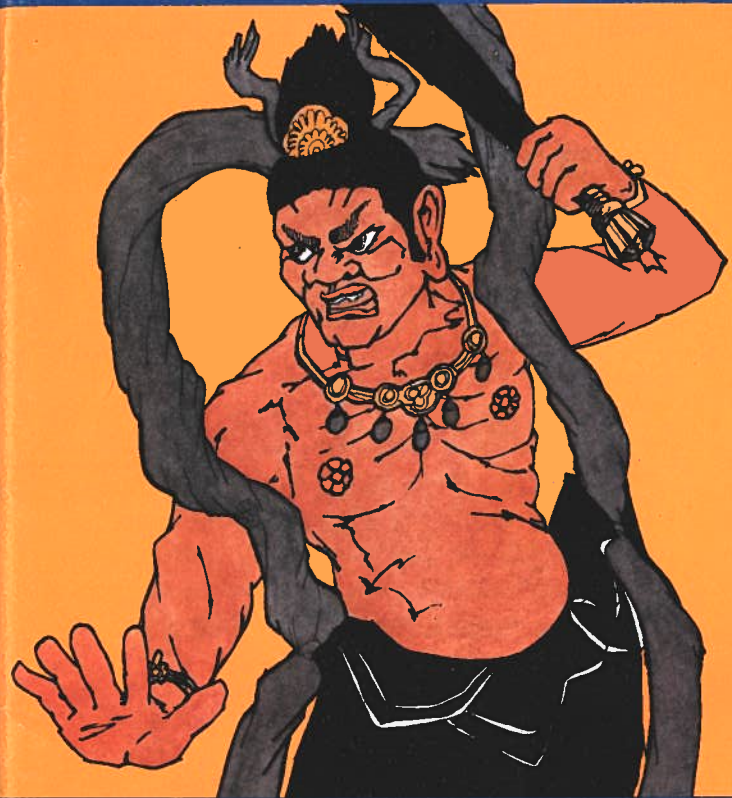




IEA '82



**The 8th Congress of
The International Ergonomics Association**

August 23 ~ 27, 1982

Tokyo, Japan

Final Announcement

CONTENTS

	Page
WELCOME TO IEA'82 TOKYO	1
HOST	2
ORGANIZATION	2
CONGRESS INFORMATION	4
PROGRAM	6
EVENTS SCHEDULES	8
OPENING CEREMONY	9
SPECIAL LECTURES	9
SYMPOSIUM	9
WORKSHOPS	10
TECHNICAL SESSIONS	15
TECHNICAL SITE VISITS	39
SCIENTIFIC EXHIBITION	39
SOCIAL PROGRAMS	40
TRAVEL INFORMATION	42
HOTEL ACCOMMODATION	45
OPTIONAL TOURS	46
LOCATION MAP	48

WELCOME TO IEA '82 TOKYO

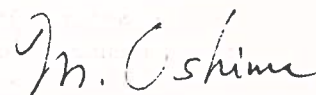
I recall an old saying now, "Time flies like an arrow". Since our Organizing Committee was established one year ago, we have been making every effort to make the 8th Congress worthy of your participation.

Our Program Committee is very glad to know that over 400 papers were submitted to the Technical Sessions. And it was most difficult to limit the number to 300. We have actually accepted 370, which thus increased the number of sessions. In addition, we have made a plan to set up Workshops and a Symposium.

Now, the overall Scientific Program is nearly finalized and is included herein. This Scientific Program will indicate the grand scale of this Congress. We have also included detailed information concerning travel and accommodation for the participants' benefit.

I sincerely hope that all of you will find IEA '82 scientifically rewarding as well as an enjoyable experience.

I look forward to seeing you soon.



Masamitsu Oshima, M.D.
Chairman
Organizing Committee

HOST

- Japan Ergonomics Research Society
- Research Foundation of Traffic Medicine

ORGANIZATION

International Ergonomics Association

President: J. Rosner (Poland)
Secretary General: H.L. Davis (U.S.A.)
Treasurer: H. Scholz (F.R.G.)

Advisory Board

(International) H.L. Davis (U.S.A.)
E.P. Grandjean (Switzerland)
B. Shackel (U.K.)

(Japan) Shizuo Asada
Kenji Ekuan
Junnosuke Kishida
Sakyo Komatsu
Naoki Toida
Eiji Toyota

Japanese Organizing Committee

Chairman: Masamitsu Oshima
Vice-Chairman: The Late Kunie Hashimoto
Secretary General: Toshiyuki Furukawa
General Affairs: Shingo Ogawa
Treasurer: Toshio Endo
Foreign Affairs: Hidemaro Nagano
Sadao Sugiyama

Scientific Liaison: Yuji Iiyama
Convention: Takao Ohkubo
Program: Akira Watanabe
Kazuyoshi Yajima

Registration: Kazuo Aoki
Proceedings: Kageyu Noro
Social Events: Kiyoshi Yamamoto
Exhibition: Kazuo Tsuchiya
Kiyoji Asai
Kazuhiko Atsumi
Sumiji Fujii
Yoshio Hayashi

Yujiro Hayashi
Masakazu Iguchi
Ichiro Kato
Haruo Kondo
Takeshi Kondo
Shigetaka Kubota
Isao Kuroda
Kinya Maruyama
Mitsuo Morioka
Hiroshi Motoaki
Junichi Nagumo
Kiho Nakao
Shinhachi Nishikawa
Masahiko Ohira
Masashi Okawa
Jun Osaki
Takeshi Ota
Hajime Saito
Hiroyuki Sakabe
Masahiko Sato
Eimatsu Takakuwa
Susumu Tsukahara
Genichi Watanabe
Sakae Yokobori
Katsumi Yokomizo
Masaaki Yoshida

CONGRESS INFORMATION

1. VENUE

Nihon Toshi Center
2-4-1, Hirakawa-cho, Chiyoda-ku, Tokyo, Japan
Phone: (03) 265-8211

(See the location map on Page 48)

2. DATE

August 23 (Mon.)~27 (Fri.), 1982

(Registration on 23.)

3. OFFICIAL LANGUAGE

The official languages of the Congress are English and Japanese. Simultaneous interpreting between two languages will be provided throughout the sessions.

4. REGISTRATION FEE

- (1) Congress participant..... ¥55,000
- (2) Accompany person..... ¥20,000
- (3) Farewell party..... ¥10,000

The enclosed official registration form must be returned to the Secretariat.

5. PAYMENT

All registration fees shall be paid in Japanese Yen by a bank draft or bank remittance to the following bank account. Neither personal nor traveller's checks will be accepted.

(1) Bank Remittance

Name of Bank:

The Kyowa Bank, Akasaka Branch
Akasaka, Minato-ku, Tokyo, Japan

Name of Account:

"IEA '82 Tokyo"

Number of Account:

No. 916302 (Ordinary Deposit)

Please send or bring a copy of bank remittance with your registration form for confirmation.

(2) Bank Draft

A bank draft should be payable to the order of "IEA '82 Tokyo".

Participants who have not paid their registration fee in advance should pay the fee in **Japanese Yen** at the "On-Site Registration Desk".

The Desk will start at 13:00 p.m. on August 23.

No credit cards will be accepted at the Desk.

6. REGISTRATION CARD

The Secretariat has been sending a registration card and a receipt to those who have paid the registration fee to confirm their registration. Please present the Card at the Registration Counter.

7. CANCELLATIONS

In case you cancel your attendance, it shall be made in writing to the Secretariat. No part of the fee will be refunded. However, a copy of Proceedings of the Congress will be sent after the Congress concluded.

8. APPLICATION FORMS

The following forms are enclosed with this announcement.

[Form 1] Official Registration Form
(Mail to the Secretariat)

[Form 2] Application Form for Hotel Accommodation & Tours
(Mail to Japan Travel Bureau)

PROGRAM

Room		Hall A	Hall B	
Date				
Aug. 24 Tues.	9:00	Opening Ceremony	X	
	10:00	< WORKSHOP I > Safety		
	10:30			Special Lectures
	12:00			
	13:00	< WORKSHOP II > Human Error		Work Load: General ①
17:30		Work Load: Industrial Applications ②		
25 Wed.	9:00	< WORKSHOP III > Productivity I — Automation & Robotization	Work Load: Muscle Activity ⑩	
		< WORKSHOP IV > VDU & Operator	Work Load: Physical ⑪	
	12:30	General Assembly	X	
	14:00			
	15:00	Special Lecture		
	16:00			
26 Thur.	9:00	< WORKSHOP V > Productivity II — Humanization & Workplace	Architecture ⑬	
			Work Load: Methodology ⑰	
	12:30	Technical Site Visits		
27 Fri.	9:00	< WORKSHOP VI > The Aged & Handicapped	Vehicle Driving ⑲	
	12:00	X	< Symposium > Past, Present & Future of Ergonomics	
	13:00			
	15:00			
	15:00			
	16:00		Closing Ceremony	

Hall C	Hall D	Hall E
X	X	X
Systems Design I — Keyboard & Others ③	Anthropometry & Clothing ⑤	Quality of Working Life ⑦
Circadian Rhythm & Shift Work ④	Motion & Gait ⑥	Environment: Noise & Vibration ⑧
System Evaluation Methodology ⑫	Eye Movement ⑭	Environment: Underwater & Space ⑨
System Design Methodology ⑬	Education & Training ⑮	Environment: Temperature & Physiological Responses ⑮
X	X	X
Evaluation of Human Activities ⑳	Introduction of Ergonomics to Industry ㉒	Environment: Heat Stress Evaluation ⑰
Systems Design II — Vehicle, Sign & Others ㉑	Ergonomics of Computer Systems ㉓	Work Load: Visual ㉔
Technical Site Visits		
Introduction of Ergonomics to Social Systems ㉗	Posture ㉘	Visual Inspection & Vigilance ㉕
	Work Load: Lifting ㉙	Perception & Recognition ㉚
Work Performance ㉛	Work Load on the Back ㉜	Working Environment ㉝
X	X	X

EVENTS SCHEDULE

	Aug. 23			Aug. 24			Aug. 25			Aug. 26			Aug. 27		
	Mor.	Aft.	Eve.	Mor.	Aft.	Eve.	Mor.	Aft.	Eve.	Mor.	Aft.	Eve.	Mor.	Aft.	Eve.
Registration															
Welcome Party															
Opening Ceremony															
Special Lectures															
General Assembly															
Workshops															
Technical Sessions															
Symposium															
Technical Site Visits															
Farewell Party															
Ladies Program															
Closing Ceremony															
Exhibition															

OPENING CEREMONY

August 24 (Tuesday) "Hall A"
8:45 ~ 10:00

8:45 ~ Music ~

9:00 • Declaration of Opening
Toshiyuki Furukawa, M.D.
Secretary General
Organizing Committee

• Opening Address
Masamitsu Oshima, M.D.
Chairman
Organizing Committee

• Presidential Address
Prof. Jan Rosner
President
International Ergonomics Association

• Address
(Japanese Guests)

• Awards & Address
Prof. Alphonse Chapanis (The Johns Hopkins Univ.)

Prof. Etienne Grandjean (Swiss Federal Institute of Technology)

10:00 ~ Music ~

SPECIAL LECTURES

1. August 24 (Tuesday) "Hall A"

10:30 ~ 12:00

"Modeling of Human Performance in Complex Systems with Emphasis on Nuclear Power Plant Operations and Probabilistic Risk Assessment"

Alan D. Swain
Statistics, Computing & Human Factors Division
Sandia National Laboratories

"The Trends of Ergonomics in Japan"

Masamitsu Oshima
Chairman of Directors
The Medical Information System Development Center

2. August 25 (Wednesday) "Hall A"

15:00 ~ 15:40

"Ergonomics in the Year 2002"

Gavriel Salvendy
Chairman, Human Factors Program and Professor of Industrial Engineering, Purdue University

SYMPOSIUM

• August 27 (Friday) "Hall B" 13:00 ~ 15:00
"Past, Present and Future of Ergonomics"

WORKSHOPS

The following order is not the presentation order. It will be announced in the Final Program.

August 24 (Tuesday)

13:00 ~ 15:15

Room Hall A

Workshop I: Safety

- Ergonomics of Safety
V.D. Keyser (Belgium)
- Life Stress and Occupational Injuries
D. Gloss (U.S.A.)
- One Method for Evaluating Safety Performance in Working Places
S. Hanayasu (Japan)
- Computer Methods in Safety Design with Highway-Vehicle-Object-Environment Simulation
B.K. Huang (U.S.A.)
- Multivariate Safety Assessment of the Level-Crossings with Automatic Full or Half Barriers
T. Ikeda, H. Ohtake (Japan)
- Human Factors in Ship Collision in Narrow Waters
N. Ohashi (Japan)
- Safety Work on Small Fishing Boat Operat by One Man
A. Hattori, N. Ohashi (Japan)
- Influences of Thermal Environment on Safety Behaviour
J.D. Ramsey (U.S.A.)
- Prevention of Occupational Injuries in Greenhouses
B. Gustafsson (Sweden)
- Towards Safer Consumer Product Design
J. Wilson (U.K.)

August 24 (Tuesday)

15:15 ~ 17:30

Room Hall A

Workshop II: Human Error

- Reliability of Human Operator in Man-Machine Systems
M. Iguchi (Japan)
- A Basic Study of the Prediction Method of Clerical Human Errors Based on Pulse Speed Variability
E. Koyano (Japan)

—10—

- Fuzzy Fault Tree Analysis for Accident Caused by Human Errors

K. Noma, H. Tanaka, K. Asai (Japan)

- Alpha Wave and Miss of Signal Detection

H. Kodama (Japan)

- An experimental Study on Human Behavior under the Sudden Hazardous Situation

W. Masada (Japan)

- Human Errors and the Safety of Nuclear Power Plant

G. Mancini, A. Amendola (Italy)

- A Case Study on a Plant Factory from the Human Factors Point of View

K. Hashimoto, M. Aoki, Y. Horie (Japan)

- Analytical Procedures on Causes of Human Errors in Plant Accidents

K. Hashimoto, M. Aoki, T. Endo (Japan)

- Hazard Analysis in the Japanese Chemical Industrial Complexes Especially on the Human Errors

Y. Hayashi (Japan)

- A Study of Human-Error Causing by Drug Naming

F. Tsuchiya (Japan)

August 25 (Wednesday)

9:00 ~ 11:00

Room Hall A

Workshop III: Productivity I — Automation & Robotization

- Ergonomics for Pure Efficiency or for Humanization?
G. Olsson (Sweden)
- The Designing of Man-Machine Systems Human Role Consideration in Modernize Industrial Systems
Y. Iiyama (Japan)
- Automation, Productivity and Stress in Inspection
C.G. Drury (Japan)
- Operator Response to Problems in Proc. Control Systems
K.M. Mallory (U.S.A.)
- Japanese Population Stereotypes for Nuclear Power Plant Control Room Operators and Engineers
R.M. Kane, J. Farbry, Jr., S. Fleger (U.S.A.)
- An Attempt to "Harmonize" Human Operate Job and Computer in Complex Industrial Processes
P.-J. Larriere (France)
- Evolution of Man/Computer Air Traffic Control Systems (The European Approach)
D. Hugh (France)

—11—

- Automation in the Office; on the Role on the Ergonomist with Regard to the Communication between Manufacturer and Customer
C.K. Pasmooij (The Netherlands)
- Japanese Robotization and Human Factors Researches
Y. Okada (Japan)

August 25 (Wednesday)

11:00 ~ 12:30

Room Hall A

Workshop IV: VDU & Operator

- Design of Human-Computer Dialogues
R.C. Williges (U.S.A.)
- An Ergonomic Study of Conversational Work with VDTs
S. Yamamoto, M. Yoshioka, A. Komatsubara, Y. Hayashi (Japan)
- The Influence of Visual Workload History Visual Monitoring Performance
M.L. Matthews (Canada)
- Study on the Evolution in the Field of Information Management and Working Conditions, as a Consequence of the Development of Digital Technology and Use of VDU Operator Stations in Steelworks
F. Bertuccio (Italy)
- Selecting a Color Monitor for an Interactive Graphics System Used to Design Integrated Circuits
A. LeCocq (U.S.A.)
- Research and Development of Airborne Integrated Display for NAL Qstol
M. Okabe, K. Tanaka (Japan)
- Some Health Hazards Associated with Word (or Text) Processing and Similar Data-Terminal Equipment. How to Avoid Them.
A.E. Haugan (Norway)

August 26 (Thursday)

9:00 ~ 12:30

Room Hall A

Workshop V: Productivity II — Humanization & Workplace

- Development of Ergonomic Methods for Productivity Improvement
K. Noro (Japan)

—12—

- Task Allocation Based on Human Needs as Tool in the Humanization of Work System
H. Mulder (The Netherlands)
- Human Interface Analysis to Assure Improved Product Performance
D. Raheja, M. Arjunan (U.S.A.)
- A Critical Analysis of Techniques of Evaluation of Working Conditions and a Proposal for a Methodological Approach
R. Edouard (France)
- Experiments in the Organization of Work in Germany — A Survey of Major Tendencies Result, and Problems
P. Hans (F.R.G.)
- A Report about the Changes of Working Environment Conditions in Sweden
C. Nilsson (Sweden)
- Adjustment of Work to People and Humanization of the Production Line
V. Parežanin (Yugoslavia)
- Organizational and Technological Aspects of the Operation of Production Lines in Yugoslavia
V. Parežanin, R. Parežanin (Yugoslavia)
- Ergonomic Workstation Design for Supermarket Scanning Systems
P.L. Martin (U.S.A.)
- Check-Out Systems for Self Service Shops Standardization and Real Working Conditions
S. Helmut (F.R.G.)
- The Effects of Developments in Grocery Distribution Systems
J. Wilson (U.K.)
- Ergonomic Design of Press Working Places
H.-J. Bullinger, P. Kern, D. Lorenz (F.R.G.)
- Analysis of Film Copy Workplaces for Improving Job Design, Environmental and Ergonomic Conditions
H. Strasser (F.R.G.)
- The Apparel Workplace: An Ergonomic Case Study
L. Middendorf (U.S.A.)

August 27 (Friday)

9:00 ~ 11:30

Room Hall A

Workshop VI: The Aged & Handicapped

- Anthropometric and Biomechanic Measurements of Elderly Women and Men
P.R. Buzzell (Canada)

—13—

- Measurement of the Older Worker's Capability
K. Yokomizo (Japan)
- A Study of Procedure of Job Redesign for Older Workers
M. Nagamachi (Japan)
- Adult Age and Human-Computer Interaction: Implications for a Model of Performance in Menu-Driven Systems
B. Somberg, G. Boggs (U.S.A.)
- Development of Sensor Pegboard for Performance Test
Y. Okada, K. Noro, (Japan)
- Work Load of Disabled People at A Small Factory
T. Hasegawa, K. Noro (Japan)
- Ergonomics for the Mentally Handicapped-Motion Study
E. Kapecka, T. Marek (Poland)
- A Study on Handwork of the Mentally Handicapped
A. Tanaka, N. Ando (Japan)
- About the Weight Ratio of a Prosthetic Arm to an Amputated Arm Segment
N. Ohnishi (Japan)
- An Evaluation of Correlation between Amputated Limb and It's Dominancy Using Dammy Protheses
T. Aoyama, Y. Saito, H. Kasahara, T. Yamashita, K. Koyama, K. Tsuchiya (Japan)
- The Effect of Foot-Sole Pressure Sensory Feedback on the Activity of the Lower Limb Amputee
S. Morimoto, K. Tsuchiya, Y. Saito (Japan)
- Development of Transfer System for the Severely Handicapped
K. Ichikawa (Japan)

TECHNICAL SESSIONS

The following order is not the presentation order. It will be announced in the Final Program.

August 24

13:00 ~ 14:30

Room Hall B

Session 1: Work Load: General

- The Development of Ergonomic Solution Proposals by the Analysis of Task
H. Bubb (F.R.G.)
- Characteristics of Office Works
A. Komatsubara, Y. Yokomizo (Japan)
- Synthetic Stress-Profiles
B.H. Müller (F.R.G.)
- A Contribution to Methodology for the Evaluation of a Welder's Work-Load
N. Dazard, E. Richard, J.-L. Flores (France)
- Cumulative Fatigue Symptoms and Conditions of Work
R. Kosugo (Japan)
- The Methodological Problem of the Predetermination of Load and Possibilities of Its Solution
W. Laurig (F.R.G.)
- Information Load and Its Norming
A. Honkasalo (Finland)

August 24

14:30 ~ 17:20

Room Hall B

Session 2: Work Load: Industrial Applications

- On Work Study and Work Load of the Computer Operator
M. Umemura (Japan)
- Eyestrain and Muscle Fatigue of Data Entry Operators Using Visual Display Terminals
N. Onishi, T. Kuroe (Japan)
- Constrained Postures at VDTs
W. Hünting, T. Läubli, E. Grandjean (Switzerland)
- Fatigue and Health Problems of Workers in a Home for Mentally and Physically Handicapped Person
Y. Ono, K. Masuda, M. Iwata, N. Hisanaga, Y. Takeuchi (Japan)

- Health Survey on Plasterers (Stucco-Workers)
L. Ekkers Kees (The Netherlands)
- The Effects of Ergonomic Measures on the Health of the Neck and the Upper Extremities of Assembly-Line Packers — A Four Year Follow-Up Study
T. Luopajarvi, I. Kuorinka, R. Kukkonen (Finland)
- A Tendonitis Control Program for the Apparel Industry
M.A. Ayoub (U.S.A.)
- Assessment of Mental and Physical Work Load For Some Agricultural Tasks
C. Canan (Malaysia)
- The Effects of Change in Transport Methods on Stress and Strain of Truck Drivers' Work
J. Ilmarinen, C.H. Nygard (Finland)
- Stress and Strain in Cleaners' Work
V. Louhevaara, J. Ilmarine, C.-H. Nygard, I. Pesonen (Finland)
- Influence of Mechanico-Assisted Blowing on the Fine-Myokinesis of the Forearms on Glass-Blowers
S. Gustav, A. Fuchs, A.v. Laer, P. Mayer (F.R.G.)
- Results of Fields Studies Concerning Stress and Strain at Three Different Blast-Furnaces
H. Peter (F.R.G.)
- Speed Skill in Short-Cycle Repetitive Work
A. Khaleque (Bangladesh)

August 24

13:00 ~ 14:30

Room Hall C

Session 3: Systems Design I — Keyboard & Others

- Ergonomic Development of a New Keyboard Design
M. Nakaseko, W. Huening, R.G.E. Granjean (Japan)
- Ergonomic Investigation of Interkey Time Distributions of Touch-Keying Operators of 10-Key Numeric Keyboard: Systems Design Implications
G.F. Rabideau, R.P.-J. Lee (Canada)
- Link Analysis of ECG Manipulation and Application for Design of ECG Equipment
N. Yamanoi, K. Yajima, T. Aoki, S. Kinoshita, H. Tanaka, T. Furukawa (Japan)
- An Educational Equipment for Learners of Keyboard Music and Consideration on the Characteristic of the Playing
I. Kitagaki, K. Suetake (Japan)
- Application of the Plane Switch Using a Pressure-Conductive Rubber Sheet to a Control Manipulator
Y. Ikeda, H. Takeda, S. Hata (Japan)

- Measurement of the Ticket-Selling Worksite-Accordig to Comfort Experiments
M. Launis (Finland)
- Teleoperator Systems, Considerations for Human Management of Remotely Controlled Tasks
N. Shield, Jr. (U.S.A.)
- The Influence of Camera Logic on Camera Ergonomics
H.L. Davis, R.L. Lucas (U.S.A.)

