTORI Workshops and Tutorial the Conference Proceed	ALS/WORKSHOPS s are summarized at the end of lings.
Jagannathan, V. Jarzembski, W. Jendrucko, R. J. Jeutter, D. C. Jones, S. M. Katz, J. L. Keller, R. W. Klain, M. Klein, F. F. Knutti, J. W. Ktonas, P. Y. Lake, R. B. Lambert, P. L. Li, C. C. Long, F. M. Lundy, J. R. Lux, R. L. Marshall, J. D. Mathews, R. G. May, G. A. Nelson, A. D.		11.6 4.5 16.4 12.6 3.4 16.3 2.8 6.3 12.7 12.2 11.7 5.1 3.1 5.3 12.3 17.6 17.5	Zicker, J. E. TUTORI Workshops and Tutorial the Conference Proceed	ALS/WORKSHOPS s are summarized at the end of ings.
Jagannathan, V. Jarzembski, W. Jendrucko, R. J. Jeutter, D. C. Jones, S. M. Katz, J. L. Keller, R. W. Klain, M. Klein, F. F. Knutti, J. W. Ktonas, P. Y. Lake, R. B. Lambert, P. L. Li, C. C. Long, F. M. Lundy, J. R. Lux, R. L. Marshall, J. D. Mathews, R. G. May, G. A. Nelson, A. D. Nelson, K. R. Nicholson, J. E.		11.6 4.5 16.4 12.6 3.4 16.3 2.8 6.3 12.7 12.2 11.7 5.1 3.1 5.3 17.6 17.5 18.2 10.4, 10.5 10.3	Zicker, J. E. TUTORI Workshops and Tutorial the Conference Proceed	ALS/WORKSHOPS s are summarized at the end of ings.
Jagannathan, V. Jarzembski, W. Jendrucko, R. J. Jeutter, D. C. Jones, S. M. Katz, J. L. Keller, R. W. Klain, M. Klein, F. F. Knutti, J. W. Ktonas, P. Y. Lake, R. B. Lambert, P. L. Li, C. C. Long, F. M. Lundy, J. R. Lux, R. L. Marshall, J. D. Mathews, R. G. May, G. A. Nelson, A. D. Nelson, K. R.		11.6 4.5 16.4 12.6 3.4 16.3 2.8 6.3 12.7 12.2 11.7 5.1 3.1 5.3 17.6 17.5 18.2 10.4, 10.5 10.3	Zicker, J. E. TUTORI Workshops and Tutorial the Conference Proceed	ALS/WORKSHOPS s are summarized at the end of ings.
Jagannathan, V. Jarzembski, W. Jendrucko, R. J. Jeutter, D. C. Jones, S. M. Katz, J. L. Keller, R. W. Klain, M. Klein, F. F. Knutti, J. W. Ktonas, P. Y. Lake, R. B. Lambert, P. L. Li, C. C. Long, F. M. Lundy, J. R. Lux, R. L. Marshall, J. D. Mathews, R. G. May, G. A. Nelson, A. D. Nelson, A. D. Nelson, K. R. Nicholson, J. E. Nowack, W. J.		11.6 4.5 16.4 12.6 3.4 16.3 2.8 6.3 12.7 12.2 11.7 5.1 3.1 5.3 17.6 17.5 18.2 10.4, 10.5 10.3	Zicker, J. E. TUTORI Workshops and Tutorial the Conference Proceed	ALS/WORKSHOPS s are summarized at the end of ings.