August 24

14:30 ~ 17:20

Room Hall C

Session 4: Circadian Rhythm & Shift Work

- Chronopsychological Approach to Human Factors
P. Naitoh (U.S.A.)
- Shiftwork Research at the UK Medical Research Council Perceptual and Cognitive Performance Unit
W.P. Colquhoun (U.K.)
- Psychophysiological Effects of Shift Work in a Small-Medium Sized Factory
M. Kumashiro, K. Miyake, K. Saito (Japan)
- A Case Study on Work Burden of Shift-Workers
T. Kondo, T. Okubo, M. Aoki, Y. Horie (Japan)
- Time-of-the-Day Effect on Human Performance in a Combined Manual and Decision Task
A. Raouf, T.K. Joseph (Canada)
- Circadian Rhythms of Body Temperature and Performance under a Weekly Rotating Shift System.
S. Milosevic, M. Cabarkapa (Yugoslavia)
- Apparent and True Phase-Shifts of Circadian Rhythms after a Transmeridian Flight
V. Zdenek (Norway)
- Diurnal Variations of Reaction Time Performance in the Mentally Retarded Children
K. Kusano (Japan)
- Critical Flicker Fusion and Grammatical Reasoning in the Evaluation of Shift Schedules
P. Brian, R. Schlegel (U.S.A.)
- Changes in the Subjective Fatigue Scale Characteristic to the Post-Nightshift Period
K. Kogi (Japan)
- Interindividual Differences in Sleep-Waking Habits of Students and Workers Samples
L. Mecacci, A. Zani (Italy)
- Human Reliability in Process Control with Shift Work
G.D. Terssac, Y. Queinnec (France)

August 24

13:00 ~ 15:20

Room Hall D

Session 5: Anthropometry & Clothing

- Problems in Determining Anthropometric Standards for Persons
D. Gloss (U.S.A.)
- Measurement of Human Body Form Using Pattern Processing Techniques
N. Ito (Japan)
- A Longitudinal Study on Physical Growth at Adolescence
Y. Furumatsu, H. Muto, S. Saito, E. Furumatsu (Japan)
- Two Dimensional Fourier Analysis of Human Torso Surface
T. Furukawa, N. Yamanoi, H. Tanaka, K. Yajima, T. Aoki, K. Aoki, S. Kinoshita, K. Hirayanagi (Japan)
- A Three-Dimensional Measurement of the Torso Shape and an Application to Early Detection of Spinal Deformities
Y. Yamashita (Japan)
- A Study of the Anthropometric Differences of the Lordotic Curvature in Adult Men and Women
N.E. O'Neill (U.S.A.)
- Head Dimension Measurement for Telephone Handset Design
H. Matsui (Japan)
- On Morphological Theorization for the Garment Modeling
S. Nakazawa (Japan)
- Physiological Evaluation of Clothing Heat Transfer
H. Ingvar (Sweden)
- Body Temperature Measurement for Appropriate Clothing by Means of Internal Temperature Measurement Device
S. Nagashio (Japan)
- The Protective Characteristics of Clothings for Protection against Heat and Fire
Y. Kawashima (Japan)
- Thermal Effects and Finger Strength Changes in Cold Water Immersion with a Survival Suit
K. Kimotsuki (Japan)
- Evaluation of Shoe-Fitting
N. Yamazaki (Japan)
- On Mannequins Especially Made for 19th Century Costumes Considering Kinesiology of Human Bodies
C. Tamagawa (Japan)

August 24

15:20 ~ 17:30

Room Hall D

Session 6: Motion & Gait

- On the Central Control of Voluntary Arm Movements
T. Kurokawa (Japan)
- Effect of Two Handed Asymmetrical Simultaneous Motions and Task Difficulty on Performance Time and Heart Rate Variability
A. Raouf, K. Tsuchiya (Canada)
- A Study on a Manner of Holding Ball-point Pen to Write Legible Characters
Y. Ishida (Japan)
- Analysis of the Human Rhythmic Movement by a Markov Process
H. Nagasaki (Japan)
- Mechanism of Microvibration and the Application to Fatigue in Works of Lifting of Weight and Typewriting
T. Usui, K. Sakamoto, K. Seki, A. Iwasaki (Japan)
- The Application of the Three Dimensional Measurement to the Motion Analysis
Y. Suzuki (Japan)
- Kinematic Analysis of Three-Dimensional Motion in Loading Operations
K. Iwata, T. Moriwaki, T. Kawano (Japan)
- Force Sensor Using Carbon Fiber and Its Application to Foot-Force Measuring System for the Gait Analysis
K. Katahira (Japan)
- Anthropometry in Relation to Ergonomics of Walking for Work Study Application in Indian Agricultural Workers
Dr. Rabindra Nath Sen (India)
- Characteristics of Spectral Analysis of Strides on Treadmill Walking
M. Yamasaki (Japan)
- Desktop Computer-Aided Analysis of Dynamics in Human Standing and Walking
T. Yamashita, T. Taniguchi, M. Ando (Japan)
- Finite State Measurement System of the Human Gait
A. Kato, K. Ito, K. Tsuchiya (Japan)
- A Study on Walking Width, Time and Speed in Manual Carrying Loads
Y. Oguro (Japan)

August 24

13:00 ~ 14:00

Room Hall E

Session 7: Quality of Working Life

- Factors in Quality of Working Life: Two Case-Studies
S. Bagnara, R. Misiti, D. Mazzonis, M. Rollier (Italy)
- Brief Description of a Complex Work Organization Change in a Big Steel Company in Italy Involving Ergonomics and Socio-Technical Approach to Improve the Quality of Working Life
S. Micheli (Italy)
- Women and Work in a Finnish Manufacturing Plant
M-L. Honkasalo, M. Lich (Finland)
- A Study on the Motivation of a Manager by Canonical Correlation Analysis
S.Y. Lee (Korea)

August 24

14:00 ~ 16:00

Room Hall E

Session 8: Environment: Noise & Vibration

- Noise Immissions from Industrial Plants and Annoyance in the Neighbourhood
G. Stefan, E. Grandjean (Switzerland)
- Tentative Evaluations of Oscillating Sounds Based on Loudness Measures
P. Schaefer (F.R.G.)
- Individual Protection against Noise
J. Ducrocq (France)
- The Influence of Environmental Noises on Performance of Repetitive Task
K. Takata (Japan)
- Studies on the influence of Infrasound to the Human Body — Physiological Effects of Long Term Exposure to Infrasound by Case of the Rabbits —
N. Machida, Y. Yoshida, H. Ito (Japan)
- Human Response to Infrasound below Hearing Threshold
O. Okai (Japan)
- Studies on the Influence of Low Frequency Vibration to the Human Body — Vertical Vibration —
Y. Yoshida, N. Machida M. Ryota (Japan)
- A Study of Vibration Effect on Muscle Fatigue in Man
K. Ohkoshi, Y. Kikuchi (Japan)

- Effects of Psychic Load on the Growth of Temporary Thresholds of Hearing during Exposure to Combination of Stable Noise and Sinusoidal vs Stochastic Low-Frequency Vibration at a Dry-Bulb Temperature of 20°C
M. Olavi (Finland)
- TTS of Vibratory Sensation Induced by Exposure to Intermittent Vibration
Y. Fukuchi, S. Watanabe (Japan)
- The Use of Resilient Handgrips to Reduce Hand Vibration from Power Tools
C.W. Suggs (U.S.A.)

August 24

16:00 ~ 17:20

Room Hall E

Session 9: Environment: Under Water & Space

- The Influence of Hyperbaric Environment (11-31ATA, He-O₂) on Disturbed Human Sleep
K. Seki (Japan)
- The Influence of Hyperbaric Environment to Fatigue in Human Deep Dives
Y. Taya, N. Kuwabara (Japan)
- Convective Heat Transfer Coefficient of Human Body in Hyperbaric Helium-Oxygen Mixed Gas Environment
H. Nakayama (Japan)
- Neutral Buoyancy Manned Maneuvering Unit—An Underwater Simulator of the Shuttle MMU
C.N. Van Valkenburgh, T.E. Loughhead (U.S.A.)
- Manned Zero-Gravity Simulations: Case Histories of Extravehicular Activity (EVA) Simulations and Techniques
E.C. Preutt (U.S.A.)
- Dynamic of Physical Fitness and Orthostatic Tolerability during Hypodynamics Exposure
H. Saiki, M. Nakaya, M. Sudo, M. Abe, K. Shioda (Japan)
- Quantitative Behaviour of Intraocular Ascorbic Acid upon Hypermetropic Amplitude in Overstraining of Fictitious High Altitude
M. Carapancea (Rumania)

August 25

9:00 ~ 10:45

Room Hall B

Session 10: Work Load: Muscle Activity

- Assessment of Physiological Cost in Dynamic Muscular Work by Oxygen Cost and Cardiac Cost
H. Sato (Japan)
- Several Aspects of the Prediction Method of Local Muscle Energy Metabolic Rate
S. Yokoyama, K. Yoshida (Japan)
- The Effect of Arm Elevation on Muscle Circulation
H. Yata, T. Fukunaga, A. Matsuo (Japan)
- Evaluation of Local Muscle Fatigue in Dynamic Muscular Work by Isometric Test Contraction
S. Kira, K. Yamasaki, H. Sato (Japan)
- Critical Power as a Measure of Muscular Fatigue and Anaerobic Threshold
A. Nagata, M. Muro (Japan)
- What Do We Neglect when Evaluating Muscle Fatigue?
G.N. Gantchev (Bulgaria)
- Trunk Muscle Activity during Dynamic forward Bending and Straightening Up
K. Tani (Japan)
- Occupational Muscular Strain Indicated by Serum Creatine Kinase
M.T.L.J. Hagberg (Sweden)
- Creatinine Excretion under Physical Exercise and Hypokinesia
Y. Zorbas, V. Petrovskiy, Y. Koichi (Greece)
- Pulling and Pushing Forces as a Function of Elbow Flexion
Y. Ikeda (Japan)

August 25

10:45 ~ 12:30

Room Hall B

Session 11: Work Load: Physical

- Psychophysiological Studies of Physical Performance
G. Borg (Sweden)
- A Study on Seasonal Variations of Circulatory and Metabolic Responses during Prolonged Exercise
A. Okada (Japan)
- Effects of Specific Dynamic Action on the Metabolism at Rest
K. Yamasaki, S. Watanuki, S. Kira (Japan)

- The Effect of Body Postural Change on Anaerobic Threshold
T. Fukunaga, H. Yata, S. Ikegawa (Japan)
- Relation between Exercise Diuresis and Running Load
T. Inomoto (Japan)
- The Effect of Additional Weight on External Mechanical Energy in Running
A. Matsuo, T. Hirata, N. Tsunoda, T. Fukunaga (Japan)
- Mechanical Efficiency in Relation to Pedaling Rate During Cycle Ergometer Work
Y. Fukuba, Y. Koya, S. Watanuki, K. Fujiie (Japan)
- Optimum Speed of Up-Hill Cycling with Special Reference to Slope Gradients and the Gear Ratio
A. Kimura, M. Morioka, S. Horino, K. Kishida, K. Uchida (Japan)

August 25

9:00 ~ 10:15

Room Hall C

Session 12: System Evaluation Methodology

- An Application of Decision Data Tables Method in Ergonomic Research
L. Pacholski, B. Mateja (Poland)
- An Ergonomic Method Diagnosing Complex Production Systems
L. Pacholski (Poland)
- Combined Use of an Ergonomic Checklist and Complaint Rating as a Means of Identifying Problems
K. Sakai, K. Kogi (Japan)
- Pluralistic Treatment in the System Research of Ergonomics
T. Marek, R. Michałek, N. Czetaw (Poland)
- The Use of Operator Workload Measures in the Evaluation of Different Telemanipulators
J. Richardson, N.F.-Savery, D. Xirau, D.A.-Lescoat (France)
- The Evaluation on the Repairmen of Motorcar Using the RS-Method
S. Nakayama (Japan)

August 25

10:15 ~ 12:15

Room Hall C

Session 13: System Design Methodology

- Ergonomical Correction of Working Conditions at the Stage of Working Station
S. Marek (Poland)
- A Systematic Ergonomics Design Procedure
J.-H. Kirchner (F.R.G.)
- The Computer Technique Usage in Design and Ergonomic Attestation Function of Controlling Devices Distribution
L. Pacholski, S. Stanisław (Poland)
- The Interaction between Ergonomic Criteria and Industrial Design
V. Popovic (Australia)
- Back-to-Front Systems Design: A Guns and Butter Approach
R.S. Didner (U.S.A.)
- The Third Dimension — Computer Modelling for Ergonomics
E. Kingsley (U.K.)
- VAD — A Video Aided Ergonomics Design System
F. Peter (Sweden)
- Use of Modular Simulators in Selection, Training and Workpost Design
J.-C. Rouhet (France)

August 25

9:00 ~ 10:10

Room Hall D

Session 14: Eye Movement

- Maximum Velocity in Smooth Pursuit Eye Movement
K. Horii, K. Tanaka, Y. Tomoda (Japan)
- Frequency Responses of the Pursuit Eye Movement System
K. Matsuoka (Japan)
- Lambda Responses and Evaluation of Visual Task Load
A. Yagi (Japan)
- Individual Differences Observed from Relationship between Percent Correct Counts and Eye Movements
H. Togami (Japan)
- A Study of the Constitution of Visual Judgment Process on the Composite Images
T. Kurabayashi (Japan)

—24—

•Modelling of Visual Scanning Sequence to Multiple Targets
M. Makikawa, H. Tamura, M. Makikawa (Japan)

•An Evaluation of the NAC Eye Mark Recorder
E.D. Megaw, J. Richardson (U.K.)

August 25

10:10 ~ 12:20

Room Hall D

Session 15: Education & Training

- A Comparison of Exponential and Hyperbolic Functions Describing Learning Curves in the Literatures of Psychology and Industrial Engineering
L. Stanley (U.S.A.)
- Time Pressure, Training and Decision Optimality
Z. Dan (Israel)
- Cost-Effectiveness of Ergonomics: Elusive Data and an Exchange Heuristic
A.B. Russell (U.S.A.)
- Cognitive Psychology of Manual Control: Expert and Novice Differences in Cognition and Performance
Y. Anzai, Y. Ishii, Y. Hayashi (Japan)
- Ergonomics Training for Computer Users
T. Houghton (France)
- The Influence of Job Knowledge in Product Quality Judgments on a Continuous Process Production Line
J. Richardson, X. Cuny (France)
- Human Factors in Instructions
N.M. Simonelli (U.S.A.)
- Introduction of Ergonomics in the Development of Educational Systems
S. Kozuki (Japan)
- An Instructional System which Permits the Students to Critically Discuss Their Own Test Answers
I. Kitagaki, Y. Shimizu, K. Suetake (Japan)
- A Trial of Introducing Game Factor into the Rehabilitation Training
N. Ohnishi, K. Tsuchiya, F. Ito, S. Nagai (Japan)
- Development of General Purpose Biofeedback System
M. Ohsuga (Japan)

—25—

August 25

9:00 ~ 11:00

Room Hall E

Session 16: Environment: Temperature & Physiological Responses

- Effects of Repeated Cold Exposures on Thermal Responses of Men
Y. Tochiara (Japan)
- Effects of Body Build and Sweat Rate on Rectal Temperature during Acute Heat Exposure in Man
K. Iwanaga, K. Yamasaki, . Yasukouchi, H. Sato, M. Sato (Japan)
- Cardiovascular and Metabolic Reactions to Work in Different Ambient Temperatures
T. Nariai, Y. Fukuba, J. Ohashi, Y. Izumitani (Japan)
- Relationships between Physique and Increase in Body Temperature during Exercise at Different Ambient Temperatures
T. Katsuura (Japan)
- Effect of Hot Dry and Hot Humid Environment in Continuous Work Performance in Man
J.S. Gupta (India)
- Effect of Ambient Temperature on Physical Work Capacity
T.L. Mathew, J.S. Gupta (India)
- The Effects of Work Rates and Ambient Temperature on Transient Physiological Responses
Y. Takasaki (Japan)
- The Effects of Exercise, Ambient Temperature and Season on Estimation of Maximal Oxygen Intake
S. Watanuki, K. Yamasaki, Y. Koya (Japan)
- Influence of Age on Circulatory Responses to Exercise at Different Air Temperature Conditions
Y. Kikuchi, T. Katsuura, A. Okada (Japan)
- Evaluation of Cardiac Output by Electrical Impedance Method under Different Ambient Temperatures
T. Azuma, T. Katsura, A. Okada, Y. Kikuchi (Japan)
- Change in Pulmonary Diffusing Capacity for CO under Various Conditions of Temperature Combined with Hypobaric Hypoxia
A. Yasukouchi, K. Iwanaga, Y. Koya, M. Sato (Japan)
- Physical Work Capacity of Young Competitive Swimmers in Water at Three Different Temperatures
T. Nomura (Japan)

August 25

11:00 ~ 12:10

Room Hall E

Session 17: Environment: Heat Stress Evaluation

- The Effects of Outside Conditions and Cab Temperature on Tractor Driver Heat Stress
D.H. O'Neill (U.K.)
- Sensitivity Analysis Supports Simplified Heat Stress Rules
J.D. Ramsey, C.P. Chai (U.S.A.)
- A Statistical Analysis of Values of WBGT Factor in Complex Production Systems
L. Pacholski (Poland)
- Analytical Determination of Heat Stresses
J.J. Vogt, V. Candas (France)
- Experimental Thermoesthesiometer
H. Mito, J.P. Libert (Japan)

August 26

9:00 ~ 10:45

Room Hall B

Session 18: Architecture

- Shaping (Size and Form) of Workrooms from the Viewpoint of Pleasant Working. Environments and Humanization of the Work System
H.F. Mulder (The Netherlands)
- The Relation between Physical Elements and Visual Effects in Living Rooms — Part 1 On the Wall Colour —
T. Yanase (Japan)
- The Relation between Physical Elements and Visual Effects in Living Rooms — Part 2 On the Wall and Light —
M. Kunishima (Japan)
- Required Clearance for Passages in Dwelling House
Y. Koh, K. Kamada (Japan)
- A Study on Walking up and down Stairs in Elderly People
K. Aoki (Japan)
- Accident Research for Safety on Stairs
H. Nagata (Japan)
- Safety Requirements of Stairs
S. Kose, H. Uno (Japan)
- Ergonomic Values of Traditional Housing in Bali
A. Manuaba (Indonesia)
- A Systems Approach to the Aetiology of Human Injury in Livestock Building Design
G.A. Bramall (U.K.)

- Experimental Study on the Cognitive Process of Street-scapes
Y. Kubota (Japan)

August 26

10:45 ~ 12:20

Room Hall B

Session 19: Work Load: Methodology

- On the Validity of Japanese Fatigue Feeling Scale
Y. Saito (Japan)
- Factorial Analysis of Fatigue
S. Kondo, M. Oshima (Japan)
- Work Load Studied by Multi-point Critical Fusion Frequency (MCFF)
H. Osaki, S. Kikuchi, M. Ogata (Japan)
- Measurement of Critical Fusion Frequency by Liquid Crystal
R. Hosaka (Japan)
- A Consideration on the Classification of Two-Dimensional Displayed Patterns of EEG
H. Takeda, Y. Takashima, Y. Ikeda, S. Hata (Japan)
- Mental Effects of Risky Behaviour Seen by Means of a Portable Heart Rate Analyzer
H. Muroya, M. Ikeda (Japan)
- A Three-Level Computer-Assisted System for the Evaluation of Physiological Changes during Work, before and After Ergonomical Intervention
F. Jaroslav (C.S.S.R.)
- Disturbances in Curve Progress Smoothness of Pupillary Reflex Induced by Mental Workload in the Long Period of Time
M. Tadeusz, N. Czesław (Poland)
- Measurement on Brain Arousal Rate
S. Inaba (Japan)

August 26

9:00 ~ 10:00

Room Hall C

Session 20: Evaluation of Human Activities

- The Evaluation of Each Daily Human Activity by the Instrumentation of a Continuous Heart Rate Measurement
S. Adachi (Japan)
- Measurement of the Effect of Central Acting Drugs on Performance and Reaction Time
H. Krueger (F.R.G.)

- Effect of Sleep Deprivation on the CNV and Dual Task Performance

M. Miyao, T. Ohga, H. Sakakibara, T. Nagasawa, F. Kobayashi, S. Kanada, K. Takihi, S. Yamada, M. Terashima, T. Endoh (Japan)

- A Biotechnological Study of Relationship between Sleep and Beds — A Polygraphic Study with Sounds

K. Fukuda (Japan)

- Responses of Sympathetic Nervous System to Hand Induced Vibration

T. Sakurai (Japan)

- On the High-Order Dynamic Activity and Its Component Activities

K. Sato (Japan)

August 26

10:00 ~ 12:10

Room Hall C

Session 21: Systems Design II — Vehicle, Sign & Others

- Safe and Easy Coupling of Tractor Implements
Sjøflot Lars (Norway)
- Improvement of Visibility for Large Truck Drivers to Prevent Unsafe Turning to the Left
S. Horino (Japan)
- Ergonomic Aspects of Operator Cabs on Earth Moving Machines
P. v.d. M. Grinten (The Netherlands)
- Design of a Vehicle for Mail Delivery. An Ergonomic Study
M. Björkstén, D. Caple, S. Carlsöö, P. Friedrich, J.E. Hansson, (Sweden)
- Ergonomic Changes of Our Automatic Welding Machine, Our Track-Pin Press Machine and Our Fellies Assembling Machine in Our Repair-Shop
Haugan, Astrid Else (Norway)
- The Use of Routing Information in a Public Environment
H.J. Zwega (The Netherlands)
- Evaluation of a Set of Graphic Symbols
H.J. Zwega (The Netherlands)
- Standardization of Public Information Symbols
H.J. Zwega (The Netherlands)
- Standardization of Geometric Radar Symbolology
R.J. Carter (U.S.A.)
- A Study of Human Cosmetic Behavioral Factors
K. Morooka, S. Morikawa (Japan)

August 26

9:00 ~ 10:25

Room Hall D

Session 22: Introduction of Ergonomics to Industry

- Ergonomic Aspects of New Technologies
Dr. K.J. Zink (F.R.G.)
- An Investigation on the Actual Condition Pertaining to Introduction of Ergonomics into Japanese Industries
S. Nishikawa (Japan)
- A Problem in Applications: An Investigation into Methods and Materials for Upgrading Nuclear Power Control Boards
D. Smith (U.S.A.)
- Ergonomics in Agriculture and Forestry — the Present and Future State
Ir. J. Zander (The Netherlands)
- Ergonomics in Agricultural Engineering in India
B.G. Yadav, L.P. Gite (India)
- Intergration of Ergonomics in Transportation in Bali
A. Manuaba (Indonesia)

August 26

10:25 ~ 12:20

Room Hall D

Session 23: Ergonomics of Computer Systems

- The Use of Ergonomics Computer Equipment
T. Houghton (France)
- The Development of User Hostility Towards Computer Systems
T. Houghton (France)
- The Influence of System Response Time and Memory Load on Problem Solving Behavior
H. Bergmand, A. Brinkman, H.S. Koelega (The Netherlands)
- Response Time Discrimination
R.M. WU, C.R. Brown, P.D. Pagerey (U.S.A.)
- Language and Computer Systems "Work Analysis and Cognitive Load"
A. Wisner (France)
- Ergonomics of Computer Commands in Restricted Natural Language
D.-L. Scapin (France)

- Reading Grade Level as a Factor in Computer Dialogue Design
J.M. Roemer (U.S.A.)

- Ergonomics of Hybrid Japanese Text Entry Method
M. Kurosu, T. Nakayama (Japan)

- "Heimen-Dentaku" — Table Generator with Personal Computer —
Y. Mori (Japan)

August 26

9:00 ~ 10:35

Room Hall E

Session 24: Work Load: Visual

- Eyestrain of Industrial Visual Workers
M. Saito, K. Kishida, T. Hasegawa (Japan)
- Subsidiary Behaviors of Bottle Inspection Workers in Three Shift System
K. Kishida, M. Saito, T. Hasegawa (Japan)
- Accommodation Responses in CRT Display Task
M. Takahashi (Japan)
- A Study on Visual Function of VDU Operators
M. Ohashi, K. Aoki (Japan)
- Visual Loads at VDT Workplace
T. Läubli, G. Etienne, H. Wilhelm (Switzerland)
- Lighting Characteristics of Visual Display Terminals of Different Makes
U. Brauninger, E. Grandjean, R. Gierer, T. Fellmann (Switzerland)
- Physiological Effects of Oscillating Luminances in Reversed Display of VDTs
K. Nishiyama, U. Bräuninger, H. DE Boer, R. Gierer, E. Grandjean (Switzerland)
- Visual Ergonomics and Existing Person-Display Design Guidelines
R. Benel, D. Benel (U.S.A.)

August 26

10:35 ~ 12:35

Room Hall E

Session 25: Visual Inspection & Vigilance

- The Method of Evaluating the Aptitude of the Visual Inspectors at Line of the Steel Product
T. Kurabayashi (Japan)

- The Distribution of Visual Inspection Times
T.J. Gallwey (Ireland)
- Conveyor Paced Visual Inspection Efficiency over Short and Extended Work Periods
M.H. Elwany (Egypt)
- Methodologies for Visual Inspection Research and Development of Inspection Robot
K. Noro (Japan)
- Personal Error of Visual Judgement in Precision Measurement
K. Tanaka (Japan)
- A Study on the Distribution of Sensory Evaluation and Angular Transformation
T. Takahashi (Japan)
- Psychophysiological Criteria in the Analysis of Hypovigilance in Control Rooms
R.J. Claude (France)
- Signal Vigilance Errors by Railway Drivers
S. Haga (Japan)
- Signal Detection Theory in Ergonomics
M.H. Christoph (F.R.G.)

August 27

9:00 ~ 11:30

Room Hall B

Session 26: Vehicle Driving

- Analysis on the Driving Operations of Drivers
S. Ueno, K. Haneishi, M. Nishikawa (Japan)
- Evaluation of the Arousal Level of Automobile Drivers Based on Their EEG etc.
T. Yanagishima (Japan)
- Evaluation of Vehicle Steering Control Characteristics by Skin Resistance Level and Heart Rate
T. Sawada (Japan)
- The On-Line Use of Driving Performance Measures to Detect Abnormal Driving Behaviour
Y.I. Noy, D.A. Attwood (Canada)
- Effects of Fatigue and Drugs on Driving Performance
K. Yajima, K. Aoki, T. Aoki, H. Tanaka, N. Yamanoi, S. Kinoshita, T. Furukawa (Japan)
- Autoregressive Analysis of Highway Driving Performance by a Simulator
S. Kinoshita, K. Yajima, K. Aoki, H. Tanaka, T. Aoki, N. Yamanoi, T. Furukawa (Japan)
- Driver and Pedestrian Speed Estimation
M.H. Bergman (U.S.A.)

- Rural Road Delineation at Night
T.J. Triggs (Australia)
- Fatigue of Bullet Train Drivers Operating on Multi-Tunnelled Sections
A. Watanabe, K. Kogi, N. Onishi, H. Shindo, K. Sakai (Japan)
- Measurement of Pilot Workload during Take Off and Landing by C-1 Jet Carrier
Y. Nagasawa, S. Aramaki, (Japan)
- A Study on the Changes of Physiological Functions on Motorcycle Riding
T. Matsumoto (Japan)
- Subjective Symptoms and Physio-Psychological Effects by Motorcycle Driving
A. Hisashige, H. Ohara, Y. Kume, M. Yamamoto, T. Ogawa, H. Aoyama (Japan)
- Performance, Physiological Stress and Mood State Changes Resulting from Vessel Motions at Sea
R.L. Pepper, S.F. Wiker, M.E. McCauley (U.S.A.)
- A Biotechnological Study of Hang Glider Crewmen
N. Ando (Japan)

August 27

9:00 ~ 11:20

Room Hall C

Session 27: Introduction of Ergonomics to Social Systems

- The Functioning of Occupational Health Service in Scandinavia — on the Basis of Empirical Research in Norway and Sweden and Experience from a Field Research Project in Denmark
O. Rieper, A.S. Johansen (Denmark)
- Applied Ergonomics in the Danish Labour Inspectorate
Lundstedt, Dorte (Denmark)
- The Tasks of an Industrial Physician
J.-I. Kamoy (Norway)
- Is Selective Traffic Code Enforcement Practical? A survey of Canadian Traffic Police
G.F. Rabideau, M.L. You (Canada)
- Human Factors in Organizational Design and Management
H.W. Hendrick (U.S.A.)
- Cognitive Complexity, Conceptual Systems and Organizational Design: Implications for Ergonomics
H.W. Hendrick (U.S.A.)
- Assessment Center Ratings as an Interim Criterion Measure in Leadership Research
H.W. Hendrick (U.S.A.)

- Accuracy of Leaders' Perceptions of Self and Others. and Actual Group Status as Functions of Cognitive Complexity
H.W. Hendrick (U.S.A.)
- The Ergonomics, Has It Its Specific Laws?
P. Burlioiu (Romania)

August 27

9:00 ~ 10:20

Room Hall D

Session 28: Posture

- Dynamic Analysis of Human Upright Posture Control Activity
K. Sato, M. Chikami, N. Tajima (Japan)
- On the Analysis of Erect Posture by the Foot-Pressure
H. Itoh, T. Sakamoto (Japan)
- An Ergonomic Evaluation of Foot-Complaints among Waiters
Jörgen Winkel (Sweden)
- The Postural and Health Problems of Workers in Pear and Apple Orchard
H. Sakakibara, M. Miyao, T. Nakagawa, F. Kobayashi, S. Kanada, K. Takahi, S. Yamada, K. Masuda (Japan)
- Localized Fatigue Complaints Related to Output and Body Posture of Dentists
K. Maeda (Japan)
- A Study of Space Allotment Procedure for Dental Treatment Area in Measurement of Human Posture
M. Ohashi (Japan)
- A Study of "Driving Position" in Passenger Vehicles
S. Takaji (Japan)
- Holding Performance of Automobile Seats
M. Sano (Japan)

August 27

10:20 ~ 11:30

Room Hall D

Session 29: Work Load: Lifting

- Energy Cost of Lifting in Sagittal and Lateral Planes by Different Techniques
S. Kumar, D. Magee (Canada)

—34—

- An Ergonomic Evaluation of Working Postures in Manual Weight Lifting
M. Morioka, A. Kimura, K. Kishida, S. Horino, M. Saito (Japan)
- An Ergonomic Approach To Reduce Hazards of Lifting Tasks
M.M. Ayoub (U.S.A.)
- Recommended Work Rates and Container Configuration for Manual Lifting and Lowering Activities
A. Mital, S.S. Asfour, M.M. Ayoub (U.S.A.)
- Guidelines for Permissible Limits for One-Handed Lifts by Women
A. Garg (U.S.A.)

August 27

9:00 ~ 11:30

Room Hall E

Session 30: Perception & Recognition

- Color Contrast and Visual Task Performance
H.L. Snyder (U.S.A.)
- The Influence of Colour Saturation on the Chromatic Error of Accommodation of the Human Eye
H. Krueger (F.R.G.)
- Effects of Television Noise Interference on Character Reading Time
A. Watanabe, M. Saito (Japan)
- Signal Detection in the Noisy Background Figure through Limited Area of Visual Field
S. Saito (Japan)
- A Discriminability Metric for VDU Characters
M. Schneider (U.S.A.)
- Interitem and Intraitem Symmetries in Same Responses to Pairs of Letters
S. Bagnara, D.B. Boles, F. Simion, C. Umilta (Italy)
- How Many Letters Can We Recognize at a Glance?
T. Fukuda (Japan)
- An Analysis of the Interaction Effects between Successively Exposed Two Figures
T. Yoshida (Japan)
- A Multidimensional Scaling Analysis on Perceptual Structures of Japanese Syllables
K. Mizuki (Japan)
- Tactile Letter Display for a Reading Aid
Y. Shimizu (Japan)

—35—

- Warmth to Touch the Building Materials
I. Matsui, Y. Kasai (Japan)
- Pain Sensation and Skin Deformation
M. Akamatsu (Japan)
- Accuracy of Time Perception in Rhythmic Movement
T. Niihara, K. Kusano (Japan)
- Study of Time-Estimation on a Reactive Simple Action
I. Yoshimura, M. Nakamura (Japan)

August 27

13:00 ~ 14:40

Room Hall C

Session 31: Work Performance

- Dependence of Human Performance on Input Information in Pursuit Manual Control Systems
O. Suenaga, M. Ihara (Japan)
- A Study of Human Operator's Dynamics during Training and Transfer Trials of the Tracking Tasks in Case of a Second-Order Lag System
T. Yamashita, E. Masuyama (Japan)
- Skill Improvement in Manual Control of a Double Integral Controlled Element
A. Tada (Japan)
- A Consideration on the Index of Precognitive Control Behaviors of Human Operator
H. Takeda, Y. Ikeda, S. Hata (Japan)
- Analysis of Precognitive Dynamics in Two Axis Pursuit Tracking Task
T. Aoki, K. Yajima, K. Aoki, H. Tanaka, S. Kinoshita, N. Yamanoi, T. Furukawa (Japan)
- Modeling the Human Operator in a Preview Compensatory Tracking Control System
K. Yoshimoto (Japan)
- On the Self-Paced Preview Manual Tracking Behaviors
K. Ito (Japan)
- Human Operator's Compensation Mechanism for Time-Delay in Manual Control System
M. Yoshizawa (Japan)
- Visual Lead Compensation in Manual Compensatory Tracking
S. Hara, K. Handa (Japan)
- Effects of Exogenic Stimulations upon Monotonous Performance
T. Watanabe (Japan)

August 27

13:00 ~ 14:40

Room Hall D

Session 32: Work Load on the Back

- Dynamic Loading of Static Truck
S. Kumar, P.R. Davis, D.P. Currier (Canada)
- Compressive Load at L₅/S₁ Spine Level as a Biomechanical Factor during Carious Lifting Techniques
T.P.J. Leskinen, H.R. Stalhammar, I. Kuorinka (Finland)
- Posture Optimization through Three-Dimensional Kinetic Biomechanical Modeling
A. Kumer, A. Mital (U.S.A.)
- Physiological Load on the Back of Postmen during Letter Distribution in Urban Districts.
K. Jogensen, H. Christensen, E. Daltom (Denmark)
- The Musculoskeletal Status in Airport Transport Workers
K. Undeutsch (F.R.G.)
- A Back-Care Program in the Building and Construction Industry in the Netherlands
E.A.P. Oningsveld (The Netherlands)

August 27

13:00 ~ 15:00

Room Hall E

Session 33: Working Environment

- Studies on Subjective Sensations on Air Movement for Creating Comfort Indoor Climate
H. Kubota (Japan)
- Passive Smoking at Work
W. Annetta (Switzerland)
- An Experimental Study on Irritations and Annoyance due to Passive Smoking
T. Muramatsu, S. Muramatsu (Japan) A. Weber, F. Akermann (Switzerland)
- A Survey on the Effects of Involuntary Smoking and Attitudes to Smoking among School Children and Students
S. Muramatsu, T. Muramatsu (Japan) A. Weber (Switzerland)
- Effect of Physical Work on Rate of Dispersal of Bacteria in the Air from Man
K. Terayama, T. Kawarabayashi, H. Ohno, F. Hirata (Japan)

- Hazardous Materials Encountered in Human Factors Design Practice

D. Gloss (U.S.A.)

- Solvent Mixtures Influence Dependent on the Working Process in the Wood Industry

R. Lödersdorf, G. Schäcke, B. Heydenreich-Adloff, A. Fuchs (F.R.G.)

- The Aggregation Method of Heterogeneous Material Environment of Work Factors

L. Pacholski, A. Jasiak (Poland)

TECHNICAL SITE VISITS

The Organizing Committee will provide the participants with the opportunities to visit the following places on 26th (Fri.).

1. Japanese National Railways
(Bullet Train Operation Control Center)
2. Metropolitan Police Headquarters
(Command & Control Center)
3. Tokyo Fire Dept.
(Rescue Control Center)
4. Telecommunication Science Hall of Nippon Telegraph and Telephone Public Corporation
5. The Federation of Bankers Association of Japan
(Data Telecommunication System)
6. Nissan Motor Co., Ltd. — Zama Plant
(Industrial Robot at Assembly Line)

Those who wish to join the Visits are requested to check the column of Form (1) — Registration Form —, and to pay the appropriate fee at the Registration Desk on site.

The fee for course 1-5 will be only fare for city transportation. The fare for a motor coach will be charged for course 6. As the number of participants in each course is limited, please apply as early as you can.

SCIENTIFIC EXHIBITION

Along with the Congress, an Exhibition is scheduled to be held and the Exhibition Committee has been making every effort to make the exhibition suitable for the Congress. Currently, the proposed exhibits are being screened for the 20-25 booths.

Participants will be able to enjoy this special Scientific Exhibition.

SOCIAL PROGRAMS

1. WELCOME RECEPTION

A welcome reception is scheduled to be held from 6:30 p.m. on 23rd, Aug. at Banquet Hall of the Congress Site. The Organizing Committee invites all participants and accompanying persons to the reception.

2. FAREWELL PARTY

Time and Date:

19:00-21:30 on 26th August.

Place:

Royal Hall, Akasaka Prince Hotel.

Features:

M.C. of the Party... Mr. Katsuya Kobayashi

Very famous for his job as a disc jockey of several radio and TV programs. He speaks fluent English.

Koto Music... Played by a Koto Music Group consisting of 4 Ladies.

Japanese Popular Song and Dance... Performed



by Miss. Sayaka Ito, Miss Yukiko Yamada, both famous singers and actresses, and Shower, a famous singing and dancing team consisting of 7 pretty girls.

Japanese Folklore Song and Dance... Performed by the Japan Folk Music Association consisting of 13 members, selected performers from the Association members.

Folk songs and dances accompanied by Shamisen, Japanese Drums, etc. will be performed.



String Quartet Music... Performed by the Musica Sacra

String Quartet as background music through the second half of the party.

Note: Price of participation in the party: Yen 10,000 per person. Please add the amount to the registration fee of the congress if you wish to participate.

The features of the party are subject to change without notice.

Applications on the Social Programs

Please fill out the attached Form 1 if you will or will not participate in each program. In case you will be participating in the farewell party, please add ¥10,000 to your registration fee of the Congress.

3. LADIES' PROGRAMS

The Organizing Committee proudly announces that all accompanying persons are invited to the ladies' programs, which will provide them with the opportunity to become familiar with the things of Japan. Both programs are available free of charge for up to limited number of seats.

LP-1: "Japanese Traditional Arts"

Full Day program on 25th Aug.

Demonstrations of tea ceremony with one cup trial to the all participants, paper-folding class and class of Kimono fitting including a demonstration of bridal Kimono. Lunch is not included in the program but may be available at Chinzanso Garden Restaurant after paper-folding class on private account basis.

LP-2: "Japanese Garden and Museum"

Morning Tour on 26th Aug.

Rikugien Garden, one of Tokyo's famous Japanese Gardens, and Tokyo National Museum will be visited.

The number of participants are strictly limited up to 35 persons for LP-1 and 40 persons for LP-2 respectively.

All above programs are subject to change without notice.

TRAVEL INFORMATION

OFFICIAL TRAVEL AGENT

The Organizing Committee has designated the Japan Travel Bureau, Inc. (JTB) as official travel agent for the Congress in Japan. JTB will handle all arrangements concerning hotel reservations, tours pre-, post- and during the Congress and other travel arrangements. All inquiries and applications in this regard should be directed to the following address:

**Japan Travel Bureau, Inc. (JTB)
Foreign Tourist Dept.,
Convention and Tours Section
1-13-1, Nihonbashi, Chuo-ku,
Tokyo, 103 Japan
Phone: (03) 271-2346
Cable: TOURIST TOKYO
Telex: J24418 TOURIST (Answer Back)**

PASSPORTS AND VISAS

All foreign visitors desiring to enter Japan must have a valid passport. Visas are not required for tourists who are citizens of the following countries:

Argentina, Austria, Bangladesh, Belgium, Canada, Chile, Colombia, Costa Rica, Cyprus, Denmark, Dominican Republic, Finland, France, Federal Republic of Germany, Greece, Guatemala, Honduras, Iran, Ireland, Iceland, Israel, Italy, Lesotho, Lichtenstein, Malta, Mauritius, Mexico, Netherlands, New Zealand, Norway, Pakistan, Peru, Portugal, El Salvador, San Marino, Singapore, Spain, Suriname, Sweden, Switzerland, Tunisia, Turkey, United Kingdom, Uruguay and Yugoslavia

VACCINATION

No special vaccinations are necessary unless a visitor enters Japan within 14 days of having been in a smallpox-infected area, in which case he must have a valid international certificate of vaccination against smallpox. A cholera certificate is also required for persons coming from an infected area. For further details, participants are advised to consult their local travel Agents or carriers.

WEATHER AND CLOTHING

The weather in Japan during the Congress period is very hot and humid, with an average temperature of about 28°C (82°F). Highest of the temperature will be 35°C in the daytime and the lowest will be 23°C in the night. Congress site and the

hotels are well air conditioned as well as any buildings, underground shopping centers and many of transportations except most of buses and the subways. Please wear light clothes informally.

TRAVEL TO JAPAN

Japan Air Lines has been appointed as the Official Carrier for the Congress. Any of your local JAL office or their travel agents will help you for travel arrangements to/from Japan. Also, the agencies Meon Travel in London, U.K. and Garber Travel in Mass. U.S.A. are the appointed travel agents in the regions respectively. For group or individual flight arrangements, please consult any of the followings:

FOR EUROPEAN COUNTRIES

Japan Air Lines
Congress Coordinator
12 Great Marlborough Street,
London W1V 1DE, England
Phone: 01-629-9244

Meon Travel
32 High Street, Petersfield,
Hampshire, GU32 3JL, England
Phone: 0730-4011
Telex: 86181

FOR CONTINENTAL AMERICA

Japan Air Lines
Convention Coordinator
655 Fifth Avenue, New York,
N.Y., 10022 U.S.A.
Phone: 212-758-8850

Garber Travel
1406 Beacon Street, Brookline,
Mass., 02146 U.S.A.
Phone: 617-734-2100

TRANSPORTATION BETWEEN NARITA (NEW TOKYO INT'L) AIRPORT AND DOWNTOWN TOKYO

There are 3 principal methods of transportation between Narita Airport and Tokyo. Among them, the Organizing Committee recommends to use Airport Limousine Bus. They have the following services which may be suitable for your most convenient travel from the airport to your hotel.

Narita Airport—Tokyo City Air Terminal 70 min.
Tokyo City Air Terminal—Ginza (for Ginza Capital Hotel) 15 min.
—Akasaka (for Akasaka Tokyu Hotel and Hotel New Otani) 20 min.

Through tickets for both final destinations are available at the airport.

SPECIAL PACKAGE TOUR FOR PARTICIPANTS IN BOTH IEA CONGRESS AND THE "OSAKA SYMPOSIUM"

To enable participants in those two meetings to travel in easy way, the following Special Package Tour is offered.

Aug. 18 (Wed.) You are requested to arrange the transportation from Osaka Airport to the hotel by yourself. The tour starts with your check-in at the hotel. Accommodation at Senri Hankyu Hotel or Toyo Hotel for 2 nights. Hotel reservation will be made by JTB according to your choice.

Aug. 19 (Thu.) Participate in "Osaka Symposium".

Aug. 20 (Fri.) Participate in the symposium. After the symposium, transferred to Kyoto. Accommodation at Kyoto Royal Hotel for 2 nights.

Aug. 21 (Sat.) Full day sightseeing in Kyoto, visiting Kinkakuji Temple (Golden Pavillion), Nijo Castle, Heian Shrine, Sanju-Sangendo Temple (Hall of 1001 Buddhas) and Kiyomizu Temple.

Aug. 22 (Sun.) Take morning bullet train from Kyoto to Odawara. Sightseeing in Hakone and drive to Tokyo. The tour end upon arrival at Tokyo.

The tour includes 2 lunches on Aug. 21 and 22 en route and 4 breakfasts.

Tour Fares: ¥106,000 per person on double occupancy basis.
¥117,000 per person on single occupancy basis.

HOTEL ACCOMMODATION

JTB has reserved a sufficient number of rooms at several hotels for the Congress period in Tokyo and for the pre-Congress period in Osaka. All individual participants wishing to make hotel reservations should fill out the attached Form 2 and address the form to JTB.

Participants in a group organized by a travel agent are requested to let JTB know the name of travel agent by using the Form to avoid possible duplicate booking.

In case you need hotel accommodations, the Form should be accompanied by the remittance of 20,000 Japanese Yen as a deposit. Otherwise, no hotel reservation will be made.

The categories and room charges of the hotels are as follows:

(a) Hotels in Tokyo

Category	Hotel Name	Twin w. bath	Single w. bath
A	Hotel New Otani (Tower)	¥18,800	¥18,400
B	Hotel New Otani (Main)	¥15,800	¥15,400
C	Akasaka Tokyu Hotel	¥14,000	¥11,800
D	Ginza Capital Hotel	¥10,640	¥6,400

Above rates include 10% tax and 10% service charge but not any meals. The balance of total hotel expense and the deposited amount may be settled on your own account.

(b) Hotels in Osaka for those who are going to participate in the "Osaka Symposium"

Hotel Name	Rate per person	
	Single Occupancy	Double Occupancy
Senri Hankyu Hotel	¥13,000	¥12,000
Hotel Toyo	¥13,000	¥12,000

Above rates include breakfast, tax and service charge, and also the rates cover transportation service between the Symposium Hall and the hotels on August 19 and 20. Please note that the applications will be accepted for those participants wishing to participate in both of IEA Congress and the "Osaka Symposium".

OPTIONAL TOURS

A variety of optional tours are planned during the Congress for delegates and accompanying persons who wish to see even more of Japan and enjoy their stay to the fullest. These tours can be booked in advance with application Form 2.

(A) During the Congress (OP)

- OP-1: "Tokyo Morning Tour"
Half-day sightseeing, visiting Tokyo Tower, 'Happoen Garden' to see tea ceremony and Imperial East Garden (or Imperial Palace Plaza).
Tour fare: ¥3,500 per person
- OP-2: "Tokyo Afternoon Tour"
Half-day sightseeing, visiting Imperial Palace Plaza, Asakusa Kannon Temple, and boating on the Sumida River.
Tour fare: ¥3,500 per person
- OP-3: "Tokyo Golden Night Tour"
Sukiyaki Dinner and Cabaret Mikado (spectacular revue) and Geisha Party.
Tour fare: ¥11,000 per person
- OP-4: "Nikko Full-day Tour"
The grandeur of 300-year-old shrines; splendor of Japan's scenic Nikko National Park (lunch included).
Tour fare: ¥16,000 per person
- OP-5: "Kamakura-Hakone Full-day Tour"
A delightful excursion into the beauty of nature, with a visit to the great Buddha at Kamakura (lunch included).
Tour fare: ¥16,000 per person

(B) After the Congress (OP-6): "Japan Golden Route"

- Aug. 28, Sat.: Morning drive to Kamakura to visit Great Image of Buddha and sightseeing in Hakone, including a cruise on the lake and the Open Air Museum. (lunch included).
Accommodation in Hakone.
- Aug. 29, Sun.: Take morning bullet train from Odawara to Kyoto (lunch included). Afternoon excursion to Nara, visiting Todaiji Temple, Deer Park and Kasuga Shrine.
Accommodation in Kyoto for 2 nights.
- Aug. 30, Mon.: Morning sightseeing in Kyoto, visiting Nijo Castle, Kinkakuji Temple (Gold Pavilion) and Old Imperial Palace. Afternoon sightseeing in Kyoto, visiting Sanjusangendo Temple, Heian Shrine and Kiyomizu Temple.
- Aug. 31, Tue.: Tour disbands on checking-out at regular check-out time.
- Tour fare: ¥69,000 per person (Dolby occupancy)
¥82,000 per person (Single occupancy)

Tour Condition for "Osaka Symposium Tour" and Optional Tours

Included in the tour fares are hotel accommodations with bath at standard grade hotels; lunch as specified in the itinerary; tourist-class reserved seats on super express trains and best available seats on private railways; sightseeing and transfers by bus on a group basis; transportation of baggages not exceeding two pieces per person; service of an English-speaking escort throughout the tour; and gratuities to hotel maids, porters, chauffeurs etc.

JTB reserves the right to cancel any tour should there be insufficient participation.

CANCELLATION

HOTEL ACCOMMODATIONS

In the event of a hotel reservation having to be cancelled, written notification should be sent to JTB. The following cancellation fees will be deducted before refunding a deposit:

If the notice of cancellation reaches JTB:

Up to 9 days before the first night of stay. ¥1,000
2-8 days before 20% of deposit
Less than 2 days before, or not notice given
100% of deposit

TOURS

In the event of tour reservations having to be cancelled, written notification should be sent to JTB. The following cancellation fees will be deducted before refunding the tour fare:

If the notice of cancellation reaches JTB:

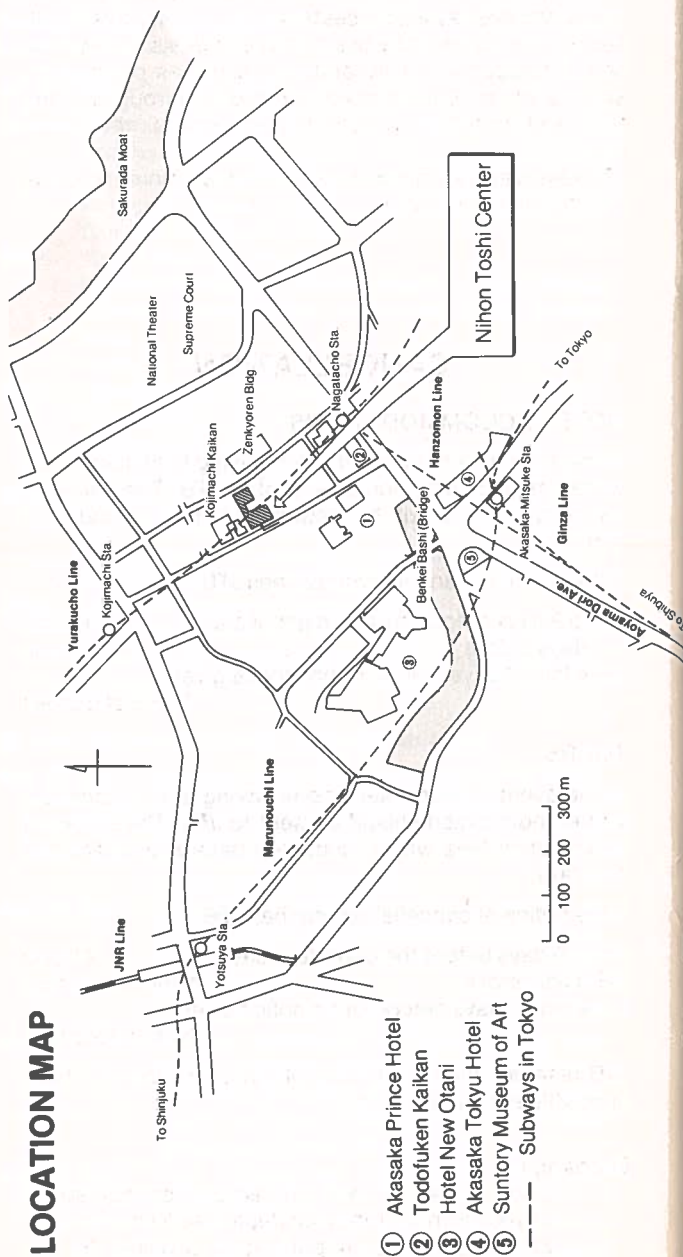
Up to 9 days before the departure day ¥1,000
2-8 days before 10% of tour fare
Less than 2 days before, or no notice given
20% of tour fare

JTB reserves the right to cancel any of the tours if there is insufficient participation.

Exchange

Upon arrival, you are advised to exchange some of your own currency for Japanese Yen currency at the banks at Airport. It is possible to exchange most of the foreign currency into Japanese money at banks or hotels. Personal Cheques can not be accepted for immediate exchange, you are advised not to reply on them.

LOCATION MAP



•Those who take a taxi from Tokyo City Air Terminal to your hotel, or from your hotel to Nihon Toshi Center are requested to show the following and inform a driver of the site to avoid misunderstanding.

● タクシー運転手の方へ (To a Taxi Driver)

この方は、国際人間工学会連合第8回会議に出席される海外の代表者です。下記の示される場所まで安全に御案内下さい。

日本都市センター…………… Nihon Toshi Center
 (平河町)

ホテル・ニューオータニ… Hotel New Otani

赤坂東急ホテル…………… Akasaka Tokyu Hotel

銀座キャピタルホテル…… Ginza Capital Hotel
 (新富町前)

For further information, Please contact:

Secretariat: IEA '82 Tokyo
 c/o Inter Group Corp.
 Akasaka Yamakatsu Bldg.
 8-5-32, Akasaka, Minato-ku
 Tokyo 107, Japan

Phone (03) 479-5318

Cable Address: INTERCONFER TOKYO



Our charming way

You'll be charmed by our service whenever you fly JAL.

To 52 cities in 31 countries across six continents.

And wherever you go, you'll always be helped by a charming stewardess whose upbringing and training go together in perfect harmony.

Our charming way is just one of the many ways that make flying the world with Japan Air Lines so delightfully memorable.