Jagannathan, V. Jarzembski, W. Jendrucko, R. J. Jeutter, D. C. Jones, S. M. Katz, J. L. Keller, R. W. Klain, M. Klein, F. F. Knutti, J. W. Ktonas, P. Y. Lake, R. B. Lambert, P. L. Li, C. C. Long, F. M. Lundy, J. R. Lux, R. L. Marshall, J. D. Mathews, R. G. May, G. A. Nelson, A. D. Nelson, K. R. Nicholson, J. E. Nowack, W. J. Orlowski, J. M.		11.6 4.5 16.4 12.6 3.4 16.3 2.8 6.3 12.7 12.2 11.7 5.1 3.1 5.3 12.3 17.6 17.5 18.2 10.4, 10.5 10.3 3.6 2.4 9.2 11.5 2.5	Zicker, J. E. TUTORI Workshops and Tutorial the Conference Proceed	ALS/WORKSHOPS s are summarized at the end of ings.
Jagannathan, V. Jarzembski, W. Jendrucko, R. J. Jeutter, D. C. Jones, S. M. Katz, J. L. Keller, R. W. Klain, M. Klein, F. F. Knutti, J. W. Ktonas, P. Y. Lake, R. B. Lambert, P. L. Li, C. C. Long, F. M. Lundy, J. R. Lux, R. L. Marshall, J. D. Mathews, R. G. May, G. A. Nelson, A. D. Nelson, K. R. Nicholson, J. E. Nowack, W. J. Orlowski, J. M. Pantulu, S. V.		11.6 4.5 16.4 12.6 3.4 16.3 2.8 6.3 12.7 12.2 11.7 5.1 3.1 5.3 17.6 17.5 18.2 10.4, 10.5 10.3 3.6 2.4 9.2 11.5 2.5	Zicker, J. E. TUTORI Workshops and Tutorial the Conference Proceed	ALS/WORKSHOPS s are summarized at the end of ings.
Jagannathan, V. Jarzembski, W. Jendrucko, R. J. Jeutter, D. C. Jones, S. M. Katz, J. L. Keller, R. W. Klain, M. Klein, F. F. Knutti, J. W. Ktonas, P. Y. Lake, R. B. Lambert, P. L. Li, C. C. Long, F. M. Lundy, J. R. Lux, R. L. Marshall, J. D. Mathews, R. G. May, G. A. Nelson, A. D. Nelson, A. D. Nelson, K. R. Nicholson, J. E. Nowack, W. J. Orlowski, J. M. Pantulu, S. V. Pilkington, T. C. Piraino, D. W.		11.6 4.5 16.4 12.6 3.4 16.3 2.8 6.3 12.7 12.2 11.7 5.1 3.1 5.3 17.6 17.5 18.2 10.4, 10.5 10.3 3.6 2.4 9.2 11.5 2.5	Zicker, J. E. TUTORI Workshops and Tutorial the Conference Proceed	ALS/WORKSHOPS s are summarized at the end of ings.
Jagannathan, V. Jarzembski, W. Jendrucko, R. J. Jeutter, D. C. Jones, S. M. Katz, J. L. Keller, R. W. Klain, M. Klein, F. F. Knutti, J. W. Ktonas, P. Y. Lake, R. B. Lambert, P. L. Li, C. C. Long, F. M. Lundy, J. R. Lux, R. L. Marshall, J. D. Mathews, R. G. May, G. A. Nelson, A. D. Nelson, K. R. Nicholson, J. E. Nowack, W. J. Orlowski, J. M. Pantulu, S. V. Pilkington, T. C.		11.6 4.5 16.4 12.6 3.4 16.3 2.8 6.3 12.7 12.2 11.7 5.1 3.1 5.3 17.6 17.5 18.2 10.4, 10.5 10.3 3.6 2.4 9.2 11.5 2.5	Zicker, J. E. TUTORI Workshops and Tutorial the Conference Proceed	ALS/WORKSHOPS s are summarized at the end of ings.