**Serving you
is our way.**



JAPAN AIR LINES
official carrier

IEA'82 TOKYO

August 23—27, 1982

IEA82



PARTICIPANTS LIST

**THE 8TH CONGRESS OF
THE INTERNATIONAL ERGONOMICS ASSOCIATION**

CONTENTS

	Page	
Australia	1	
Belgium	1	
Brazil	1	1
Bulgaria	1	
Canada	1	
China	2	1
Columbia	2	1
Czechoslovakia	2	
Denmark	2	
Finland	2	
France	3	
F.R.G.	4	1
Greece	5	1
India	5	1
Indonesia	5	1
Ireland	5	
Israel	5	
Italy	5	
Japan	6	
Korea	23	
Malaysia	23	
The Netherlands	23	
Norway	23	
Poland	23	
Rumania	23	
Spain	24	
Sweden	24	
Switzerland	25	
Thailand	25	
U.K.	25	
U.S.A.	25	
Yugoslavia	28	

Australia

Adams, Austin S
C/- Richard Green
25-5, 3 Chome, Sasabe
Matsumoto, Nagano
Japan

Croft, Peter G.
Traffic Authority of NSW
P.O. Box 110, Rosebery, NSW, 2018
Australia

Hall, Roger R.
Dept. of Transport Engineering
University of NSW
P.O. Box 1, Kensington, NSW, 2033
Australia

Howie, Alan
Shell Company of Australia Ltd.
155 William St.
Melbourne, Australia 3000

McPhee, Barbara J.
Commonwealth Institute of Health
Building A27, University of Sydney,
NSW, 2006
Australia

Popobic, Vesna
Queensland Institute of Technology
School of the Built Environment
George St. Brisbane 4000
Australia

Belgium

Keyser, Veronique de
84 Rue du Tabellion
1050 Bruxelles
Belgium

Sporcq, Jacques
Rwaluwerlaan 41
B 1650 Beersel
Belgium

Brazil

Fischer, Frida M.
University of São Paulo
School of Public Health
Avenida Dr., Arnaldo, 715
012 55 São Paulo
Brazil

Bulgaria

Gantchev, Gantcho N.
Institute of Physiology
Bulgarian Academy of Sciences
G. Bontchev Str. Bl. 1
Sofia 1113, Bulgaria

Canada

Kelly, Ray
Ontario Hydro SSD Pickering A7 A8

Kumar, Shrawan
Dept. of Physical Therapy
University of Alberta
Edmonton, Alberta
Canada, T6G 2G4

Matthews, Michael L.
Dept. of Psychology
Univ. of Guelph, Guelph
Ontario, N1G 2W1
Canada

Noy, Ian Y.
c/o Dciem

P.O. Box 2000
Downsview, Ontario
Canada M3M 3B9

Rabideau, Gerald F.
Dept. of Systems Design Engineering
University of Waterloo
Waterloo, Ontario N2L 3G1
Canada

Raouf, Abdul
Dept. of Industrial Engineering
Univ. of Windsor
Windsor, Ontario
Canada, N9B 3P4

Schneider, Franz
Ontario Hydro SSD
Pickering A7 A8

China (P.R.O.C.)

Cang, Xu Lian
Institute of Psychology
Academia Sinca
Beijing (P.R.O.C)

Colombia

Buitrago, Alfredo
Aptado Aereo #72-75
Cali, Colombia
South America

Czechoslovakia

Formánek, Jaroslav
Institute of Hygiene and
Epidemiology Šrobárova 48,100 42
Praha 10 Czechoslovakia

Vaneckova, Magda
Institute of Hygiene and
Epidemiology Srobaroa 48,100 42,
Praha 10 Czechoslovakia

Denmark

Johansen, Agnes Saaby
Dept. for Industrial Psychology
Technological Institute
Gregersensvej, DK-2630 Taastrup

Jorgensen, Kult
August Krogh Institute
University of Copenhagen
Universitetsparken 13
DK 2100 Copenhagen 0

Leschly, Vibeke
Boegevang 1, 2830 Virum

Mordhorst, Jytte
Scandinavian Airlines System, IL
P.O. Box 150, 2770 Kastrup

Finland

Ahonenm, Mauno K.
Institution of Occupational Health
Haartmaninkatu 1,
00250 Helsinki 25

Tuulikki, Tuomi Haapiainen
Institute of Occupational Health
Laajaniityntie 1, SF-01620
Vantaa 62

Harma, Mikko I.
Kuopion Korkeakoulu/
Fysiologian Laitos PL-138,70101
Kuopio 10

Honkasalo, Antero
Lappeenranta University of
Technology
Hakamaki 4 K-127-Espoo 12

Honkasalo, Maria-Liisa
Finish Foundation for Alcohol Studies
Kaleuankatu 12
SF-00100 Helsinki-10

Ilmarinen, Juhani
Institute of Occupational Health
Laajaniityntie 1, SF-01620
Vantaa 62

Kirjonen, Juhani
Dept. Public Health, University of
Tampere, P.O. Box 607 SE 33101
Tampere 10

Kuorinka, Ilkka
Institute of Occupational Health
Laajaniityntie 1, SF-01620
Vantaa 62

Luopajarvi, Tuulikki
Institute of Occupational Health
Laajaniityntie 1, SF-01620
Vantaa 62

Oittila, Eva
Dept. of Household Technology
University of Helsinki
Viikki F-Talo 00710 Helsinki 71

Parvinen, Arvi Lauri
Vihtapolku 11, SF-28200 Pori 36

France

Andanson, Jack
Villa la Raspierre - 482
Chemin de la Calade, Toulon 83000

Berenger, Jean-Victor
Residence es Tamaris 3 Bis Avenue
des Tamaris, 13100 Aix En Provence

Berlatier, German
Asmtbtp Services Medicaux du
Travail Batiment et T.P. 344
Boulevard Michelet 13009
Marseille

Cornu, Lucienne Cabare
6 Boulevard Reynaud
13008 Marseille

Cavalier, Jacques
Michelin Service Spo
Place des Carmes, 63000
Cleamont, Ferrand

Ducrolq, Julien
Ergos
B.P. 42 77201 Marne la Vallee
Cedex 02

Fecci, Roger
Asmtbtp Services Medicaux du
Travail Batiment, Et T.P. 344
Bd Michelet 13009 Marseille

Heiter, Helene
Ergonome Credit Lgonnais
Paris le di Junse

Houghton, Antony
Ergos S.A. BP 42
77201 Marne la Vallee Cedex 02

Larriere, Jean Pierre
Raffinerie Elf Donges
44480 Donges

Masson, Yves le
19 Rue du Gord, 91580 Etretchy

Medail, Jacques
11 Parc Ferber
06200 Nice

Mondo, Hugues
111 Avenue de la Bourdonnais
75007 Paris

Muffang, Yves
Electricite de France-Gaz de France
30 Aeneu de Wagram
75382 Paris Cedex 08

Pottier, Michel
10 Place de la Bastille
75011 Paris

Quarin, Serge
Raffinerie Elf Donges
44480 Donges

Quere, Jean le
Raffinerie Elf Donges
44480 Donges

Richard, Edouard
Center De Recherche Et D'application
En Ergonomie, Universite Jean
Moulin-Lyon 3
74 Rue Pasteur, 69224
Ryon Cedex 1
France

Rouhet, Jean Claude
Ergos S.A. BP 42
77201 Marne la Vallee Cedex 02

Scapin, Dominique
Inria. Domaine de Voluceau,
Rocquen Court, BP 105, 78153
Lechesnay

Schlumberger, Henry-Georges
Service General de Medecine du
Travail, E.D.F.-G.D.F.
30 Avenue de Wagram 75382 Paris
Cedex-08

Terssac, Glibert De
Centre National de la
Recherche Scientifique
Laboratoire D'automatique et
D'analyse des Systems
7 Avenue du Colonel-Roche-31400
Toulouse

Vogt, Jean Jacques
Centre d'Etudes Bioclimatiques
21 Rue Becquerel, 67087
Strasbourg-Cedex

Wisner, Alain L.
Conservatoire National des Arts et
Metiers, 41 Rue Gay-Lussac 75005
Paris

F.R.G.

Bubb, Heiner R.
Institut für Ergonomie der
Technischen Universität
München Barbarastrasse 16/II
D-8000 München 40

Bullinger, Hans-Jörg
Fraunhofer-Institut für
Arbeitswirtschaft und
Organization, Holzgartenstr
17, 7000 Stuttgart 1

Jaeck, Siegfried
c/o Pressag Ag-Hauptverwaltung
Leibnizufer 9, 3000 Hannover 1
West Germany P.O. Box 48 27

Kern, Peter
Iao
Holzgartenstr. 17
7000 Stuttgart 1
West Germany

Kirchner, Johannes-Henrich
Fachgebiet Arbeitswissenschaft
Technische Universität Braunschweig
Postfach 3329, D-3300 Braunschweig

Knauth, Peter
Institut für Arbeitsphysiologie an
der Universität Dortmund
Ardeystrasse 67 - 4600 Dortmund

Krueger, Helmut
Institut f. Arbeitsphysiologie
d. Techn. Univ.
Barbarastr. 16
8000 München 40
West Germany

Luczak, Holger
University of Bremen
P.O. Box 330440
D-2800 Bremen

Ludersdorf, Reinhard P.M.
Institut für Arbeitsmedizin der
Freien Universität Berlin
Königsberger Str. 36, D-1000,
Berlin 45

Müller, Bernd
Universität-GH-Wuppertal
Gausstrasse 20, 5600 Wuppertal 1
West Germany

Peters, Helmut
University of Wuppertal
D 56 Wuppertal, Gausstrasse 20

Pornschlegel, Hans
Sozialakademie Dortmund
Hohe Strasse 141
D-4600 Dortmund 1

Rahhahn, Hans
Geschäftsführer Rewa-
Forschungs GmbH, Sperberweg 5D
5503 Konz

Rohmert, Walter
Institut F. Arbeitswissenschaft,
Petersenstr. 30, D-6100 Darmstadt

Schacke, Gustav G.G.
Dept. of Occupational Medicine
University of Berlin
Königsberger Str. 36
D-1000 Berlin 45

Schaefer, Peter M.
Institut für Ergonomie der
Technischen Universität München
Barbarastrasse 16/II, D 8000
München 40

Scholz, Herbert
Gesellschaft für Arbeitswissens
Schaff Ardeystr. 67
D-4600 Dortmund 1
West Germany

Strasser, Helmut
Institut für
Arbeitsphysiologie der
Technischen Universität München
Barbarastr. 16/II
8000 München 40

Undeutsch, Klaus
Muddepenningweg 50
D-4600 Dortmund 50

Werner, Gerhard
Viktoriastrasse 21
5600 Wuppertal 1

Willi, Wirths
University of Bonn
Romerstr. 164
5300 Bonn

Zademack, Lothar
Max-Brauer-Allee 44
D-2000 Hamburg 50

Zink, Klaus J.
Universität Kaiserslautern
Lehrstuhl F.
Industriebetriebslehre und
Arbeitswissenschaft, Postfach 3049
D-6750-Kaiserslautern

Greece

Zorbas, Yan
European Institute of Environmental
Cybernetics, Life Sciences Division
4 Kerasundos Road, Athens 514/I

India

Sen, Rabindra Nath
Ergonomics Laboratory
Dept. of Physiological
Calcutta University
11A, Mohan Bagan Lane
Calcutta-700 004

Indonesia

Manuaba, Adnyana
Dept. of Physiology, School of Med.
University of Udayana
Jalan P.B. Sudirman, Denpasar,
Bali

Ireland

Currie, Sackuille J.
c/o C.R.C Japan Ltd.

Ogasawara Building, 2-7 Kanda
Tsukasacho, Chiyoda-ku, Tokyo 1010

Gallwey, Joseph T.
The National Institute for Higher
Education
Limerick

Israel

Korn, Israel
General Federation of Labour
in Israel
Tel-Aviv, 93 Arlosoroff St.

Italy

Bagnara, Sebastiano
Istituto di Psicologia del CNR
Via Dei Monti Tiburtini 509
00157 Roma, Italy

Luciano, Mecacci
Istituto di Psicologia
del Consiglio Nazionale Delle
Ricerche via Dei Monti Tiburtini
509, 00157 Roma

Micheli, Sergio
Nuova Italsider S.P.A.
Via Corsica 4
Genova

Ruggeri, Remigio
Politecnico di Milano
Dept. Meccanica-SEZ. Ergotecnica
P. za L. Da Vinci, 32 20133
Milano

JAPAN

Adachi Sunao
School of Medicine Keio University
35 Shinanomachi, Shinjuku-ku
Tokyo 160

Ajimine Akio
Vehicle Research Lab., Nissan Motor
Co., Ltd.
1 Natsushima-cho, Yokosuka City 237

Akamatsu Motoyuki
Keio Univ. Fac. of Eng. Department
of Administration Eng.
3-14-1 Hiyoshi Kohoku-ku Yokohama
City
Kanagawa Pref.

Ando Nobuyoshi
University of Hosei
171 Mejiro, 2-20-27 Toshima-ku
Tokyo

Anzai Yuichiro
Keio University Fac. of Eng.
Dep. of Administration Eng.
3-14-1 Hiyoshi, Kohoku-ku
Yokohama City, Kanagawa pref.

Aoki Kazuo
Dept. of Health Administration
Faculty of Medicine, Univ. of Tokyo
7-3-1 Hongo, Bunkyo-ku, Tokyo

Aoki Michiyoshi
College of Industrial Technology
Nihon University
1-2-1 Izumi Narashino City
Chiba Pref.

Aoki Takao
Institute of Medical Electronics
Faculty of Medicine, University of
Tokyo
7-3-1 Hongo Bunkyo-ku Tokyo

Aoyama Takashi
Clinical Evaluation Lab.
1-10-5 Komei-cho Minato-ku
Nagoya City. 455

Aramaki Sadahito
1410, Nakada-cho, Totsuka-ku
Yokohama City, Kanagawa

Asai Kiyoji
Industrial Eng., College of
Eng., University of Osaka Pref.
Mozu-Umemachi, Sakai, Osaka Pref.
591

Azuma Toru
Faculty of Engineering
Chiba University
1-33 Yayoi-cho, Chiba City 260

Azumi Kaoru
Keio University
5-10-29 Kajigaya Takatsu-ku
Kawasaki City Kanagawa 213

Doi Tadashi
Faculty of the Science of
Living, Osaka City University
3-3-138, Sugimoto, Sumiyoshi-ku
Osaka 558

Egawa Yoshiyuki
Nihon University
College of Industrial Technology
1-2-1, Izumi, Narashino City
Chiba

Ekuan Kenji
GK Design Institute
1-404 Shimo Ochiai, Sinjuku-ku,
Tokyo 113

Endo Toshio
1-22-1, Kitahara-cho, Tanashi City
Tokyo 188

Fujii Sumiji
Tokyo Denki University
Ishizaka, Hatoyama-machi, Hiki-gun
Saitama Pref. 350-03

Fujiie Kaoru
Spinal Cord Injury Center
550-4, Igisu, Iizuka City,
Fukuoka Pref.

Fujimura Seizo
F and F Design Office
3-6-1 Fuyohdai Mishima-shi
Shizuoka-Ken 411

Fujita Mitsuko
3-54-5 Koi Naka, Nishi-ku
Hiroshima City 733

Fukada Kyoji
Hosei University
445 Shimokodanaka Nakahara-ku
Kawasaki City, Kanagawa Pref.

Fukuba Yoshiyuki
Dept. of Biometrics, Research
Institute for Nuclear Medicine
and Biology
1-2-3 Kasumi, Minami-ku,
Hiroshima Pref. 734

Fukuchi Yasuma
Siga university of Medical Science
Seta-tsukinowa-cho, Ohtsu City 520-21

Fukuda Tadahiko
NHK Broadcasting Science Research
Laboratories
10-11, Kinuta 1-chome, Setagaya-ku
Tokyo 157

Fukunaga Tetsuo
Department of Health and Physical
Education, University of Tokyo
3-8-1, Komaba, Meguro-ku, Tokyo

Furukawa Toshiyuki
University of Tokyo
7-3-1, Hongo Bunkyo-ku, Tokyo

Furumatsu Yayoi
Jumonji College
2-2-8 Nishisugamo, Toshima-ku
Tokyo

Futatsuka Makoto
Department of Public Health
Kumamoto University Medical School
Honjo, Kumamoto 860

Haga Shigeru
Railway Labor Science Research Institut
2-5-6 Izumi-cho, Kokubunji City
Tokyo 185

Hagihara Hiroko
Aeromedical Laboratory
1-2-10, Sakae-cho, Tachikawa-city

Hanaoka Toshimasa
Department of Living Culture
Notre Dame Women's College
No.15, Tamon-cho, Nara City, Nara Pref.

Hanayasu Shigeo
Industrial Sefty Research Institute
of Raver Ministry
5-35-1 Shiba, Minato-ku, Tokyo

Haneishi Kanju
Setsunan University
17-8 Ikeda Nakamachi, Neyagawa City
Osaka

Hara Hiroshi
Dept. of Mechanical Engineering
Faculty of Engineering
University of Tokyo
7-3-1 Hongo Bunkyo-ku Tokyo 113

Hara Shinji
Technological University of Nagaoka
Kamitomioka, Nagaoka 949-54

Hasegawa Tetsuya
Dept. of Human Engineering
U. of Occupational and
Environmental Health, Japan
1-1 Iseigaoka, Yahatanishi-ku
Kitakyushu 807

Hashida Manabu
Tokyo Association of Health Service
1-2 Ichigaya Sadohara-cho, Shinjuku-ku
Tokyo 162

Hashimoto Takayuki
Dept. of Technology, Faculty
of Education, Osaka Kyoiku University
28 Nishimachi 3-chome Nishiiru
Ichijo-Onmae-dori, Kamigyō-ku
Kyoto

Hata Shiroh
Faculty of Engineering, University
of Osaka Prefecture
Mozu-Umemachi, Sakai, Osaka 591

Hatayama Toshiteru
Department of Psychology,
Tohoku University
Kawauchi, Sendai 980

Hattori Akira
Maritime Labour Research Institute
4-5-1 Kojimachi Chiyoda-ku Tokyo
102

Hayashi Yoshio
Keio University
4-7-22, Maehara-cho, Koganei City
Tokyo

Hijikata Sadahisa
Japan Institute of Human Posture
Research
Daichi Seimei Bldg.
1-9 Yuraku-cho, Chiyoda-ku, Tokyo

Hirao Osamu
MUKTA Resarch Institute
Diamond Plaza Bldg.
25 Ichiban-cho, Chiyoda-ku, Tokyo

Hiroishi Yukiko
Japan Ergonomics Research Society
5th FL. Ikebukuro Branch of Kyowa Bank
1-9-3, Higashi-Ikebukuro, Toshima-ku
Tokyo 170

Hisashige Akinori
Kochi Medical School
Okoh-cho, Nankoku, Kochi 781-51

Hodaka Ryusuke
Institute of Medical Electronics
Faculty of Medicine
University of Tokyo
7-3-1 Hongo, Bunkyo-ku, Tokyo 113

Honda Katsumi
Nippon Electric Co., Ltd.
Software Product Engineering Laborator
4-28 Mita 1 chome, Minato-ku
Tokyo

Horii Ken
Department of Industrial
Engineering Faculty of
Engineering
Kansai University
Suita, Osaka 564

Horino Sadao
Faculty of Technology
Kanagawa University
3-27-1 Rokkakubashi, Kanagawa-ku
Yokohama City, Kanagawa Pref. 221

Ichikawa Kiyoshi
Tokyo Metropolitan
Prosthetic and Orthotic Research
Institute
3-17-3 Toyama, Shinjuku-ku, Tokyo

Ichimiya Akihiro
Minolta Camera Co., Ltd.
2-Higashiakatsuchi, Yawata-cho
Toyokawa 442

Igarashi Hiroya
GK Industrial Design Associates
2-19-16, Shimo-Ochiai, Shinjuku-ku,
Tokyo

Iguchi Masakazu
Tokyo University
7-3-1, Hongo Bunkyo-ku, Tokyo

Iiyama Yuji
Matsushita Electric Industrial
Co. Ltd.
974-52 Shimofuda-cho
Chofu City, Tokyo

Ikeda Moritoshi
Laboratory of Work Physiology
Railway Labour Science Research
Institute, Japanese National
Railways, Kokubunji
6-5-2 Izumi-cho Kokubunji City,
Tokyo

Ikeda Toshihisa
Railway Labour Science Research
Institute
Japanese National Railways
2-5-6 Izumi-cho, Kokubunji City,
Tokyo

Ikeda Yoshihiro
Faculty of Engineering, University
of Osaka Prefecture
Mozu-Umemachi, Sakai, Osaka 591

Ikeda Yoshio
Aichi Institute of Technology
Department of Industrial Engineering
1247 Yagusa-cho, Toyota 470-03

Inaba Shotaro
Inaba Institute of Human Engineering
No. 2-801, Mimomi-cho, Narashino City
Chiba Pref. 275

Inoue Seiichi
Fukui Technical College
2-6-25, Nishikida, Fukui City
Fukui Pref. 910

Ishibashi Hirobumi
Nihon University, College of
Industrial Technology
1-2-1 Izumi, Narashino, Chiba

Ishida Yoshio
Tokyo Metropolitan Technical College
2-421 Honmoku, Naka-ku, Yokohama City
Kanagawa Pref. 231

Ishii Masaru
Fukuoka University of Education
Akama-729, Munakata, Fukuoka
811-4118

Ishikawa Fumitake
Insitute of Agricultural Machinery
1-40-2, Nisshin, Omiya, Saitama Pref.
330

Ito Koji
On the Self-paced Preview Manual
Tracking Behaviors
405, 34-38, 2-chome, Koihigashi
Nishiku, Hiroshima 733

Ito Nobuyasu
Dept. of Biophysical Engineering
Fac. of Engineering Sci.
Osaka University
1-1 Machikaneyama-cho Toyonaka
Osaka 560

Ito Norio
1-27-3 Shimoigusa Suginami-ku
Tokyo

Itow Hidesaburo
Body Reformatory School
3-19-6 Shoan
Suginami-ku
Tokyo

Iwanaga Kouichi
Dept. of Ergonomics, Kyushu
Institute for Design Research
226 Shiobaru, Minami-ku
Fukuoka Pref.

Kamataki Akio
Department of Administration
Engineering
Fukuoka Institute of Technology
Shimowajiro, Higashiku, Fukuoka Pref.
811-02

Kaneko Hidetatsu
Dept. of Electrical Engineering
Toyota Technical College
2-1 Eisei-cho, Toyota City 471

Katahira Kiyooki
Second Department of Physiology
Fukushima Medical College
5-75 Sugitsuma-cho, Fukushima Pref.
960

Kato Atsuo
Assist Professor
Aichi Institute of Technology
1247 Yachigusa Yagusa, Toyota
Toyota 470-03

Kato Ichiro
Waseda University
3-4-1 Okubo, Shinjuku-ku 160

Kato Shuzo
Development Engineer
Engineering Division
Engineering and Manufacture
Oiso, NCR Japan Ltd.
2333 Oiso, Oiso-machi
Naka-gun, Kanagawa Pref. 255

Katsuura Tetsuo
Dept. of Ergonomics,
Chiba University
1-33 Yayoi-cho, Chiba 260

Kawaguchi Kunitomo
Industrial Safety Research
Institute of Labor Ministry
5-35-1, Shiba, Minato-ku, Tokyo

Kawahara Hiroyasu
National Aerospace Laboratory
1880 Jindaiji-machi, Chofu
Tokyo 182

Kawahara Yuri
Japan Women's University
1-3-9, Higashi-magome
Ota-ku, Tokyo

Kawano Ryutaro
Tokyo Area Control Center
Namiki 1-12, Tokorozawa City
Saitama Pref. 359

Kawano Tsuneo
Electronics Engineering Dept.
21-7 4-chome, Ishibashi, Ikeda
Osaka 563

Kawashima Syuzo
651, Chuodai, Ottozawa,
Ohkuma-cho, Futaba-gun
Fukushima Pref.

Kawashima Yoshikatsu
Yokohama National University
5-25-10 Take, Yokosuka,
Kanagawa Pref.

Kikuchi Yasuyuki
Laboratory of Ergonomics, Dept. of
Industrial Design Faculty of
Engineering
Chiba University
33 Yayoi-cho 1-chome
Chiba Pref. 260

Kimotsuki Kuninori
Institute for Science of Labour
1544 Sugao, Takatsu-ku
Kawasaki 213

Kimura Arata
Ergonomics Laboratory, Department
of Industrial Engineering, Faculty
of Tech., Kanagawa University
3-27-1 Rokkakubashi, Kanagawa-ku
Yokohama City 221

Kimura Kunihiro
Japan Institute of Human Posture
Research
1-9 Yuraku-cho, Chiyoda-ku, Tokyo

Kinoshita Shigehiro
Institute of Medical Electronics
Faculty of Medicine, University of
Tokyo
7-3-1 Hongo Bunkyo-ku Tokyo

Kira Satoru
Takasaki City University of Economics
277 Yono, Yono City, Saitama Pref.

Kishida Koya
Takasaki City University of Economics
277 Yono, Yono City, Saitama Pref.

Kitagaki Ikuo
Center for Educ. Technol.
Fukuoka University of Educ.
729 Akama, Munakata City 811-41

Kobayashi Takeshi
Health Administration Dept.
Nissan Motor Co., Ltd.
1-31-5 Shinkoyasu, Kanagawa-ku
Yokohama City 221

Kogi Kazutaka
Research Chief, Institute for
Science of Labour
1544 Sugao, Takatsu-ku
Kawasaki 213

Koh Yoshiro
Architectural Dept., Faculty of
Engineering, Hokkaido University
Kita 13 jo, Nishi 8 chome
Kita-ku, Sapporo City 060

Koinumaru Tanenobu
1, Kirihara-cho, Fujisawa City
Kanagawa Pref. 252

Komachiya Asao
Associate Professor
Tokyo Geijutsu University
2-33-2 Kamiikedai Ota-ku, Tokyo 145

Komagari Kiyomi
Dept. of Industrial Engineering
Faculty of Technology
Kanagawa University
3-27-1 Rokkakubashi, Kanagawa-ku
Yokohama City, Kanagawa Pref. 221

Komatsu Kenzi
Railway Labour Science Research
Institute 2-5-6, Izumi-cho,
Kokubunji City, Tokyo 185

Komatsubara Akinori
Dept. of Industrial Engineering
School of Science and Engineering
Waseda University
1-38-4, Amanuma, Suginami-ku
Tokyo 167

Kondo Susumu
Hitachi Ltd.
Software Works
23-15 6-chome, Minamiohi, Shinagawa-ku
Tokyo 140

Kondo Taiji
6-4-8 Minaminagasaki Toshima-ku
Tokyo 171

Kondo Takeshi
College of Industrial Technology
Nihon University

Kose Satoshi
Building Research Institute
Tatehara, Oho, Tsukuba
Ibaragi

Kosugo Rokuro
Institute for Science of Labour
1544 Sugao, Takatsu-ku, Kawasaki City

Koyano Eiichi
Aoyama-gakuin University
5-6-5, Asagaya-kita, Suginami
Tokyo

Kozuki Setsuko
1-2-10, Shinzenji-dori, Chuo-ku
Kobe City Hyogo Pref.

Kubota Hideki
Dept. of Architecture and Building
Engineering, Muroran Institute of
Technology
27-1 Mizumoto-cho, Muroran, Hokkaido

Kubota Tsuneo
Japan Institute of Human Posture
Research
Daichi Seimei Bldg.
1-9 Yuraku-cho, Chiyoda-ku, Tokyo

Kubota Yoichi
Dept. of Construction Eng.
Faculty of Eng., Saitama University
255 Simo-Okubo, Urawa City
Saitama Pref. 338

Kumasaka Hiroshi
Kanagawa University
3-27 Rokkakubashi Kanagawa-ku
Yokohama City, Kanagawa Pref.

Kato Atsuo
Assist Professor
Aichi Institute of Technology
1247 Yachigusa Yagusa, Toyota
Toyota 470-03

Kato Ichiro
Waseda University
3-4-1 Okubo, Shinjuku-ku 160

Kato Shuzo
Development Engineer
Engineering Division
Engineering and Manufacture
Oiso, NCR Japan Ltd.
2333 Oiso, Oiso-machi
Naka-gun, Kanagawa Pref. 255

Katsuura Tetsuo
Dept. of Ergonomics,
Chiba University
1-33 Yayoi-cho, Chiba 260

Kawaguchi Kunitomo
Industrial Safety Research
Institute of Labor Ministry
5-35-1, Shiba, Minato-ku, Tokyo

Kawahara Hiroyasu
National Aerospace Laboratory
1880 Jindaiji-machi, Chofu
Tokyo 182

Kawahara Yuri
Japan Women's University
1-3-9, Higashi-magome
Ota-ku, Tokyo

Kawano Ryutarō
Tokyo Area Control Center
Namiki 1-12, Tokorozawa City
Saitama Pref. 359

Kawano Tsuneko
Electronics Engineering Dept.
21-7 4-chome, Ishibashi, Ikeda
Osaka 563

Kawashima Syuzo
651, Chuodai, Ottozawa,
Ohkuma-cho, Futaba-gun
Fukushima Pref.

Kawashima Yoshikatsu
Yokohama National University
5-25-10 Take, Yokosuka,
Kanagawa Pref.

Kikuchi Yasuyuki
Laboratory of Ergonomics, Dept. of
Industrial Design Faculty of
Engineering
Chiba University
33 Yayoi-cho 1-chome
Chiba Pref. 260

Kimotsuki Kuninori
Institute for Science of Labour
1544 Sugao, Takatsu-ku
Kawasaki 213

Kimura Arata
Ergonomics Laboratory, Department
of Industrial Engineering, Faculty
of Tech., Kanagawa University
3-27-1 Rokkakubashi, Kanagawa-ku
Yokohama City 221

Kimura Kunihiro
Japan Institute of Human Posture
Research
Daichi Seimei Bldg.
1-9 Yuraku-cho, Chiyoda-ku, Tokyo

Kinoshita Shigehiro
Institute of Medical Electronics
Faculty of Medicine, University of
Tokyo
7-3-1 Hongo Bunkyo-ku Tokyo

Kira Satoru
Takasaki City University of Economics
277 Yono, Yono City, Saitama Pref.

Kishida Koya
Takasaki City University of Economics
277 Yono, Yono City, Saitama Pref.

Kitagaki Ikuo
Center for Educ. Technol.
Fukuoka University of Educ.
729 Akama, Munakata City 811-41

Kobayashi Takeshi
Health Administration Dept.
Nissan Motor Co., Ltd.
1-31-5 Shinkoyasu, Kanagawa-ku
Yokohama City 221

Kogi Kazutaka
Research Chief, Institute for
Science of Labour
1544 Sugao, Takatsu-ku
Kawasaki 213

Koh Yoshiro
Architectural Dept., Faculty of
Engineering, Hokkaido University
Kita 13 jo, Nishi 8 chome
Kita-ku, Sapporo City 060

Koinumaru Tanenobu
1, Kirihara-cho, Fujisawa City
Kanagawa Pref. 252

Komachiya Asao
Associate Professor
Tokyo Geijutsu University
2-33-2 Kamiikedai Ota-ku, Tokyo 145

Komagari Kiyomi
Dept. of Industrial Engineering
Faculty of Technology
Kanagawa University
3-27-1 Rokkakubashi, Kanagawa-ku
Yokohama City, Kanagawa Pref. 221

Komatsu Kenzi
Railway Labour Science Research
Institute 2-5-6, Izumi-cho,
Kokubunji City, Tokyo 185

Komatsubara Akinori
Dept. of Industrial Engineering
School of Science and Engineering
Waseda University
1-38-4, Amanuma, Suginami-ku
Tokyo 167

Kondo Susumu
Hitachi Ltd.
Software Works
23-15 6-chome, Minamiohi, Shinagawa-ku
Tokyo 140

Kondo Taiji
6-4-8 Minaminagasaki Toshima-ku
Tokyo 171

Kondo Takeshi
College of Industrial Technology
Nihon University

Kose Satoshi
Building Research Institute
Tatehara, Oho, Tsukuba
Ibaragi

Kosugo Rokuro
Institute for Science of Labour
1544 Sugao, Takatsu-ku, Kawasaki City

Koyano Eiichi
Aoyama-gakuin University
5-6-5, Asagaya-kita, Suginami
Tokyo

Kozuki Setsuko
1-2-10, Shinzenji-dori, Chuo-ku
Kobe City Hyogo Pref.

Kubota Hideki
Dept. of Architecture and Building
Engineering, Muroran Institute of
Technology
27-1 Mizumoto-cho, Muroran, Hokkaido

Kubota Tsuneko
Japan Institute of Human Posture
Research
Daichi Seimei Bldg.
1-9 Yuraku-cho, Chiyoda-ku, Tokyo

Kubota Yoichi
Dept. of Construction Eng.
Faculty of Eng., Saitama University
255 Simo-Okubo, Urawa City
Saitama Pref. 338

Kumasaka Hiroshi
Kanagawa University
3-27 Rokkakubashi Kanagawa-ku
Yokohama City, Kanagawa Pref.

Kumashiro Masaharu
Dept. of Human Engineering
U. of Occupational and
Environmental Health, Japan
1-1 Iseigaoka, Yahatanishi-ku
Kitakyushu 807

Kunishima Michiko
Faculty of Home Economics
Nara Women's University
Kitauoya-nishimachi
Nara, 630

Kurioka Yutaka
Electrotechnical Laboratory
Osaka Branch
3-11-46 Nakaji, Amagasaki, Hyogo 661

Kurabayashi Takeshi
Japan Institute of
Synthetic Technology
201 Hanzomon Haimu
1-8 Kojimachi, Chiyoda-ku 102

Kurata Chikara
Nihon University
College of Industrial Technology
1-2-1 Izumi, Narashino, Chiba

Kuroe Toshiharu
The Kanto Teishin Hosp.
c/o Shisei Bldg.
1-3 Hibiya Park, Chiyoda-ku
Tokyo

Kuroiwa Masayuki
Shimonoseki Chyuou Technical
High School
Hiyoshida, Yahatanishi-ku
Kitakyushu Fukuoka Pref.

Kuroda Isao
Aeromedical Laboratory, JASDF
1-2-10, Sakae-cho, Bunkyo-ku
Tokyo

Kurokawa Takao
Dept. of Biophysical Engineering
Fac. of Engineering Sci.
Osaka University
1-1 Machikaneyama-cho, Toyonaka
Osaka 560

Kurosu Masaaki
Central Research Laboratory
Hitachi Ltd.
1-280 Higashi-koigakubo Kokubunji
Tokyo 185

Kuto Yoshiaki
Keio University Fac. of Eng.
Dep. of Administration Eng.
3-14-1 Hiyoshi Kohoku-ku
Yokohama City, Kanagawa Pref.

Machida Nobuo
Nihon University, College of
Science and Technology
24-1 7-chome, Narashinodai
Funabashi City, Chiba Pref. 274

Maeda Katsuyoshi
Department of Environmental Health
Kurume University School of Medicine
67 Asahi-machi Kurume City
Fukuoka Pref. 830

Makikawa Masaaki
Department of Orthopaedic Surgery
Shiga University of Medical Science
Tsukinowa-cho, Otsu City, Siga Pref.
520-21

Manabe Haruzo
Professor of Ergonomics
Ohtemongakuin University
26-19 Hanaten Higashi 3-chome
Tsurumi-ku, Osaka Pref. 538

Maruyama Kinuya
Department of Psychology
Tohoku University
Kawauchi, Sendai 980

Masada Wataru
Dept. of Psychology
Rikkyo University
School of Literature
4-16-29, Huginidai, Nerima-ku, Tokyo

Masuyama Eitaro
11-204, Miyamae-daira Green Heights 430
Mukogaoka, Takatsu-ku, Kawasaki City

Matsui Hideji
University of Nagoya
Reserach Center of Health Physical
Fitness and Sport
Chikusa-ku, Nagoya

Matsui Hiroyuki
Yokosuka Electrical
Communication Laboratory
Nippon Telegraph and Telephone
Public Corporation
1-2356 Take, Yokosuka City
Kanagawa Pref. 238-03

Matsui Isamu
College of Industrial Technology
Nihon University
Izumi-cho, Narashino City
Chiba Pref. 275

Matsumoto Minoru
Matsushita Electric Industrial Co.,
Ltd. C.Q.A.D.
1-6 Matsuo-cho, Kadoma, Osaka 571

Matsumoto Tadao
Dept. of Public Health, Nagoya City
University Medical School
Kawasumi Mizuho-cho, Mizuho-ku
Nagoya 467

Matsuno Masanori
5-3-17 Denechofu Otaku 5-3-17
Tokyo

Matsuo Akifumi
Department of Health and Physical
Education, University of Tokyo
3-8-1 Komaba, Meguro-ku, Tokyo

Matsuoka Kiyotoshi
The Kyushu Institute of Technology
Tobata, Kitakyushu

Mikami Kohki
Department of Industrial Engineering
Hokkaido Institute of Technology
419-2, Maeda, Teine, Nishi-ku
Sapporo 061-24

Misawa Tetsuo
Dept. of Environmental Med. &
Occup. Health, School of Med.
Tokai University
Bohseidai, Isehara City
Kanagawa Pref. 259-11

Mito Hideki
Department of Public Health
Kinki University School of Medicine
Sayama, Minamikawachi-gun, Osaka 589

Miura Nobuyasu
Kokushikan University
4-28-1 Setagaya Setagaya-ku, Tokyo

Miura Toyohiko
Institute for Science of Labour
1544 Sugao, Takatsu-ku, Kawasaki City
Kanagawa Pref. 213

Miura Yoshiko
2-7 Asahigaoka-cho, Suita City
Osaka 564

Miyagi Masao
Sibaura Institute of Technology
307 Hukasaku, Omiya City
Saitama Pref. 330

Miyake Takeo
Nihon Univ. School of Med.
Dept of Public Health
30-1 Ohayaguchi-Kamimachi
Itabashi-ku Tokyo 173

Miyao Masaru
Department of Public Health
Nagoya University School of Medicine
65 Tsurumai-cho, Showa-ku,
Nagoya, City, Aich Pref. 466

Miyashiro Nobuo
Hokkaido Institute of Technology
419-2 Maeda Teine Nishi-ku
Sapporo Hokkaido

Mizuki Kumiko
Keio Univ. Fac. of Eng. Department
of Administration Eng.
3-14-1 Hiyoshi Kohoku-ku
Yokohama City, Kanagawa Pref.

Mori Yukinori
Central Research Laboratories
Ajinomoto Co., Inc.
1-1, Suzuki-cho, Kawasaki-ku
Kawasaki 210

Morikawa Shinichiro
61, Kugino, Shikatsu-cho,
Nishikashugai-gun
Aichi Pref. 481

Morimoto Shoji
Rosai Gishi Center
1-10-5 Komei-cho Minato-ku
Nagoya 455

Morioka Mitsuo
Department of Hygiene
Nihon University School of Medicine
30 Ohyaguchi-Kamimachi, Itabashi-ku
Tokyo 173

Morisada Chikami
Matsuyama Institute of Kinesiology
1-524-17 Oguri, Matsuyama City 790

Morooka Kozi
Management Engineering Dept.
Tokai University
1117 Kitakaname, Hiratsuka,
Kanagawa Pref. 259-12

Motoaki Hiroshi
Waseda University
1, Totsuka-cho, Shinju-ku, Tokyo

Muramatsu Sonoe
Tokai Gakuen Junior College
Hirabari, Tenpaku-cho, Tenpaku-ku
Nagoya City, Aichi Pref.

Muramatsu Tsuneji
Aichi University of Education
1 Hirosawa, Igaya-cho, Kariya City
Aichi Pref.

Muroya Hideyuki
Laboratory of work physiology
Railway Labour Science Research
Institute,
Japanese National Railways
Kokubunji City Tokyo

Musha Yoshinori
Iron Corporation
No. 3-7 1-home, Honjo, Sumida-ku
Tokyo

Muto Haruko
North-sho College
2-21-8 Nishimachi, Kokubunji City
Tokyo 185

Nagamachi Mitsuo
Hiroshima University
1-12-42, Agakita Kure City
Hiroshima Pref.

Nagano Hidemaro
JAL
2-1-1, Haneda Airport Ota-ku
Tokyo

Nagao Naruhiko
Department of Morphology,
Institute of
Constitutional Medicine
Kumamoto University
Wakaba 5-11-6, Kumamoto 862

Nagasawa Yuko
1-2-10, Sakae-cho Tachikawa
Tokyo

Nagashio Shizuko
Faculty of Living Science
Shizuoka Womens' University
409 Yata, Shizuoka City
Sizuoka Pref.

Nagata Akira
Faculty of Science
Tokyo Metropolitan University
1-1-1 Yagumo, Meguro-ku
Tokyo 152

Nagata Hisao
Industrial Safety Research
Institute of Labor Ministry
5-35-1, Shiba, Minato-ku, Tokyo

Nakamura Marumi
Itoh Seiki Co.
5-23-7 Ohmiyadai, Chiba Pref. 980

Nakane Yoshikazu
Faculty of the Science of
Living, Osaka City University
3-3-138, Sugimoto, Sumiyoshi-ku
Osaka 558

Nakano Noboru
Lion Corporation
No. 13-12 7-chome, Hirai, Edogawa-ku
Tokyo

Nakaya Masayuki
Space Medicine Laboratory
The Jikei University School of
Medicine
3-25-8 Nishi-shimbashi, Minato-ku,
Minato-ku, Tokyo

Nakayama Hideaki
2-15, Natsushima-cho, Yokosuka City
Kanagawa Pref.

Nakayama Shunichi
Meiji University
69 Urayama Yagoto Tenpaku-cho,
Tenpaku-ku Nagoya 468

Nakazawa Susumu
Musashino College of Fine Arts
Tatekawa 3-18-11-404, Sumida-ku
Tokyo 130

Nariai Takayuki
Dept. of Ergonomics, Kyushu Institute
for Design Research
226 Shiobaru, Minami-ku,
Fukuoka Pref.

Niihara Tomoko
Dept. of Special Education
University of Miyazaki
1-1 Funatsuka, Miyazaki City

Nishibe Tetsuichi
Japan Captains Association, Corp.
Aggregate
4-5 Kojimachi, Chiyoda-ku
Tokyo 102

Nishikawa Shinpachi
Nihon Univ. School of Medicine
30, Ohtaniguchi Kamimachi
Itabashi-ku, Itabashi-ku
Tokyo

Nishizaki Kunio
Institute of Agricultural Machinery
1-40-2, Nisshin-cho, Omiya City

Noma Keisuke
I.E. Dept. University of Osaka
Prefecture
Moju Umemachi, Sakai, Osaka 591

Noma Takaaki
A Lecturer of College and Membership
423, Futocho Kohoku-ku Yokohama
Kanagawa

Noro Kageyu
University of Occupational and
Environmental Health, Japan
1-1, Ishogaoka Nishi-ku Hachiman
Kitakyushu City, Fukuoka Pref.

Ogawa Iiji
Windsor
3-15-11, Hirai, Edogawa-ku,
Tokyo 132

Ogawa Shingo
Human Factors Research Institute Co.,
Ltd
2-26-7, Hyakunin-cho, Shinjuku-ku,
Tokyo

Oguma Masayuki
Lion Corporation
No. 13-12, 7-chome, Hirai,
Edogawa-ku, Tokyo

Oguro Yoshio
Kanagawa University,
Associate Professor
2-9-6 Wakabadai, Shiroyama-machi
Tukui-gun, Kanagawa Pref.

Ohara Hiroshi
Department of Public Health
Kochi Medical School
Okohcho, Nankoku, Kochi 781-51

Ohashi Masayoshi
Nihon University Shi Gakubu
Rikogaku Kyoshitsu
1-8-13 Surugadai Kanda,
Chiyoda-ku, Tokyo

Ohashi Masayuki
Health Care Service Division
of Computer Services Corporation
2-6-1, Nishi-shinjuku, Shinjuku-ku
Tokyo

Ohashi Nobuo
Maritime Labour Research Institute
4-5-1, Kojimachi Chiyodaku
Tokyo 102

Ohkoshi Kunichika
Laboratory of Ergonomics, Dept. of
Industrial Design, Faculty of
Engineering
Chiba University
33 Yayoi-cho 1-chome,
Chiba Pref. 260

Ohkubo Takao
College of Industrial Technology
Nihon University
1-2-1 Izumi Narashino City
Chiba Pref.

Ohnaka Tadakatsu
Department of Hygiene School
of Medicine
Shows University 1-5-8
Hatanodai, Shingawa-ku Tokyo 142

Ohnishi Noboru
Rosai Gishi Center
1-10-5 Komei-cho, Minato-ku,
Nagoya 455

Onishi Noriaki
Division of Work Physiology
Institute for Science of Labour
1544 Sugao, Takatsu-ku,
Kawasaki 213

Ohshima Masamitsu
2-3-4, Akasaka Minato-ku, Tokyo

Ohsuga Mieko
Mitsubishi Electric Corp.
Central Research Lab.
Nakano 80, Minamishimizu Amagasaki
Hyogo 661

Ohta Takeshi
Japan Institute of Human
Posture Research
Daiichi Seimei Bldg. 1-9, Yuraku-cho
Chiyoda-ku, Tokyo

Ohtagaki Zuichiro
1-15-7, Gotokuji
Setagaya-ku
Tokyo

Ohtake Hisa
Railway Labour Science Research
Institute
Japanese National Railways
2-5-6 Izumi-cho, Kokubunji City,
Tokyo

Okabe Masanorio
Head of Human Engineering Section
Instr. & Control Div., National
Aerospace Laboratory
1880 Jindaiji-Machi, Chofu,
Tokyo 182

Okada Akira
Nihon Univ. School of Medicine
Ohyaguchi-Kamimachi, Itabashi-ku
Tokyo

Okada Yoshitomo
Dept. of Human Engineering, University
of Occupational and Environmental
Health, Japan
1-1 Iseigaoka, Yahatanishi-ku
Kitakyushu 807

Okai Osamu
Dept. of Physiol., Kyorin University
School of Health Science
1-20-8 Yamato-cho, Nakano-ku,
Tokyo 165

Ono Yuichiro
Department of Hygiene
Nagoya University School of Medicine
65 Tsurumai-cho, Showa-ku,
Nagoya 66

Osakabe Akiko
Showa Women's University
1-7 Taishido, Setagaya-ku
Tokyo 154

Osaki Hirokazu
Associate Professor
School of Engineering Okayama
University
1-1 Tushima Naka 3-chome,
Okayama Pref.

Osumi Yoshimasa
Assistant Manager,
Toyota Motor Corporation
Higashifuji Technical Center
1200 Mishuku, Susono City
Shizuoka Pref. 410-11

Saito Ichiro
Research Foundation of Traffic
Medicine
1-15-2 Kita, Seki-machi, Nerima-ku
Nerima-ku
Tokyo 177

Saitoh Ichiroh
Industrial Products Research
Institute, 1-1-4, Yatabe-Machi Higashi
Tsukuba-Gun, Ibaraki Pref. 305

Saito Murako
Dept. of Health Administration
School of Health Science
Faculty of Medicine,
University of Tokyo
7-3-1 Hongo, Bunkyo-ku, Tokyo

Saito Shin
Nihon University, College of
Industrial Technology
1-2-1 Izumi, Narashino, Chiba

Saito Susumu
Dept. of Physiology
Fukushima Medical College
Sugizuma-cho 5, 75, Fukushima City
Fukushima Pref.

Sakai Kazuhiro
Division of Work Physiology
Institute for Science of Labour
1544 Sugao, Takatsu-ku,
Kawasaki 213

Sakakibara Hisataka
Department of Public Health
Nagoya University School of Medicine
65 Tsurumai-cho, Showa-ku

Sakamoto Kazuyoshi
The University of Electro-
Communications
1-5-1, Chofu-ga-oka, Chofu City
Tokyo 182

Sakamoto Motoichi
Body Reformatory School
2-7-17 Kugayama Suginami-ku
Tokyo

Sano Masahide
Shibaura Institute of Technology
307 Fukasaku, Omiya City
Saitama Pref. 330

Sato Kensuke
Research Foundation on Traffic
Medicine
1-9-3 Higashi Ikebukuro, Toshimaku
Tokyo 170

Sato Sugako
Chiba University
3-28-11 Musashidai, Fuchu City
Tokyo 183

Sawada Touichi
Shibaura Institute of Technology
307 Fukasaku, Omiya City
Saitama Pref. 330

Sawada Yoshio
Department of Morphology,
Institute of
Constitutional Medicine
Kumamoto University
Suizenji 6-26-13, Kumamoto 862

Seki Kunihiro
Japan Marine Science and
Technology Center
2-15, Natsushima-cho, Yokosuka City
Kanagawa Pref. 237

Sekido Tatsuya
Toyota Central Research & Development
Laboratories, Inc.
Nagakute-cho, Aichi-gun, Aichi Pref.

Seko Yasutoshi
Vehicle Research Lab. Nissan Motor
Co., Ltd.
1 Natsushima-cho,
Yokosuka City 237

Shibahara Takeo
Shika Orientation Kyokai
Rm, 818 Plaza Umeshin Bldg.
4-15-18 Nishitenma Kitaku, Osaka

Shimizu Yutaka
Industrial Products Research
Institute
1-4-4 Higashi, Yatabemachi
Tsukuba-gun, Ibaraki Pref. 305

So Shiipo
Nihon University, College of
Industrial Technology
1-2-1 Izumi, Narashino, Chiba

Sudo Seiji
Power Reactor and Nuclear
Fuel Development Corporation
Tokai Village, Ibaraki Pref.

Sugasawa Yoshio
Nihon University College of
Industrial Technology
1-2-1 Izumi, Narashino, Chiba

Suge Yasutaka
GK Industrial Design Associates
2-19-6, Shimo-Ochiai, Shinjuku-ku,
Tokyo

Sugimoto Takaji
Nissan Motor Co., Ltd.
Equipment Test Section,
Body Test Department
560-2, Okatsukoku, Atsugi City
Kanagawa Pref.

Sugiyama Sadao
Kansei Gakuin University
1-29, Asahigaoka Ashiya, Hyogo Pref.

Suzuki Yoshitake
Rosai Gishi Center
1-10-5 Komei-cho, Minatoku
Nagoya 455

Tada Akira
National Aerospace Laboratory
Jindaiji-Machi 1880, Chofu City
Tokyo

Tajima Naoya
Department of Orthopedic Surgery
Miyazaki Medical College
5200 Ooaza Kihara, Kiyotake-machi
Miyazaki-gun Miyazaki Pref. 889-16

Takabayashi Morihisa
2-20-11 Nishigahara, Kita-ku,
Tokyo 114

Takagi Kanichi
4-11-9, Setagaya-ku
Tokyo 154

Takahashi Haruhiko
1 Kirihara-cho, Fujisawa City
Kanagawa Pref. 252

Takahashi Makoto
Accommodation Responses in CRT
Display Work, The Institute for
Science
1544, Sugao, Takatsu-ku,
Kawasaki, Kanagawa Pref. 213

Takahashi Takenori
Bunka Women's College
3-22-1 Yoyogi, Shibuya-ku, Tokyo

Takahashi Tomoyuki
1 Kirihara-cho, Fujisawa City
Kanagawa Pref. 252

Takakuwa Eimatsu
Hokkaido Univ. School of Medicine
7-chome Nishi, 15-joh Kita
Kita-ku, Sapporo, Hokkaido 060

Takasaki Yuji
Department of Hygiene, School of
Medicine, Showa University
1-5-8 Hatanodai, Shinagawa-ky
Tokyo 142

Takata Kazuyuki
Toyota Technical College
2-1 Eisei-cho, Toyota City 471

Takeda Harumi
Associate Professor
Osaka Electro-Communication
University
18-8 Hatsu-cho, Neyagawa, Osaka
Osaka Pref. 572

Tamagawa Choichiro
Kyoto Costume Institute
Wacoal Bldg., 29 Kisshoin
Nakajima-cho, Minami-ku, Kyoto

Tanaka Akira
Hosei University
Honmachi 4-501-3,
Higashi-Muroyama City
Tokyo 189

Tanaka Atsushi
Institute for Future Technology
2-1 Kitanomaru-Koen, Chiyoda-ku,
Tokyo 201

Tanaka Kenichi
Measurement System Section
National Research Laboratory of
Metrology, Keiryō Kenkyūjo
1-1-4, Sakura-mura, Niihari-gun
Ibaragi Pref.