R.Hanka Ph.D. School of Clinical Medicine University of Cambridge England

Summary.

An application of statistical pattern recognition techniques to the analysis of ballistocardiograms is described. The data consisted of 131 recordings which were divided into two groups (normal, pathological). The discriminatory potential of the individual waves of the ballistocardiogram was assessed by standard feature selection techniques. The results of the analysis confirm most of the clinical views and also offer some new information about the importance of the individual peaks of the ballistocardiogram for correct diagnosis. overall performance of the constrained hyperquadric classifier was very encouraging. Using an optimal subset of features the classification error was lower than 4%.

Introduction.

Ballistocardiography (BCG) is a technique of graphic representation of the movements of the body caused by the ballistic forces associated with cardiac contraction and ejection of blood and with the subsequent deceleration of blood flow through the large vessels.

Although it is accepted that ballistocardiography can give valuable information about the heart which is otherwise difficult to obtain, the technique has not yet found wider use. The complexity of the BCG waveform together with its rather subjective interpretation are perhaps the main reasons behind its relative unpopularity.

Pattern recognition techniques were used in this study to throw some objective light on the significance of individual features of a BCG waveform and to clarify their importance for efficient diagnosis.

Method.

The data consisted of 10 seconds long simultaneous recordings of ballistocardiograms and electrocardiograms. It is a standard practice to begin each BCG on the peak of the CRS complex of the ECG and this method was used in this study. The ECG records were scanned by the computer for the QRS complexes and the BCG signals coresponding to the individual cardiac cycles were then extracted into records of a fixed number of samples, in our case 100, of variable sampling frequency. Altogether there were 131 ballistocardiograms which were divided into two groups. Normal and abnormal consisting of 81 and 50 records respectively.

The normal ballistocardiogram is essentially a series of consecutive waves, named H,I,',K,L,M,N,O, forming a distinctive pattern (Fig. 1). The upward waves, H,',L,N, represent

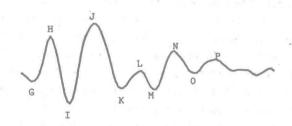


Fig. 1.

headward impacts or recoils of the body, whereas the downward waves I,K,M,O, represent footward movements. The waves H,I,I,K, occur during the systole while the waves L M,N,C, are diastolic. Preceding the H wave could be a group of smaller waves F and G associated with the ballistic effects of atrial systole. The H wave itself coincides with isometric contraction and may be due to headward motion of both atrioventricular septum and the blood in the atria. The I is a deep, downward wave and the I a prominent, upward wave, both occurring during ventricular ejection.

The ! wave is usually the most prominent wave of the ballistocardiogram and is caused by the impact of blood on the arch of the acrts and the bifurcation of the main pulmonary artery.

The K wave occurs just before the second heart sound and is attributed to deceleration of blood flow in the aorta. The L,M,N, and other waves occur in diastole and are normally much less prominent than the systolic waves.

Deterministic representation of BCG waveform.

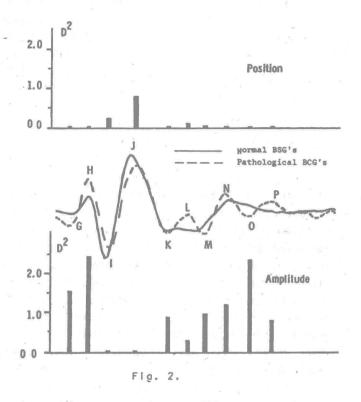
The diagnostic parameters of the BCG trace which are recognised by physicians were evaluated first. A physician would base his classification of a BCG record on the absence or existence of individual peaks, on their amplitude, and to a certain degree, on their relationship in time.

A similar approach was adopted for computer classification. A computer program identifying and extracting amplitudes of the ten standard peaks (G to P see Fig.1.) was used to form a set of tendimensional pattern vectors.

All available data consisting of 131 such vectors were then used for feature extraction. The importance of individual features was assessed by calculating the Mahatanobis distance (D^2) , both statistically robust computationally relatively simple. The results are in Fig.2. It appears that the two most important features are the amplitudes of the peaks H and O. The H wave is due to the headward motion of the atrioventricular septum and of the blood in atria and it is known that increased amplitude of this wave is observed with myocardial disease and heart failure and in cases of hypertension. The wave 0 is one of the diastolic waves and no particular importance has so far been attributed to it.

Waves H and O are, in the order of decreasing D^2 , followed by waves G,N,K and M. Of these only the K wave is recognised as having some diagnostic importance. Its amplitude is known to increase when there is an increased peripheral resistance as in essential hypertension or arteriosclerosis.

It is very surprising that the waves I and J which are generally believed to contain most of 1.1.2



the diagnostic information have received the lowest ranking on the part which their amplitudes play in efficient classification.

An explanation of this paradox may be in the tact that so far we have been considering only the amplitudes of the individual peaks without any regard to their position. This was confirmed when the positions of the peaks were also taken into account. The results of the analysis are given on the lower half of Fig.2 where are drawn the Mahalanobis distances coresponding to the positions of the peaks.

It would appear that the only important differences in the timing of the individual peaks are in the positions of the waves I and J which obtained the lowest ranking on the D^2 of their amplitudes. The positions of other peaks seem to have minimal discriminatory potential when compared with that of their amplitudes. Each of the ten peaks was therefore represented by its amplitude with the exception of the waves I and J which were represented by their positions. The best subsets (in terms of D^2) were then evaluated starting with one and finishing with all ten features giving the following result