Taniguchi Takao
Kyushu Institute of Technology
1-1 Sensui, Tobata, Kitakyushu 804

Taniyama Kazumi
15-13 Higashikaniya-cho, Higashi-ku
Hiroshima Pref. 730

Taya Yasushi
Japan Marine Science and
Technology Center
2-15, Natsushima-cho, Yokosuka City
Kanagawa Pref. 237

Terayama Kazuyuki
Department of Hygiene and
Preventive Medicine, Asahikawa
Medical College
5 Go, 4 Sen, Nishikagura
Asahikawa 078-11

Tochihara Yutaka
The Japanese Society of Ergonomics
1-5-8 Hatanodai, Shinagawa-ku
Tokyo 142

Tomoda Yasuyuki
Department of Industrial
Engineering Faculty of
Engineering
Kansai University
Suita, Osaka 564

Tsuchihashi Masahiko
Nihon Univ. School of Med.
Dept of Public Health
30-1, Ohayaguchi-Kamimachi,
Itabashi-ku Tokyo 173

Tsuchiya Kazuo
1-10-5, Komei, Minato-ku
Nagoya City, Aichi Pref. 466

Tsukahara Susumu
Department of Physiology
Fukushima Medical College
Sugizuma-cho 5-75
Fukushima City, Fukushima Pref. 980

Tsukihashi Masami
Knazawa Institute of
Technology
Re 166 Shirayama, Tsurugi-Machi
Ishikawa-gun, Ishikawa Pref.

Tsumura Toshihiro
University of Osaka Prefecture

Uchimura Yoshiyuki
Industrial Products Research
Institute

MITI
1-1-4, Yatabe-machi Higashi
Tsukuba-gun, Ibaraki Pref. 305

Ueno Seichiro
Kanazawa Institute of Technology
7-1 Ogigaoka, Nonoich Town
Ishikawa District, Ishikawa Pref.

Ueno Seijun
Osaka Institute of Technology
c/o Osaka Institute of Technology
5-16-1, Omiya, Asahi-ku, Osaka 535

Ugajin Hiroshi
Railway Labour Science Research
Institute, Japanese National
Railways
5-6, 2-chome, Izumi-cho,
Kokubunji-shi, Tokyo

Umemura Mamoru
11-15-301 Masago 1-chome Chiba City
Chiba Pref.

Une Shoji
Kinki University
1000 Hiro-machi Kure
Hiroshima Pref. 737-01

Uryuu Teruaki
Nippon Electric Company Ltd. CID
Office
33-1, Shiba Gochome, Minato-ku,
Tokyo 108

Ushioke Masaaki
Nihon University, College of
Industrial Technology
1-2-1 Izumi-cho, Narashino City
Chiba 275

Wada Kinichiro
Nippon Silhouette Co.,
Ogura Bldg., 6fl.
6-6 Nihonbashi Kofune-cho, Chuo-ku
Tokyo 103

Watanabe Akihiko
Division of Work Physiology
and Psychology
Institute for Science of Labour
1544 Sugao, Takatsu-ku
Kawasaki 213

Watanabe Akira
Faculty of Medicine, Univ. of
Tokyo
Hongo, Bunkyo-ku Tokyo 113

Watanabe Makoto
Chiba Institute of Technology
of Technology
2-17 Tsudanuma, Narashino-shi
Chiba Pref.

Watanabe Toshio
Nippon University
4-15-3, Soshigaya, Setagaya-ku
Tokyo

Watanabe Yasuo
IBM, Fujisawa Institute
1, Kirihara-cho, Fujisawa City
Kanagawa Pref. 252

Watanabe Yosaku
Dept. of Applied Physics
Toyota Technical College
2-1 Eisei-cho, Toyota City 471

Watanuki Shigeki
Dept. of Ergonomics
Kyushu Institute for Design
Research
226 Shiobaru, Minami-ku
Fukuoka Pref.

Yagi Akihiro
Industrial Products
Research Institute
1-1-4, Yatabemachi-Higashi
Tsukuba Science City Ibaraki Pref.
305

Yajima Kazuyoshi
Institute of Medical Electronics
Faculty of Medicine, University
of Tokyo
7-3-1 Hongo Bunkyo-ku Tokyo

Yamada Minoru
Japan Marine Science and
Technology Center
2-15, Natsushima-cho, Yokosuka City
Kanagawa Pref. 237

Yamaguchi Yoshiomi
Japan Institute of Human Posture
Research
Daichi Seimei Bldg.
1-9 Yuraku-cho, Chiyoda-ku, Tokyo

Yamamoto Sakae
Lab. of Ergonomics, Sangyo
University
1-1, Ishohgoka, Nishi-ku, Hachiman
Kita-Kyusyu City Fukuoka Pref.

Yamanoi Noboru
Institute of Medical Electronics
Faculty of Medicine, University of
Tokyo
7-3-1 Hongo Bunkyo-ku Tokyo

Yamasaki Kazuhiko
Dept. of Ergonomics,
Kyushu Institute
for Design Research
226 Shiobaru, Minami-ku,
Fukuoka Pref.

Yamasaki Masahiro
Dept. of Physiol., Inst.
of Constitutional Med. Kumamoto
Univ.
Kuhonji 4-24-1, Kumamoto City
Kumamoto 862

Yamashita Tadashi
Kyushu Institute of Technology
1-1 Sensui, Tobata, Kitakyushu 804

Yamashita Toshiyuki
Tokyo Metropolitan University
Faculty of Humanities
2-3-15-101 Yokodai, Isogo-ku
Kanagawa Pref. 235

Yamauchi Kazuyasu
Railway Labour Science Research
Institute,
Japanese National Railways
2-5-6 Izumi-cho, Kokubunji-shi
Tokyo

Yamazaki Nobutoshi
Faculty of Science and Technology
Keio University
Yokohama 223

Yanagishima Takayuki
Research Engineer
Vehicle Research Lab., Nissan Motor
Co., Ltd.
1 Natsushima-cho, Yokosuka City 237

Yanase Takuko
Faculty of Home Economics
Nara Womens' University
Kitauoya-nishimachi Nara Pref. 630

Yasukouchi Akira
National Institute of Industrial
Health
21-1, Nagao 6-chome, Tama-ku
Kawasaki 213

Yata Hideaki
Department of Physical Education
Wako University
2160 Kanai, Machida, Tokyo

Yatsu Yusuke
Aoyama-Gakuin University
Dept. of Science and Technology
6-16-1 Chitosedai, Setagaya-ku,
Tokyo 175

Yazawa Heihachiro
Laboratory of Work Physiology,
Railways Labour Science Research
Institute,
Japanese National Railways,
2-5-6 Izumi-cho Kokubunji City
Tokyo

Yokoi Kiyokazu
Japan Automobile Research
Institute Inc.
Yatabe-cho, Tsukuba-gun,
Ibaraki Pref.

Yokomizo Yoshimi
Dep. of Industrial Engineering
School of Science and Engineering
Waseda University
1-4-40, Miyamaedaira, Takatsu-ku
Kawasaki City, Kanagawa Pref. 213

Yokoyama Eisei
Nihon Univ. School of Med.
Dept of Public Health
30-1, Ohyaguch-Kamimachi,
Itabashi-ku, Tokyo 173

Yokoyama Shintaro
Industrial Health Research
Department of Sanitary Engineering
Hokkaido University, Sapporo 060

Yoneyama Shinzoh
Railway Labour Science Research
Institute JNR.
2-5-6 Izumi-cho, Kokubunji, Tokyo

Yonezawa Fujio
University of Osaka Prefecture
70-6, Nojiri-cho, Sakai City
Osaka Pref.

Yoshida Tatsuo
NHK Broadcasting Science Research
Labs.
10-11, Kinuta 1-chome, Setagaya-ku
Tokyo 157

Yoshida Masaaki
Chuo University
1-13-27, Kasuga Bunkyo-ku
Tokyo

Yoshida Masao
General Research Center for Rural
Life
19 Ichiba-cho, Chiyodaku, Tokyo

Yoshida Tatsuo
NHK Broadcasting Science Research
Labs.
10-11, Kinuta 1-chome, Setagaya-ku
Tokyo 157

Yoshida Yoshiyuki
Nihon Univ. College of Science
and Technology
24-1, 7-chome Narashinodai
Funabashi city, Chiba Pref. 274

Yoshimoto Kenichi
Tokyo University
7-3-1, Hongo, Bunkyo-ku, Tokyo

Yoshimura Isao
Kansai University
261, Hachijo-cho, Yamatokoriyama-shi,
Nara-ken 639-11

Yoshitsugu Kunio
Fukuoka Dental College
700 Ta Sawara-ku Fukuoka Pref.

Yoshizawa Makoto
Graduate School Student
Dept. of Electrical Eng.
Faculty of Engi., Tohoku University
Aramaki Aza Aoba, Sendai 980

Yurioka Yutaka
Electro Technical Laboratory
Osaka Branch
3-11-46, Nakoji, Amagasaki
Hyogo 661

Korea

Lee, Soon YO
Dept. of Industrial Engineering
College of Engineering
Korea University
1, 5-ka, Anam-Dong, Sungbuk-ku
Seoul, Korea

Malaysia

Cilingir, Canan F.
Fakulti Kejuruteraan Jentera
UTM, Jalan Gurney, Kuala Lumpur
Malaysia

The Netherlands

Boresema, Theo
Malakkastraat 134b
2585 SV Den Haag
Netherlands

Grinten, Maarten v.d.
Wassenaarseweg 56
2300 AC Leiden, P.O. Box 124
The Netherlands

Koningsveld, Ernst A.P.
Foundation Occupational Health and
Building and Construction Industry
P.O. Box 8114, 1005 AC Amsterdam
The Netherlands

Mulder, H.F.
Twente Technological University
Working Group Ergonomics
Albert Van Der Meerstraat 21
7555 Le Hengelo (0)
The Netherlands

Zwaga, Harm J.
University of Utrecht
2, Varkenmarkt, Utrecht
The Netherlands

Norway

Arrås, Arne
Finstad Kroken 12, 1475
Finstadgordet
Normay

Benjaminson, Tore
Tunmarcksv 13, 3600 Kongsberg
Norway

Haaland, Finn
Peder claussøns Gt. 3
Oslo 1, Norway

Haugan, Astrid E.
Pay & Brinch A/S, E
Engineering Division
Dyno Industrier, Boks 65,
Rislokk, Oslo 5, Norway

Roaldsnes, Jostein
1600 Fredrikstad
Norway

Sjøflot, Lars
Norwegian Institute of
Agricultural Engineering
Box 65, N-1432 ÅS-NLH.
Norway

Vokac, Zdenek
Institute of Work Physiology
P.O. Box 8149
Dept. Oslo 1
Norway

Poland

Cwirko, Halina
Department Medycyny Pracy
Miodowa 15
00-923 Warszawa
Poland

Rosner, Jan
02-536 Warszawa, UL. Narbutta 15
M.L., Poland

Rumania

Carapancea, Mihai Titus
21 Prof. I Bogdan St.
R-71149 Bucharest 22
Soc. Rep. of Rumania

Spain

Garcia, Luis Revillo
Cieloy Gonzalo N-036-7-D
Madrid, Spain

Ridruejo, Pedro
University Automa
Vegafria 1, Madrid 35
Spain

Sweden

Biarke, Inger
Karlav 3
S-11424 Stockholm
Sweden

Borg, Gunnar V.
PTI-unit, Dept. of Psychology
Box 5602, S-114 86 Stockholm
Sweden

Danell, Gosta
Sågstigen 7, S-18147
Lidingo, Sweden

Friedrich, Peter
National Board of Occupational
Safety and Health
S-17184 Solna
Sweden

Hagberg, Mats T.L.J.
National Board of Occupational
Safety and Health, Research Dept.
Medical Division, Box 6104,
S-900 06 Umea, Sweden

Holmér, Ingvar
National Board of Occupational Safety
and Health
Dept. of Work Physiology
S-171 84 Solna, Sweden

Jonsson, Bengt
National Board of Occupational
Safety and Health, Division of
Physiology
Box 6104, S-900 06 Umea
Sweden

Klasen, Hans K.R.
Safety Manager, Oxens Fhc
S-106 09 Stockholm
Sweden

Mikaelsson, Bo
Dept. of Social & Preventive
Medicine University Hospital
S-58185 Linköping, Sweden

Munters, Susanna
Ostermalms Företagshälsövård Central
Box 5605, S-11486 Stockholm
Sweden

Nilsson, Carina
Landorganisation 1 Sverige
S-10553 Stockholm
Sweden

Olsson, Göran
University of Luleå
S-951 87 Luleå
Sweden

Österman, Mary-Anne
3 Ergonomer AB, Hjärnegatan 3
S-11229 Stockholm
Sweden

Rehn, Magnus
Landorganisationen 1 Sverige
S-105 53 Stockholm
Sweden

Schröder, Curt
Lund University of Technology
Tunnbindaregatan 6, 223 36 Lund
Sweden

Winkel, Jørgen
University of Luleå, Dept. of Human
Work Sciences,
Work Physiology Division
S-951 87 Lulea, Sweden

Wirstand, Jan
Box 100 32, S-650 10 Karlstad
Sweden

Switzerland

Bräuninger, Ulrich
Swiss Federal Institute of Technology
CH-8092 Zurich
Switzerland

Gierer, Robert
Swiss Federal Institute of Technology
CH-8092 Zurich
Switzerland

Grandjean, Etienne
Swiss Federal Institute of Technology
ETH-Zentrum, Dept. Ergonomics
CH-8092 Zurich
Switzerland

Gyr, Stephan
Institute Fuer Hygiene &
Arbeitsphysiologie
8092, ETH-Zurich, Switzerland

Laubli, Thomas
Institut Für Hygiene Und
Arbeitsphysiologie
ETH-Zentrum, CH-8092 Zurich
Switzerland

Rey, Paule
Institute of Social and Preventive
Medicine
10 Rue Tules-Crosnier, Switzerland

Weber, Annetta
Federal Institute of Technology
CH-8092 Zurich, ETH-Zentrum
Switzerland

Thailand

Perera, S.E.G.
International Labour Organisation,
P.O. Box 1759, Bangkok, Thailand

U.K.

Bryett, H.E.
Redgarth
27 Woodside Road, Beaconsfield
Bucks. HP9 1JJ, U.K.

Corlett, E. Nigel
Dept. of Production Engineering
and Production Management
University of Nottingham
Nottingham NG7 2RD
England

Hamley, Ernest
Dept. of Human Sciences
University of Technology
Loughborough, Leics., LE11 3TU
England

Lewis, Stanley A.
Taylor & Francis Ltd.
4 John Street, London WC1N 2ET
U.K.

McEwan, John
ITT Europe
Great Eastern House, Edinburgh Way
Harlow, Essex. CM20 2BN
England

Megaw, Ted
University of Brimingham
P.O. Box 363
Birmingham B15 2TT
U.K.

Novak, Zdenek
P.O. Box 63 Westbury House
Bury St., Guildford GU2 5BH
Surrey, U.K.

U.S.A.

Ayoub, Mohammed M.
Dept. of Industrial Engineering
Texas Tech University
Lubbock, TX. 70409
U.S.A.

Bender, Henry E.
4 White Oak Tree Rd.
Laurel Hollow, N.Y. 11791
U.S.A.

Bergman, Michael H.
White Sand Misasile Range
P.O. Box 205
White Sand, New Mexico 88002
U.S.A.

Bliss, William D.
459 North Main Street
Oregon, Wisconsin, U.S.A.

Brown, Charles
64 JA/410 IBM
Neighbourhood Road
Kingston, N.Y. 12401
U.S.A.

Burch, John L.
Ergosyst Associates Inc.
P. O. Box 3708, Lawrence,
Kansas 66044
U.S.A.

Champney, Paul C.
Eastman Kodak Company
Kodak Park, Bldg. 69, 6th Floor
Rochester, New York 14650
U.S.A.

Chapanis, Alphonse
The Jhon Hopkins University
Suite 302, 7402 York Road
Baltimore, Maryland 21204
U.S.A.

Davis, Harry L.
83 New Wickham Dr.
Penfield, N.Y. 14626
U.S.A.

Didner, Rober S.
AT & T
1776 On The Green
Morristown, New Jersey 07960
U.S.A.

Harper, Howard P.
22 Chamberlin Dr.
Huntigton, CT. 06484
U.S.A.

Hendrick, Hendrik W.
849 Hahaione St.
Honolulu, Hawaii 96825
U.S.A.

Hopkins, Charles O.
Professor, University of Illinois
28 Foothill Road
Monticello, Illinois 61856
U.S.A.

Jex, Henry R.
1615 Georgina Ave.
Santa Monica, CA. 90402
U.S.A.

Kumar, Alok
Mech. & Aerospace Engineering
Univ. of Delaware,
New Ark, DE. 19711
U.S.A.

Lauber, J
3456 Bryant Street
Palo Alto CA. 94035
U.S.A.

Lippert, Stanley
9000 Wonderland Ave.
Los Angeles, CA.
U.S.A.

Martin, Patricia L.
IBM Corp., P.O. Box 12195,
Dept. G 92/B602
Research Triangle Park, NC. 27709
U.S.A.

Mehr, Morton H.
Measurement Systems, Inc.
121 Water St.
Norwalk, CT. 06854
U.S.A.

Mital, Anil
Dept. of Mechanical & Industrial
Engineering, ML #72
University of Cincinnati
Cincinnati, Ohio 45221
U.S.A.

Naitoh, Paul
Naval Health Research Center
P.O. Box 85122
San Diego, CA. 92152
U.S.A.

O'Hara, John J.
Office of Naval Research
Engineering Psychology Group
800 N. Quincy St.
Arlington, VA. 22217
U.S.A.

O'Neill, Noreen Elizabeth
4895 Lafayette St.
Santa Clara, CA. 95050

Parsons, H. McIlvaine
300 North Washington St.
Alexandria, VA. 22314
U.S.A.

Peacock, John Brian
School of Industrial Engineering
University of Oklahoma
Norman, OK. 73019
U.S.A.

Pearson, Richard G.
3305 Old Saybrook Court, Raleigh
N.C. 27612
U.S.A.

Ramsey, Jerry D.
Texas Tech University, P.O. Box 4609
Lubbock, TX. 79409
U.S.A.

Raheja, Dev G.
12904 Bentley Grove Place
Laurel, Maryland 20708
U.S.A.

Roemer, Joan M.
7360 Cascade Circle
Tucson, AZ. 85715
U.S.A.

Salvendy, Gavriel
School of Industrial Engineering
Purdue University
West Lafayette, IN. 47907
U.S.A.

Schneider, Michael
Sperry Univac, P.O. Box 500
Blue Bell, PA. 19424
U.S.A.

Smith, Donna L.
Human Factors Engineer, Sr.,
Lockheed Missiles & Space Co., Inc.
1111 Lockheed Way, ORGN 62-91,
Bldg. 538 Sunnyvale, CA. 94086
U.S.A.

Smith, Wanda Joyce
Hewlett Packard, Computer Groups
19447 Pruneridge Ave.
Cupertino, CA. 95014
U.S.A.

Smolensky, Michael H.
University of Texas Health
Science Center P.O. Box 20186
Houston, TX. 77025
U.S.A.

Snyer, Harry
IEOR Dept. VPI & SU
130 Whittemore Hall
Blacksburg, VA. 24061
U.S.A.

Swain, Alan D.
Division 7723, Sandia National
Laboratories, Albuquerque,
NM 87185, U.S.A.

Thompson, Daid
IEEM, Terman Center
Stanford, CA. 94305
U.S.A.

Williges, Barbara
130 Whittemore Hall, VPI & SU
Blacksburg, VA. 24061
U.S.A.

Williges, Robert Carl
130 Whittemore Hall, VPI & SU
Blacksburg, VA. 24061
U.S.A.

WU, R. M.
64JA/410 IBM
Heighborhood Road
Kingston, N.Y. 12401
U.S.A.

Yugoslavia
Parezānin, Vidomir Jovan
27, Mart 80/419
Masinski Fakultet-Katedra Za
Organizaciju Rada 11000 Beograd
Yugoslavia

Vuksan, Bulat Peter
27, Mart 80/19
Masinski Fakultet-Katedra Za
Organizaciju Rada 11000 Beograd
Yugoslavia

[Faint, mostly illegible text, likely bleed-through from the reverse side of the page]

[Faint, mostly illegible text, likely bleed-through from the reverse side of the page]

IEA'82 TOKYO

August 23—27, 1982

IEA'82



PROGRAM

THE 8TH CONGRESS OF
THE INTERNATIONAL ERGONOMICS ASSOCIATION

CONTENTS

ORGANIZATION	2
GENERAL INFORMATION	4
INFORMATION ON SCIENTIFIC PROGRAM	6
WELCOME RECEPTION	7
OPENING CEREMONY	7
SPECIAL LECTURES	8
SYMPOSIUM	9
WORKSHOPS	9
TECHNICAL SESSIONS	14
FAREWELL PARTY	38
CLOSING CEREMONY	38
LADIES' PROGRAM	38
TECHNICAL SITE VISITS	39
EXHIBITION	42
LACATION MAP	43
FLOOR ARRANGEMENT	44
PROGRAM SCHEDULE	45

This international congress was executed with the assistance of a grant from the Commemorative Association for the Japan World Exposition.

IEA '82 ORGANIZATION

Sponsor

- International Ergonomics Association (IEA)

Host

- Japan Ergonomics Research Society
- Research Foundation of Traffic Medicine

Support

- | | |
|--|--|
| <ul style="list-style-type: none"> •Ministry of Education, Japan •Ministry of Health and Welfare, Japan •Ministry of International Trade and Industry, Japan •Ministry of Labor, Japan •Ministry of Transport, Japan •Science Council of Japan •Anthropological Society of Nippon •Architectural Institute of Japan •Biophysical Society of Japan •Information Processing Society of Japan •Institute of Electronics and Communication Engineers of Japan •Institute of Television Engineers of Japan •Japan Association of Industrial Health •Japan Industrial Designers' Associations •Japan Industrial Management Association •Japan Society Electroencephalography and Electromyography •Japan Society for Aeronautical and Space Science •Japan Society for Artificial Organs and Tissues •Japan Society of Aerospace and Environmental Medicine •Japan Society of Automated Multiphasic Health Testing and Service | <ul style="list-style-type: none"> •Japan society of Mechanical Engineers •Japan Society of Medical Electronics and Biological Engineering •Japan Society of Plastic and Reconstructive Surgery •Japan Society of Ultra Sonics in Medicine •Japanese Association of Anatomists •Japanese Association of Rehabilitation Medicine •Japanese Association of Rural Medicine •Japanese Association of Transportation Medicine •Japanese Counsel of Traffic Science •Japanese Psychological Association •Japanese Society for Hygiene •Japanese Society for Science of Design •Japanese Society of Physical Fitness and Sports Medicine •Japanese Society of Public Health •Japanese Society on Hospital Administration •Medical Instrument Society of Japan •Operations Research Society of Japan •Physiological Society of Japan •Society of Industrial and Control Engineers |
|--|--|

ORGANIZING COMMITTEE

International Ergonomics Association

- President: Jan Rosner (Poland)
Secretary General: Harry L. Davis (U.S.A.)
Treasurer: Herbert Scholz (F.R.G.)

Advisory Board

(International)

- Harry L. Davis (U.S.A.)
Etienne Grandjean (Switzerland)
Brian Shackel (U.K.)

(Japan)

- Shizuo Asada
Kenji Ekuan
Junnosuke Kishida
Sakyo Komatsu
Naoki Toida
Eiji Toyota

Fund Committee

- Advisor: Shizuo Asada
Chairman: Kentaro Takagi
Masakatsu Fujinawa
Seitoku Hamada
Hideo Itokawa
Hajime Karatsu
Kunitomo Kawaguchi
Seiji Kaya
Hidemasa Kimura
Sakyo Komatsu
Shigetaka Kubota
Noboru Makino
Kenya Murano
Reiji Natori
Kenzaburo Tsuchiya
Kiichi Tsuchiya
Hajime Saito

Japanese Organizing Committee

- Chairman: Masamitsu Oshima
Vice-Chairman: The Late
Kunie Hashimoto
Secretary General: Toshiyuki Furukawa
General Affairs: Shingo Ogawa
Treasurer: Toshio Endo
Foreign Affairs: Hidemaro Nagano
Sadao Sugiyama
Scientific Liaison: Yuji Iiyama
Convention: Takao Ohkubo
Program: Akira Watanabe
Kazuyoshi Yajima
Registration: Kazuo Aoki
Proceedings: Kageyu Noro
Social Events: Kiyoshi Yamamoto
Kazuo Tsuchiya
Exhibition: Kiyoji Asai
Kazuhiko Atsumi
Sumiji Fujii
Yoshio Hayashi
Yujiro Hayashi
Masakazu Iguchi
Ichiro Kato
Haruo Kondo
Takeshi Kondo
Shigetaka Kubota
Isao Kuroda
Kinuya Maruyama
The late Mitsuo Morioka
Hiroshi Motoaki
Jinichi Nagumo
Kiho Nakao
Shinhachi Nishikawa
Masahiko Ohira
Masashi Okawa
Jun Osaki
Takeshi Ota
Hajime Saito
Hiroyuki Sakabe
Masahiko Sato
Eimatsu Takakuwa
Susumu Tsukahara
Genichi Watanabe
Sakae Yokobori
Yoshimi Yokomizo
Masaaki Yoshida

GENERAL INFORMATION

Registration

Registration is required of all participants including Accompanying persons. Registration desks are located on the Entrance of Nihon Toshi Center. Preregistrants are requested to present their registration cards. Registrants at site have to pay the registration fee, ¥55,000 in Japanese Yen. All registrants can receive name card and congress bag which contains the final program, Proceedings and other materials. Accompanying Persons registered can receive ladies program tickets.

Registration desks will be open during the following periods:

August	23 (Mon.)	13:00	17:30
	24 (Tues.)	08:30	17:30
	25 (Wed.)	08:30	16:00
	26 (Thur.)	08:30	13:00
	27 (Fri.)	08:30	12:00

Name Cards

Different colors of name cards are used as follows:

Orange	Invited Persons
Red	Chairman, Co-chairman
Green	Committee Members
Blue	General Participants
Pink	Accompany Persons
Brown	Secretarial Staff Members (including Press)

All participants must put on their name cards to obtain admission to all events during the Congress.

General Information Desk

The information desk, located on the 1st floor, will be open during the Congress. Since the information desk is the clearing point for general inquiries, and gives advice on shopping, etc., all participants feel free to make use of the service.

Travel Information Desk

The travel desk of Japan Travel Bureau (JTB), our official travel agent, will be open during the Congress. They receive the bookings of excursion, reconfirmation of your flight and other travel arrangements.

Bulletin Board

A bulletin board is installed near the General Information Desk. Message exchange between participants and information on the Congress can be posted on the bulletin board.

Hotels

Main hotels for IEA '82 are following:

Hotel New Otani	Phone 265-1111
Akasaka Tokyu Hotel	580-2311
Ginza Capital Hotel	543-8211

When you call from other area than Tokyo, dial 03 before the above number.

Secretariat of the Congress

Room No. 8 (1st floor of Nihon Toshi Center)
Open: 08:30 — 18:00 Phone 265-8211 ext. 130

Secretariat: IEA '82 Tokyo
c/o Inter Group Corp.
Akasaka Yamakatsu Bldg.
8-5-32, Akasaka, Minato-ku
Tokyo 107, Japan
Phone (03) 479-5318
Cable Address: INTERCONFER TOKYO

INFORMATION ON SCIENTIFIC PROGRAM

Official Languages

The official languages of the congress are English and Japanese. Simultaneous interpretation from Japanese to English, and vice versa is available in Workshops, Special Lectures, Symposium and Technical Sessions for all participants.

Time allotted to Paper Presentation

10 min. or 7 min. is allotted to one presentation plus Q & A period. All the speakers are strongly requested to be punctual in presenting their papers. A buzzer will ring **once** two minutes before the end of the allotted time, and **twice** when the time is over.

Slides

All the slides will be restricted to 35mm in size. The speakers who use slides are requested to hand the slides to a slide receptionist at the entrance of each room **45 minutes** before the presentation begins. When the presentation is over, they should receive the used slides from the slide receptionist at an earliest opportunity. In addition to a slide projector, 16mm film projector is also available in each session room.

Cancellation of Papers and Change in Speakers

Those who wish to cancel their papers or change speakers are requested to get in touch with a **slide receptionist** at the entrance of the presentation room at an earliest opportunity.

Next Speaker's Seat

A next speaker's seat is found at the front row. All the speakers are requested to take "next speaker's seat" as soon as the preceding presentation begins.

Session Secretary

A session secretary is assigned to each Technical Session and Workshop. He or she will help speakers in presentation if necessary.

WELCOME RECEPTION

August 23 (Mon.) 18:30 — 21:00

Nihon Toshi Center "Banquet Hall"

All participants including Accompanying persons are welcomed to enjoy drink and meals

OPENING CEREMONY

August 24 (Tues.) 9:00 — 10:00

Nihon Toshi Center "Hall A" (2F)

8:45

— Music —

9:00

Declaration of Opening

Toshiyuki Furukawa

Secretary General

Organizing Committee

Opening Address

Masamitsu Oshima

Chairman

Organizing Committee

Presidential Address

Jan Rosner

President

International Ergonomics Association

Address

Japanese Guests

Awards and Address

Master of Ceremony

Harry L. Davis

Secretary General

International Ergonomics Association

Alphonse Chapanis

Professor

The Johns Hopkins University

Etienne Grandjean

Professor

Swiss Federal Institute of Technology

10:00

— Intermission —

(Special Lectures follow)

ROGI
8:30

SPECIAL LECTURES

August 24 (Tuesday)

10:30 — 12:00

Room: Hall A

Special Lecture 1

Chairman: Y. Hayashi (Japan)

Modeling of Response to Nuclear Power Plant Transients for Probabilistic Risk Assessment
Alan D. Swain (Sandia National Laboratories, U.S.A.)

Special Lecture 2

Chairman: E. Takakuwa (Japan)

Ergonomics in Japan
Masamitsu Oshima (Medical Information System Development Center, Japan)

August 25 (Wednesday)

15:00 — 15:50

Room: Hall A

Special Lecture 3

Chairman: M. Oshima (Japan)

Human-Computer Communication with Special Reference to Technological Developments.
Occupational Stress and Educational Needs
Gavriel Salvendy (Purdue University, U.S.A.)

SYMPOSIUM

August 27 (Friday)

13:00 — 15:00

Room: Hall B

Past, Present & Future of Ergonomics

Chairman: M. Oshima (Japan)

Co-Chairman: A. Watanabe (Japan)

1.
E. Grandjean (Switzerland)
2.
A. Chapanis (U.S.A.)
3. Criteria for the Choice of Topics of Ergonomic Research
J. Rosner (Poland)
4. Ergonomics in Developing Countries
A. Wisner, S. Dogmo, L.L. Ferreira, C. Rubio, N. Sahbi (France)

WORKSHOPS

August 24 (Tuesday)

13:00 — 15:15

Room: Hall A

Workshop I: Safety

Chairman: B.K. Huang (U.S.A.)

Co-Chairman: Y. Hayashi (Japan)

1. Ergonomics of Safety
V. de Keyser (Belgium)
2. One Method for Evaluating Safety Performance in Working Places
S. Hanayasu (Japan)

3. Influences of Thermal Environment of Safety Behavior
J.D. Ramsey, C.L. Burford, M.Y. Beshir, R.C. Jensen (U.S.A.)
4. Prevention of Occupational Injuries in Greenhouses
B. Gustafsson P. Lunoqvist (Sweden)
5. Computer Methods in Safety Design with Roadway-Vehicle-Object-Environment Simulation
B.K. Huang (U.S.A.)
6. Multivariate Safety Assessment of Level Crossings with Automatic Full or Half Barriers
T. Ikeda, H. Ohtake (Japan)
7. Human Factors in Ship Collision in Narrow Waters
N. Ohashi (Japan)
8. Safety of Work on Small Fishing Boats Operated by One-Man
A. Hattori, N. Ohashi (Japan)
9. Life Stress and Occupational Injuries
D. Gloss (U.S.A.)

August 24 (Tuesday)

15:15 — 17:30

Room: Hall A

Workshop II: Human Error

Chairman: A. Swain (U.S.A.)
Co-Chairman: K. Asai (Japan)

1. Reliability of Human Operators in Man-Machine Systems
M. Iguchi, H. Hara (Japan)
2. A Basic Study of the Prediction Method for Clerical Errors Based on Pulse-Speed Variability
E. Koyano (Japan)
3. Fuzzy Fault Tree Analysis for Accident Caused by Human Errors
K. Noma, H. Tanaka, K. Asai (Japan)
4. Alpha Wave and Miss of Signal Detection
H. Kodama (Japan)
5. An Experimental Study on Human Behavior under the Sudden Hazardous Situation
W. Masada (Japan)
6. A Comprehensive Long-Range Human Factors Plan for Nuclear Power in the United States
C.H. Hopkins (U.S.A.)
7. Analytical Procedures on Causes of Human Errors in Plant Accidents
K. Hashimoto, M. Morioka, T. Endo, M. Aoki (Japan)
8. A Case Study on a Plant Factory from the Human Factors Point of View
K. Hashimoto, M. Morioka, T. Endo, M. Aoki (Japan)

9. Hazard Analysis in the Japanese Chemical Industrial Complexes Especially on the Human Errors
Y. Hayashi (Japan)
10. A Study of Human-Error Causing by Drug Naming
F. Tsuchiya, I. Tsuchiya (Japan)

August 25 (Wednesday)

9:00 — 10:40

Room: Hall A

Workshop III: Productivity I—Automation & Robotization

Chairman: T. Houghton (U.S.A.)
Co-Chairman: I. Kato (Japan)

1. The Designing of Man-Machine Systems from Human Role Consideration in Modernized Industrial Systems
Y. Iiyama, K. Yamauchi (Japan)
2. Ergonomics for Pure Efficiency or for Humanization?
G. Olsson (Sweden)
3. Operator Response to Problems in Process Control Systems
K.M. Mallory D. Benel, D. Mccafferty (U.S.A.)
4. Harmonizing Human Operator and Computer Responsibilities in Complex Industrial Processes
P.J. Larriere, J. Le Quere, A. Quarin (France)
5. Japanese Robotization and Human Factors Researches
Y. Okada, I. Kato, K. Noro (Japan)

August 25 (Wednesday)

10:40 — 12:20

Room: Hall A

Workshop IV: VDU & Operator

Chairman: R.C. Williges (U.S.A.)
Co-Chairman: K. Tsuchiya (Japan)

1. Design of Human-Computer Dialogues
R.C. Williges (U.S.A.)
2. An Ergonomic Study of Conversational Work with VDUs
S. Yamamoto, M. Yoshioka, K. Noro, A. Komatsubara, Y. Hayashi (Japan)

3. The Influence of Visual Wrokload History on Visual Monitoring Performance
M. L. Matthews (Canada)
4. Study on the Evolution of Information Management
B. Francesco (Italy)
5. Selecting a Color Monitor for an Interactive Graphics System Used to Design Integrated Circuits
A.D. Lecocq (U.S.A.)
6. Research and Development of Airborne Integrated Display for NAL QSTOL
M. Okabe, K. Tanaka, H. Kawahara, N. Isu (Japan)
7. Some Health Hazards Associated with Work (or Text) Processing and Data-Terminal Equipment. How to Avoid Them.
A.E. Haugan (Norway)

August 26 (Thursday)

9:00 — 12:10

Room: Hall A

Workshop V: Productivity II — Humanization & Workplace

Chairman: H. Strasser (F.R.G.)
Co-Chairman: K. Noro (Japan)

1. Development of Ergonomic Methods for Productivity Improvement
K. Noro (Japan)
2. Human Interface Analysis to Assure Improved Product Performance
D. Raheja, M. Arjunan (U.S.A)
3. A Critical Analysis of Techniques of Evaluation of Working Conditions and a Proposal for a Methodological Approach
E. Richard (France)
4. Experiments in the Organization of Work in Germany — A Survey of Major Tendencies, Results, and Problems
H. Pornschlegel (F.R.G.)
5. A Study of Changes in Work Environment Conditions and Psycho-Social Work Problems
C. Nilsson (Sweden)
6. Ergonomic Work Load Problems among Members of the Swedish Trade Union Confederation - LO
M. Rehn (Sweden)
7. Rhythmical Work in Production Lines and Humanization of Work
V. Bulat, J. Danon, D.Z. Marković V. Parezanin, R. Parezanin (Yugoslavia)
8. Organizational and Technological Aspects of the Operation of Production Lines in Yugoslavia
V. Parezanin, R. Parezanin (Yugoslavia)
9. Checkout Systems in Self Service Shops - Standardiazation and Real Working Conditions
H. Strasser, W. Müller-Limmroth (F.R.G.)

10. Analysis of Film Copy Workplaces to Improve Job Design, Environmental and Ergonomics Conditions
H. Strasser (F.R.G.)
11. Ergonomic Workstation Design for Supermarket Scanning Systems
P.L. Martin (U.S.A.)
12. Ergonomic Design of Press Work Places-Analysis of Strain and Stress Situation
H.J. Bullinger, P. Kern, D. Lorenz (F.R.G.)
13. The Apparel Workplace: An Ergonomic Case Study
L. Middendorf (U.S.A.)
14. Task Allocation Based on Human Needs as Tool in the Humanization of Wrok Systems
F. Mulder (The Netherlands)

August 27 (Friday)

9:00 — 11:10

Room: Hall A

Workshop VI: The Aged & Handicapped

Chairman: B. Williges (U.S.A.)
Co-Chairman: K. Tsuchiya (Japan)

1. Measurement of the Older Worker's Capability
Y. Yokomizo (Japan)
2. A Study of Procedure of Job-Redesign for older Workers
M. Nagamachi, K. Ito, S. Une (Japan)
3. Development of Sensor Pegboard for Performance Test
Y. Okada, K. Noro (Japan)
4. Work Load of Disabled People at a Small Factory
T. Hasegawa, K. Noro (Japan)
5. Ergonomics for the mentally Handicapped-Motion Study
E. Kapecka, T. Marek (Poland)
6. A Study of Handwork of the Mentally Handicapped
A. Tanaka, N. Ando, K. Fukada, K. Hanaoka (Japan)
7. About the Weight Ratio of a Prosthetic Arm to an Amputated Arm Segment
N. Ohnishi, K. Tsuchiya (Japan)
8. An Evaluation of Correlation between Amputated Limb and It's Dominancy Using Dummy Prostheses
T. Aoyama, Y. Saito, H. Kasahara, T. Yamashita, K. Koyama, K. Tsuchiya (Japan)
9. The Effect of Foot-Sole Pressure Sensory Feedback on the Activity of the Lower Limb Amputee
S. Morimoto, K. Tsuchiya, Y. Saito (Japan)
10. Development of Transfer System for the Severely Handicapped
K. Ichikawa, I. Yoneda, M. Suzuki, I. Hirose, K. Ise, T. Hayashi (Japan)

TECHINICAL SESSIONS

August 24 (Tuesday)

13:00 ~ 14:40

Room: Hall B

Session 1: Work Load: General

Chairman: H. Bubb (F.R.G.)
Co-Chairman: K. Saito (Japan)

1. The Development of Ergonomic Solution Proposals by the Analysis of Task
H. Bubb (F.R.G.)
2. Characteristics of Office Works
A. Komatsubara, Y. Yokomizo (Japan)
3. Synthetic Stress-Profiles
B.H. Müller (F.R.G.)
4. A Contribution to Methodology for the Evaluation of a Welder's Work-Load
N. Dazard, E. Richard, J.-L. Flores (France)
5. Cumulative Fatigue Symptoms and Conditions of Work
R. Kosugo (Japan)
6. Information Load and Its Norming
A. Honkasalo, H. Kautto (Finland)
7. Recovery Allowance Calculated by Assessment of Recovery rather than by the Preceding Amount of Effort
E.J. Hamley (U.K.)

August 24 (Tuesday)

14:40 ~ 17:30

Room: Hall B

Session 2: Work Load: Industrial Applications

Chairman: G. Schäcke (F.R.G.)
Co-Chairman: Y. Yokomizo (Japan)

1. On Work Study and Work Load of the Computer Operator
M. Umemura (Japan)
2. Eyestrain and Muscle Fatigue of Data Entry Operators Using Visual Display Terminals
N. Onishi, T. Kuroe (Japan)

3. Constrained Postures at VDTs
W. Huenting, T. Laeubli, E. Grandjean (Switzerland)
4. Trade Studies of Occupational Environments — An Analysis Based on a Survey of the Electrician Profession
C. Schröder (Sweden)
5. Fatigue and Health Problems of Workers in a Home for Mentally and Physically Handicapped Persons
Y. Ono, K. Masuda, M. Iwata, N. Hisanaga, Y. Takeuchi (Japan)
6. Comparative Analysis of Shoulder Muscle Load in Different Jobs
B. Jonsson (Sweden)
7. The Effects of Ergonomic Measures on the Health of the Neck and Upper Extremities of Assembly-Line Packers—A Four Year Follow-Up Study
T. Luopajarvi, I. Kuorinka, R. Kukkonen (Finland)
8. Tendonitis Control Program for the Apparel Industry
M.A. Ayoub (U.S.A.)
9. Influence of Mechanico-Assisted Blowing on the Fine-Myokinesis of the Forearms on Glass-Blowers
G. Schäcke, A. Fuchs, A.V. Laer, P. Mayer (F.R.G.)
10. Assessment of Mental and Physical Work Load for Some Agricultural Tasks
C. Cilingir (Turkey)
11. Physical Strain in Delivery of Dairy Products
J. Ilmarinen, C.H. Nygård (Finland)
12. Stress and Strain in Cleaners' Work
V. Louhevaara, J. Ilmarinen, C.H. Nygård, I. Pesonen (Finland)
13. Results of Field Studies Concerning Stress and Strain at Different Blast Furnaces
H. Peters (F.R.G.)
14. Speed Skill in Short-Cycle Repetitive Work
A. Khaleque (Bangladesh)

August 24 (Tuesday)

13:00 ~ 15:00

Room: Hall C

Session 3: Systems Design I — Keyboard & Others

Chairman: G.F. Rabideau (Canada)
Co-Chairman: Y. Uchimura (Japan)

1. Ergonomic Development of a New Keyboard Design
M. Nakaseko, W. Huenting, R. Gierer, E. Grandjean (Switzerland)
2. Inter-Key Time and Digit Keying Sequences of 10-key Numeric Touch-Keying Operators
G.F. Rabideau, R.P. Lee, P.G. McGuire (Canada)

3. Link Analysis of Electrocardiograph Manipulation and Application for Design of Electrocardiograph
N. Yamanoi, K. Yajima, T. Aoki, K. Aoki, S. Kinoshita, H. Tanaka, T. Furukawa (Japan)
4. An Educational Equipment for Learners of Keyboard Music and Consideration on the Characteristic of the Playing
I. Kitagaki, K. Suetake (Japan)
5. Application of the Plane Switch Using a Pressure-Conductive Rubber Sheet to a Control Manipulator
Y. Ikeda, H. Takeda, S. Hata (Japan)
6. Measurement of the Ticket-Selling Worksite According to Comfort Experiments
M. Launis (Finland)
7. The Influence of Camera Logic on Camera Ergonomics
H.L. Davis, R.L. Lucas (U.S.A.)
8. Problems About Diver's Watch
M. Yamada, H. Yamagata (Japan)
9. Evaluation of Tactual Sense for Fitting of Plastic Parts
T. Kamoshita, H. Yano (Japan)

August 24 (Tuesday)

15:00 ~ 17:10

Room: Hall C

Session 4: Circadian Rhythm & Shift Work

Chairman: R.N. Sen (India)
Co-Chairman: K. Kogi (Japan)

1. Chronopsychological Approach to Human Factors
P. Naitoh (U.S.A.)
2. Psychophysiological Effects of Shift Work in a Small-Medium Sized Factory
M. Kumashiro, K. Mikami, K. Saito (Japan)
3. A Case Study on Work Burden of Shift-Workers
T. Ohkubo, Y. Horie (Japan)
4. Energy Expenditure and Energy Intake in Selected Groups of Shiftworker
W. Wirths (F.R.G.)
5. Diurnal Variations of Reaction Time Performance in the Mentally Retarded Children
K. Kusano (Japan)
6. Critical Flicker Fusion and Grammatical Reasoning in the Evaluation of Shift Schedules
B. Peacock, R. Schlegel, R. Glube (U.S.A.)
7. Changes in the Subjective Fatigue Scale Characteristic to the Post-Nightshift Period
K. Kogi (Japan)
8. Interindividual Differences in Sleep-Waking Habits of Students and Workers Samples
L. Mecacci, A. Zani (Italy)

9. Apparant and True Phase-Shifts of Circadian Rhythms after a Transmeridian Flight and during Night Shift
Z. Vokac, E. Jebens, M. Vokac (Norway)
10. Human Reliability in Process Control with Shift Work
G. de Terssac, Y. Queinnec (France)
11. Time of Day Effect on Human Performance in Combined Manual and Decision Task
A. Raouf, T.K. Joseph (Canada)

August 24 (Tuesday)

13:00 ~ 15:50

Room: Hall D

Session 5: Anthropometry & Clothing

Chairman: A. Wisner (France)
Co-Chairman: K. Yanagisawa (Japan)

1. Problems in Determing Anthropometric Standards for Persons
D. Gloss (U.S.A.)
2. Measurement of Human Body Form Using Pattern Processing Techniques
N. Ito, T. Kurokawa, A. Shinozaki, H. Nakano (Japan)
3. A Longitudinal Study on Physical Growth at Adolescence
Y. Furumatsu, H. Muto, S. Sato, E. Furumatsu (Japan)
4. Two Dimensional Fourier Analysis of Human Torso Surface
T. Furukawa, N. Yamanoi, H. Tanaka, K. Yajima, T. Aoki, K. Aoki (Japan)
5. A Study of the Anthropometric Differences of the Lodotic Curvature in Adult Men and Women
N.E. O'Neill (U.S.A.)
6. Head Dimension Measurement for Telephone Handset Design
H. Matsul (Japan)
7. Anthropometry in Relation to Ergonomics of Walking for Work Study Application in Indian Agricultural Workers
R.N. Sen (India)
8. Morphological Theorization for Garment Modeling
S. Nakazawa (Japan)
9. Physiological Evaluation of Clothing Heat Transfer
I. Holmér (Sweden)
10. Body Temperature Measurement for Appropriate Clothing by Means of Internal Temperature Measurement Device
S. Nagashio (Japan)
11. The Protective Characteristics of Clothings for Protection against Heat and Fire
Y. Kawashima (Japan)

12. Thermal Effects and Finger Strength Changes in Cold-Water Immersion with a Survival Suit
K. Kimotsuki (Japan)
13. Evaluation of Shoe-Fitting
N. Yamazaki (Japan)
14. On Mannequins Especially Made for 19th Century Costumes
C. Tamagawa (Japan)

August 24 (Tuesday)

15:50 ~ 17:50

Room: Hall D

Session 6: Motion & Gait

Chairman: W. Rohmert (F.R.G.)
Co-Chairman: S. Nishikawa (Japan)

1. On the Control of Voluntary Arm Movements
T. Kurokawa, K. Mishima (Japan)
2. Effect of Two Handed Asymmetrical Simultaneous Motions and Task Difficulty on Performance Time and Heart Rate Variability
A. Raouf, K. Tsuchiya (Canada)
3. A Study on a Manner of Holding Ball-Point Pen to Write Legible Characters
Y. Ishida (Japan)
4. Mechanism of Microvibration and the Application to Fatigue in Works of Lifting of Weight and Typewriting
T. Usui, K. Sakamoto, K. Seki, A. Iwasaki (Japan)
5. The Application of the Three Dimensional Measurement to the Motion Analysis
Y. Suzuki (Japan)
6. Kinematic Analysis of Three-Dimensional Motion in Loading Operations
K. Iwata, T. Moriwaki, T. Kawano (Japan)
7. Force Sensor Using Carbon Fiber and Its Application to Foot-Force Measuring System for the Gait Analysis
K. Katahira, S. Saito, S. Tsukahara (Japan)
8. Desktop Computer-Aided Analysis of Dynamics in Human Standing and Walking
T. Yamashita, T. Taniguchi, M. Andoh (Japan)
9. Finite State Measurement System of the Human Gait
A. Kato, K. Ito, K. Tsuchiya (Japan)
10. Characteristics of Spectral Analysis of Step Lengths on Treadmill Walking
M. Yamasaki, T. Sasaki (Japan)
11. A Study on Walking Width, Time and Speed in Manual Load Carrying
Y. Oguro (Japan)

August 24 (Tuesday)

13:00 ~ 14:10

Room: Hall E

Session 7: Quality of Working Life

Chairman: P. Rey (Switzerland)
Co-Chairman: T. Ohkubo (Japan)

1. Factors in Quality of Working Life: Two Case-Studies
S. Bagnara, R. Misiti, D. Mazzonis, M. Rollier (Italy)
2. Complex Work Organization Change Involving Ergonomics and Socio-Technical Approach to Improve the Quality of Working Life
S. Micheli (Italy)
3. Work and Health of Working-Class Women in Finland
M.L. Honkasalo, I. Kandolin (Finland)
4. A Study on the Difference of Work Feelings of Both Japanese and Chinese Female Workers Engaged in Light Repetitive Work
T. Ohkubo, M. Aoki, Y. Horie (Japan)
5. A Study on the Motivation of a Manager by Canonical Correlation Analysis
S.Y. Lee (Korea)

August 24 (Tuesday)

14:10 ~ 16:10

Room: Hall E

Session 8: Environment: Noise & Vibration

Chairman: E. Grandjean (Switzerland)
Co-Chairman: O. Kitamura (Japan)

1. Noise Immissions from Industrial Plants and Annoyance in the Neighbourhood
S. Gyr, E. Grandjean (Switzerland)
2. Tentative Evaluations of Oscillating Sounds Based on Loudness Measures
P. Schaefer (F.R.G.)
3. Individual Protection against Noise
J. Ducrocq (France)
4. The Influence of Environmental Noise on Performance of Repetitive Task
K. Takata, H. Kakeno, Y. Watanabe, S. Takeuchi (Japan)
5. Studies on the Influence of Infrasound to the Human Body—Physiological Effects of Long Term Exposure to Infrasound by Case of the Rabbits
N. Machida, Y. Yoshida, H. Itow (Japan)

6. Human Response to Infrasound below Hearing Threshold
O. Okai (Japan)
7. Studies on the Influence of Low Frequency Vibration to the Human Body—Vertical Vibration —
Y. Yoshida, N. Machida, R. Miki (Japan)
8. TTS of Vibratory Sensation Induced by Exposure to Intermittent Vibration
Y. Fukuchi, S. Watanabe (Japan)
9. Vibration Absorbing Handle
K.T. Hogskolan (Sweden)

August 24 (Tuesday)

16:10 ~ 17:40

Room: Hall E

Session 9: Environment: Under Water & Space

Chairman: J. Lauber (U.S.A.)
Co-Chairman: G. Matsuda (Japan)

1. The Influence of Hyperbaric Environment on Fatigue in Human Deep Dive
Y. Taya, N. Kuwabara (Japan)
2. The Influence of Hyperbaric Environment (11-31ATA, He-O₂) on Disturbed Human Sleep
K. Seki (Japan)
3. Convective Heat Transfer Coefficient of the Human Body in Hyperbaric Helium-Oxygen Mixed Gas Environment
H. Nakayama, N. Kakitsuba (Japan)
4. Telecontrol of Breathing Apparatus in a Lock Out
Y. Le Masson (France)
5. Heat Protection in Respiratory Channels
Y. Le Masson (France)
6. Head Protection and Total Vision in Underwater Diving
Y. Le Masson (France)
7. Dynamic of Physical Fitness and Orthostatic Tolerability during Hypodynamics Exposure
H. Saiki, M. Nakaya, M. Sudo, M. Abe, M. Kohno, K. Shioda (Japan)
8. Quantitative Behaviour of Intraocular Ascorbic Acid upon Hypermetropic Amplitude in Overstraining of Fictitious High Altitude
M. Carapancea (Rumania)

August 25 (Wednesday)

9:00 ~ 11:00

Room: Hall B

Session 10: Work Load: Muscle Activity

Chairman: J. Ilmarinen (Finland)
Co-Chairman: H. Matsui (Japan)

1. Assessment of Physiological Cost in Dynamic Muscular Work by Oxygen Cost and Cardiac Cost
H. Sato (Japan)
2. The Effect of Arm Elevation on Muscle Circulation
H. Yata, T. Fukunaga, A. Matsuo (Japan)
3. Several Aspects of the Prediction Method of Local Muscle Energy Metabolic Rate
S. Yokoyama, K. Yoshida (Japan)
4. Evaluation of Local Muscle Fatigue in Dynamic Muscular Work by Test Contraction
S. Kira, K. Yamasaki, H. Sato (Japan)
5. Critical Power as a Measure of Muscular Fatigue and Anaerobic Threshold
A. Nagata, M. Muro, T. Moritani (Japan)
6. What Do We Neglect when Evaluating Muscle Fatigue?
G. G. Gantchev (Sweden)
7. Occupational Muscular Strain Indicated by Serum Creatine Kinase
M. Hagberg (Sweden)
8. Creatinine Excretion under Hyporinesia Physical Exercise
Y. Zorbas, V. Petrovskiy (Greece)
9. Pulling and Pushing Forces as a Function of Elbow Flexion
Y.T. Ikeda (Japan)

August 25 (Wednesday)

11:00 ~ 12:15

Room: Hall B

Session 11: Work Load: Physical

Chairman: G. Borg (Sweden)
Co-Chairman: T. Endo (Japan)

1. Psychophysiological Studies of Physical Performance
G. Borg (Sweden)
2. A Study on Seasonal Variations of Circulatory and Metabolic Responses during Prolonged Exercise
A. Okada, T. Katsuura, T. Azuma, Y. Kikuchi (Japan)

3. Effects of Specific Dynamic Action on the Metabolism at Rest
K. Yamasaki, S. Watanuki, S. Kira (Japan)
4. The Effect of Body Postural Change on Anaerobic Threshold
T. Fukunaga, H. Yata, S. Ikegawa (Japan)
5. The Effect of Additional Weight on External Mechanical Energy in Running
A. Matsuo, T. Hirata, N. Tsunoda, T. Fukunaga (Japan)
6. Mechanical Efficiency in Relation to Pedaling Rate during Cycle Ergometer Work
Y. Fukuba, Y. Koya, S. Watanuki, K. Fujiie (Japan)
7. Optimum Speed of Up-Hill Cycling with Special Reference to Slope Gradients and the Gear Ratio
A. Kimura, M. Morioka, S. Horino, K. Kishida, K. Uchida (Japan)

August 25 (Wednesday)

9:00 ~ 10:30

Room: Hall C

Session 12: System Evaluation Methodology

Chairman: J. Rosner (Poland)
Co-Chairman: T. Furukawa (Japan)

1. An Application of Decision Tables Method in Ergonomic Research
L. Pacholski, B. Mateja (Poland)
2. An Ergonomic Method Diagnosing Complex Production Systems
L. Pacholski (Poland)
3. Combined Use of an Ergonomic Checklist and Complaint Rating as a Means of Identifying Problems
K. Sakai, K. Kogi (Japan)
4. Pluralistic Treatment in the System Research of Ergonomics
T. Marek, R. Michatek, C. Noworol (Poland)
5. The Use of Operator Workload Measures in the Evaluation of Different Telemanipulators
J. Richardson, N. Fiori-Savary, D. Xirau, D.A. Lescoat (France)
6. The Evaluation of the Repairmen of Motorcar Using the RS-Method
S. Nakayama, R. Sakai (Japan)

August 25 (Wednesday)

10:30 ~ 12:10

Room: Hall C

Session 13: System Design Methodology

Chairman: J.-H. Kirchner (F.R.G.)
Co-Chairman: Y. Iiyama (Japan)

1. The Computer Technique in Ergonomic Attestation and in Design of Controlling Devices Distribution
L. Pacholski, S. Szczebelski (Poland)
2. A Systematic Ergonomics Design Procedure
J.H. Kirchner (F.R.G.)
3. Ergonomical Correction of Working Conditions at the Stage of Working Station
M. Spychata (Poland)
4. The Interaction between Ergonomic Criteria and Industrial Design
V. Popovic (Australia)
5. Back-to-Front Systems Design: A Guns and Butter Approach
R.S. Didner (U.S.A.)
6. Use of Modular Simulators in Selection, Training and Workpost Design
J.-C. Rouhet (France)
7. VAD — A Video Aided Ergonomics Design System
P. Friedrich (Sweden)

August 25 (Wednesday)

9:00 ~ 10:30

Room: Hall D

Session 14: Eye Movement

Chairman: J.-C. Rouhet (France)
Co-Chairman: S. Tsukahara (Japan)

1. Maximum Velocity in Smooth Pursuit Eye Movement
K. Horii, K. Tanaka, Y. Tomoda (Japan)
2. Frequency Responses of the Pursuit Eye Movement System
K. Matsuoka, Y. Ueda (Japan)
3. Lambda Responses and Evaluation of Visual Task Load
A. Yagi (Japan)
4. Individual Differences Observed from Relationship between Percent Correct Counts and Eye Movements
H. Togami, K. Noro (Japan)

5. A Study of the Constitution of Visual Judgement Process of the Composite Images
T. Kurabayashi (Japan)
6. Modelling of Visual Scanning Sequence to Multiple Targets
M. Makikawa, H. Tamura (Japan)
7. An Evaluation of the NAC Eye Mark Recorder
T. Megaw, J. Richardson (U.K.)

August 25 (Wednesday)

10:30 ~ 12:30

Room: Hall D

Session 15: Education & Training

Chairman: W.B. Knowles (U.S.A.)
Co-Chairman: S. Sugiyama (Japan)

1. Cost-Effectiveness of Ergonomics: Elusive Data and an Exchange Heuristic
A.B. Russell (U.S.A.)
2. Exponential and Hyperbolic Learning Curves in Psychology and Industrial Engineering
S. Lippert (U.S.A.)
3. Time-Pressure, Training and Decision Optimality
D. Zakay (Israel)
4. Cognitive Psychology of Manual Control: Expert and Novice Differences in Cognition and Performance
Y. Anzal, Y. Ishii, Y. Hayashi (Japan)
5. Ergonomics Training for Computer Users
T. Houghton (France)
6. The Influence of Job Knowledge in Product Quality Judgements on a Continuous Production Line
J. Richardson, X. Cuny (France)
7. Introduction of Ergonomics in the Development of the Educational System
S. Kozuki (Japan)
8. An Instructional System which Permits the Students to Critically Discuss Their Own Test Answers
I. Kitagaki, Y. Shimizu, K. Suetake (Japan)
9. A Trial of Introducing Game Factor into the Rehabilitation Training
N. Ohnishi, K. Tsuchiya, F. Ito, S. Nagai (Japan)
10. Development of General Purpose Biofeedback System
M. Ohsuga (Japan)

August 25 (Wednesday)

9:00 ~ 11:15

Room: Hall E

Session 16: Environment: Temperature & Physiological Responses

Chairman: I. Holmér (Sweden)
Co-Chairman: Y. Kikuchi (Japan)

1. Cardiovascular and Metabolic Reactions to Work in Different Ambient Temperatures
T. Narial, Y. Fukuba, J. Ohashi, Y. Izumitani (Japan)
2. Relationships between Physique and Increase in Body Temperature During Exercise in a Warm Environment
T. Katsuura, A. Okada, T. Azuma, Y. Kikuchi (Japan)
3. Effect of Hot Dry and Hot Humid Environment in Continuous Work Performance in Men
J.S. Gupta (India)
4. Effect of Ambient Temperature on Physical Work Capacity
L. Mathew, J. S. Gupta (India)
5. The Effects of Work Rates and Ambient Temperature on Transient Physiological Responses
Y. Takasaki (Japan)
6. The Effects of Exercise, Ambient Temperature and Season on Estimation of Maximal Oxygen Intake
S. Watanuki, K. Yamasaki, Y. Koya (Japan)
7. Influence of Age on Circulatory Responses to Exercise at Different Air Temperature Conditions
Y. Kikuchi, T. Katsuura, A. Okada (Japan)
8. Evaluation of Cardiac Output by Electrical Impedance Method under Different Ambient Temperatures
T. Azuma, T. Katsuura, A. Okada, Y. Kikuchi (Japan)
9. Change in Pulmonary Diffusion Capacity for CO under Various Conditions of Temperature combined with Hypobaric Hypoxia
A. Yasukouchi, K. Iwanaga, Y. Koya, M. Sato (Japan)
10. Effects of Repeated Cold Exposures on Thermal Responses of Men
Y. Tochiara, T. Ohnaka, K. Yoshida (Japan)
11. Physical Work Capacity of Young Competitive Swimmers in Water at Three Different Temperatures
T. Nomura (Japan)

August 25 (Wednesday)**11:15 ~ 12:30****Room: Hall E****Session 17: Environment: Heat Stress Evaluation**

Chairman: J.J. Vogt (France)
 Co-Chairman: M. Sato (Japan)

1. Effects of Body Build and Sweat Rate on Rectal Temperature during Acute Heat Exposure in Man
K. Iwanaga, A. Yasukouchi, K. Yamasaki, H. Sato, M. Sato (Japan)
2. Sensitivity Analysis Supports Simplified Heat Stress Rules
J.D. Ramsey, C.P. Chai (U.S.A.)
3. Analytical Determination of Heat Stresses
J.J. Vogt, V. Candas, J.P. Libert (France)
4. A Statistical Analysis of WBGT Factor in Complex Production Systems
L. Pacholski (Poland)
5. Experimental Thermoesthesiometer
H. Mito (Japan)
6. Vibration Effects and Cold Storage Exposures for Workers in -20° to $+30^{\circ}\text{C}$ Environments
E.J. Hamley (U.K.)

August 26 (Thursday)**9:00 ~ 11:10****Room: Hall B****Session 18: Architecture**

Chairman: F. Mulder (The Netherlands)
 Co-Chairman: S. Fujimura (Japan)

1. Sharing (Size and Form) of Workrooms from the Viewpoint of Pleasant Working Environments
F. Mulder (The Netherlands)
2. Ergonomic Values of Traditional Housing in Bali
A. Manuaba (Indonesia)
3. The Relation between Physical Element and Visual Effects in Living Rooms—Part 1. On the Wall Color
T. Yanase, M. Kunishima (Japan)
4. The Relation between Physical Element and Visual Effects in Living Room—Part 2. On the Wall Light
M. Kunishima, T. Yanase (Japan)

5. Required Clearance for Passages in Dwelling House
K. Koh, K. Kamada (Japan)
6. A Study on Walking Up and Down Stairs in Eldery People
K. Aoki (Japan)
7. Accident Research for Safety on Stairs
H. Nagata (Japan)
8. Safety Requirements of Stairs
S. Kose, H. Uno (Japan)
9. A Systems Approach to the Aetiology of Human Injury in Livestock Building Design
G.A. Bramall (U.K.)
10. Experimental Study on the Cognitive Process of Streetscape
Y. Kubota (Japan)

August 26 (Thursday)**11:10 ~ 12:50****Room: Hall B****Session 19: Work Load: Methodology**

Chairman: H.L. Snyder (U.S.A.)
 Co-Chairman: Y. Saito (Japan)

1. On the Validity of Japanese Fatigue Feeling Scale
Y. Saito (Japan)
2. Factorial Analysis of Fatigue
S. Kondo, M. Oshima (Japan)
3. Work Load Studied by Multi-Point Critical Fusion Frequency (MCFF)
H. Osaki, S. Kikuchi, M. Ogata, H. Miyake, S. Okumura (Japan)
4. Measurement of Critical Flicker Fusion Frequency Liquid Crystal
K. Hosaka, O. Nishino, A. Watanabe, M. Saito, H. Takashita, Y. Yamazaki (Japan)
5. A Consideration on the Classification of Two-Dimensional Displayed Patterns of EEG
H. Takeda, Y. Takashima, Y. Ikeda, S. Hata (Japan)
6. Mental Effects of Risky Behaviour Seen by Means of a Portable Heart Rate Analyzer
H. Muroya, M. Ikeda, H. Yazawa (Japan)
7. A Three-Level Computer-Assisted System for the Evaluation of Physiological Changes during Work, before and after Ergonomical Intervention
J. Formánek, J. Kubát, J. Dvorák, M. Fires, M. Vanícková, J. Anđel, T. Chipra, Z. Fabian, P. Reháč, F. Klátil, P. Zajicek, M. Vaněcková (Czechoslovakia)
8. Disturbances in Curve Smoothness of Pupillary Reflex under Mental Workload
T. Marek, C. Noworol (Poland)
9. Measurement on Brain Arousal Rate
S. Inaba (Japan)

August 26 (Thursday)

9:00 ~ 10:30

Room: Hall C

Session 20: Evaluation of Human Activities

Chairman: E.J. Hamley (U.K.)
Co-Chairman: K. Sato (Japan)

1. The Evaluation of Each Daily Human Activity by the Instrumentation of a Continuous Heartrate Measurement
S. Adachi (Japan)
2. Measurement of the Effect of Central Acting Drugs on Performance and Reaction Time
H. Krueger (F.R.G.)
3. Effect of Sleep Deprivation on the CNV and Dual Task Performance
M. Miyao, T. Ohga, H. Sakakibara, T. Nakagawa, F. Kobayashi, S. Kanda, K. Takihi, S. Yamada, M. Terashima, T. Endo (Japan)
4. A Biotechnological Study of the Relation between Sleep and Beds
K. Fukada, N. Ando, A. Tanaka, S. Ichikawa, Y. Ando (Japan)
5. Responses of Sympathetic Nervous System to Hand Induced Vibration
T. Sakurai (Japan)
6. On the High-Order Dynamic Activity and Its Component Activities
K. Sato (Japan)

August 26 (Thursday)

10:30 ~ 12:30

Room: Hall C

Session 21: Systems Design II — Vehicle, Sign & Others

Chairman: A. Chapanis (U.S.A.)
Co-Chairman: T. Kondo (Japan)

1. Improvement of Visibility for Large Truck Drivers to Prevent Unsafe Turning to the Left
S. Horino (Japan)
2. Safe and Easy Coupling of Tractor Implements
L. Sjøfløt (Norway)
3. Ergonomic Aspects of Operator Cabins on Earth Moving Machinery
M.P. van der Grinten, C.K. Pasmooij (The Netherlands)
4. Design of a Vehicle for Mail Delivery. An Ergonomic Study
M. Björkstén, D. Caple, S. Carlsöö, P. Friedrich, J.E. Hansson (Sweden)

5. Ergonomic Changes of Our Automatic Welding Machine, Our Track-Pin Press Machine and Our Fellies Assembling Machine in Our Repair-Shop
A.E. Haugan (Norway)
6. The Use of Routing Information in a Public Environments
H.F. Zwaga (The Netherlands)
7. Evaluation of a Set of Graphic Symbols
T. Boersema, H.J. Zwaga (The Netherlands)
8. Developing Effective Symbols for Public Information: The ISO Testing Procedure
H. Zwaga, R. Easterby (The Netherlands)
9. Standardization of Geometric Radar Symbology
R.J. Carter (U.S.A.)
10. A Study of Human Cosmetic Behavioral Factors
K. Morooka, S. Morikawa (Japan)

August 26 (Thursday)

9:00 ~ 10:55

Room: Hall D

Session 22: Introduction of Ergonomics to Industry

Chairman: K.J. Zink (F.R.G.)
Co-Chairman: T. Sugi (Japan)

1. Ergonomic Aspects of New Technologies
K.J. Zink (F.R.G.)
2. Contribution of Human Automatics to Man Machine System Analysis
N. Malvache, J.C. Angue, D. Willaëys (France)
3. An Investigation on the Actual Condition Pertaining to Introduction of Ergonomics into Japanese Industries (Japan)
S. Nishikawa, M. Tsuchihashi (Japan)
4. The Development of the Scientific Basis of Ergonomic Norms and Requirements
V.M. Munipov (U.S.S.R.)
5. A Problem in Applications: An Investigation into Methods and Materials for Upgrading Nuclear Power Control Boards
D.L. Smith, J.L. Seminara (U.S.A.)
6. Ergonomics in Agricultural and Forestry—the Present and Future State
J. Zander (The Netherlands)
7. Ergonomics in Agricultural Engineering in India
B.G. Yadav, L.P. Gite (India)
8. Integration of Ergonomics in Transportation in Bali
A. Manuaba (Indonesia)

9. Signal Detection Theory in Ergonomics
H.C. Micko (F.R.G.)

August 27 (Friday)

9:00 ~ 11:10

Room: Hall B

Session 26: Vehicle Driving

Chairman: A. Chapanis (U.S.A.)
Co-Chairman: K. Yajima (Japan)

1. Analysis of the Driving Operation of Drivers
S. Ueno, K. Haneishi, M. Nishikawa (Japan)
2. Evaluation of the Arousal Level of Automobile Drivers Based on Their EEG, etc.
T. Yanagishima, Y. Seko, A. Ajimine, T. Kobayashi, N. Fukasawa (Japan)
3. Evaluation of Vehicle Steering Control Characteristics by Skin Resistance Level and Heart Rate
T. Sawada (Japan)
4. The On-Line Use of Driving Performance Measures to Detect Abnormal Driving Behavior
D.A. Attwood, Y.I. Noy (Canada)
5. Effects of Fatigue and Drugs on Driving Performance
K. Yajima, K. Aoki, T. Aoki, N. Yamanoi, H. Tanaka, S. Kinoshita, T. Furukawa (Japan)
6. Autoregressive Analysis of Highway Driving Performance by a Simulator
S. Kinoshita, K. Yajima, K. Aoki, H. Tanaka, T. Aoki, N. Yamanoi, T. Furukawa (Japan)
7. Driver and Pedestrian Speed Perceptions
M.H. Bergman (U.S.A.)
8. Fatigue of Bullet Train Drivers Operating on Multi-Tunnelled Sections
A. Watanabe, K. Kogi, N. Onishi, H. Shindo, K. Sakai (Japan)
9. Measurement of Pilot Workload During Take Off and Landing by C-1 Jet Carrier
Y. Nagasawa, S. Aramaki, N. Utsuki (Japan)
10. A Study on the Changes of Physiological Functions on Motorcycle Riding
T. Matsumoto (Japan)
11. Subjective Symptoms and Physio-Psychological Effects by Motorcycle Driving
A. Hisashige, H. Ohara, Y. Kume, M. Yamamoto, T. Ogawa, H. Aoyama (Japan)
12. A Biotechnological Study of Pilots of Hang Gliders
N. Ando, A. Tanaka, K. Fukuda (Japan)

August 27 (Friday)

9:00 ~ 10:45

Room: Hall C

Session 27: Introduction of Ergonomics to Social Systems

Chairman: R.G. Pearson (U.S.A.)
Co-Chairman: M. Yoshida (Japan)

1. The Functioning of Occupational Health Service in Scandinavia — on the Basis of Empirical Research in Norway and Sweden and Experience from a Field Research Project in Denmark
O. Rieper, A.S. Johansen (Denmark)
2. The Tasks of an Industrial Physician
J.I. Kamoy (Norway)
3. Is Selective Traffic Code Enforcement Practical? A Survey of Canadian Traffic Police
G.F. Rabideau, M. You, G. Smith (Canada)
4. Human Factors in Organizational Design and Management
H.W. Hendrick (U.S.A.)
5. Cognitive Complexity, Conceptual Systems and Organizational Design Implications for Ergonomics
H.W. Hendrick (U.S.A.)
6. Assessment Center Ratings as an Interim Criterion Measure in Leadership Research
H.W. Hendrick (U.S.A.)
7. Accuracy of Leader's Perceptions of Self and Others, and Actual Group Status as Functions of Cognitive Complexity
H.W. Hendrick (U.S.A.)
8. The Ergonomics, Has It Its Specific Laws?
P. Burloiu (Rumania)
9. Impact of Technology Transfer on Asian Developing Countries
S.E.G. Perera (Thailand)

August 27 (Friday)

9:00 ~ 10:30

Room: Hall D

Session 28: Posture

Chairman: S. Kumar (Canada)
Co-Chairman: S. Hijikata (Japan)

1. Dynamic Analysis of Human Upright Posture Control Activity
K. Sato, C. Morisada, N. Tajima (Japan)

2. On the Anyalysis of Erect Posture by the Foot-Pressure
M. Sakamoto, H. Itoh (Japan)
3. An Ergonomic Evaluation of Foot Complaints among Waiters as a Basis for Job Design
J. Winkel (Sweden)
4. The Postural and Health Problems of Workers in Pear and Apple Orchard
H. Sakakibara, M. Miyao, T. Nakagawa, F. Kobayashi, S. Kanada, K. Takihi, S. Yamada, K. Masuda (Japan)
5. Localized Fatigue Complaints Related to Output and Body Posture of Dentists
K. Maeda, H. Hayashida, T. Suenaga, M. Takamatsu (Japan)
6. A Study of Space Allotment Procedure for Dental Treatment Area in Measurement of Human Posture
T. Shibahara, M. Ohashi (Japan)
7. A Study of "Driving Position" in Passenger Vehicles
T. Sugimoto (Japan)
8. Holding Performance of Automobile Seats
M. Sano, M. Miyagi (Japan)

August 27 (Friday)

10:30 ~ 11:45

Room: Hall D

Session 29: Work Load: Lifting

Chairman: M.M. Ayoub (U.S.A.)
Co-Chairman: K. Kimura (Japan)

1. Energy Cost of Lifting in Sagittal and Lateral Planes by Different Techniques
S. Kumar, D. Magee (Canada)
2. An Ergonomic Evaluation of Working Postures in Manual Weight Lifting
M. Morioka, A. Kimura, K. Kishida, S. Horino, M. Saito (Japan)
3. An Ergonomic Approach to Reduce Hazards of Lifting Task
M.M. Ayoub (U.S.A.)
4. Recommended Work Rates and Container Configuration for Manual Lifting and Lowering Activities
A. Mital, S.S. Asfour, M.M. Ayoub (U.S.A.)
5. Guidelines for Permissible Limits for One-Handed Lifts by Women
A. Garg (U.S.A.)
6. The Physiological Costs of Boxlifting by Females
J.F. Kelley, E. Michael, R.N. Parrish (U.S.A.)

August 27 (Friday)

9:00 ~ 11:40

Room: Hall E

Session 30: Perception & Recognition

Chairman: H. Krueger (F.R.G.)
Co-Chairman: K. Fukushima (Japan)

1. Color Contrast and Visual Task Performance
H.L. Snyder (U.S.A.)
2. The Influence of Color Saturation on the Chromatic Error of Accommodation of the Human Eye
H. Krueger (F.R.G.)
3. Effects of Television Noise Interference on Character Reading Time and Error Rate
A. Watanabe, M. Saito, M. Oshima (Japan)
4. Signal Detection in the Noisy Background Figure through Limited Area of Visual Field
S. Saito, K. Katahira, S. Tsukahara (Japan)
5. A Discriminability Metric for VDU Characters
K. Hirsh-Pasek, M.L. Schneider, S. Nudelman (U.S.A.)
6. Intraitem and Interitem Symmetries in Same Responses to Pairs of Letters
S. Bagnara, D.A. Boles, F. Simion, C.A. Umilta (Italy)
7. How Many Letters Can We Recognize at a Glance?
T. Fukuda (Japan)
8. An Analysis of the Interaction Effects between Successively Exposed Two Figures
T. Yoshida (Japan)
9. A Multidimensional Scaling Analysis on Perceptual Structures of Japanese Syllables
K. Mizuki (Japan)
10. Tactile Letter Display for a Reading Aid
Y. Shimizu (Japan)
11. Warmth to Touch the Building Materials
I. Matsui, Y. Kasai (Japan)
12. Pain Sensation and Skin Deformation
M. Akamatsu (Japan)
13. Accuracy of Time Perception in Rhythmic Movement
T. Niihara, K. Kusano (Japan)
14. Study on the Time-Estimation to Some Reactive Simple Actions
I. Yoshimura, M. Nakamura (Japan)

August 27 (Friday)

13:00 ~ 14:40

Room: Hall C

Session 31: Work Performance

Chairman: J.J. O'Hare (U.S.A.)
Co-Chairman: M. Iguchi (Japan)

1. Dependence of Human Performance on Input Information in Pursuit Manual Control Systems
O. Suenaga, M. Ihara (Japan)
2. A Study of Human Operator's Dynamics During Training and Transfer Trials of the Tracking Tasks in Case of a Second-Order Lag System
T. Yamashita, E. Masuyama (Japan)
3. Skill Improvement in Manual Control of a Double Integral Controlled Element
A. Tada (Japan)
4. A Consideration on the Index of Precognitive Control Behaviors of Human Operator
H. Takeda, Y. Ikeda, S. Hata (Japan)
5. Analysis of Precognitive Dynamics in Two Axis Pursuit Tracking Task
T. Aoki, K. Yajima, K. Aoki, H. Tanaka, S. Kinoshita, N. Yamanoi, T. Furukawa (Japan)
6. Modeling the Human Operator in a Preview Comensatory Tracking Control System
K. Yoshimoto (Japan)
7. On the Self-Paced Preview Manual Tracking Behaviors
K. Ito, M. Ito (Japan)
8. Human Operator's Compensation Mechanism for Time-Delay in Manual Control System
M. Yoshizawa, H. Takeda (Japan)
9. Visual Lead Compensation in Manual Compensatory Tracking
S. Hara, K. Hanada (Japan)
10. Effects of Exogenic Stimulation upon Monotonous Performance
T. Watanabe, Y. Kawahara (Japan)

August 27 (Friday)

13:00 ~ 14:30

Room: Hall D

Session 32: Work Load on the Back

Chairman: A. Mital (U.S.A.)
Co-Chairman: T. Ota (Japan)

1. Dynamic Loading of Static Trunk
S. Kumar, P.R. Davis, D.P. Currier (Canada)

2. Trunk Muscle Activity during Dynamic Forward Bending and Straightening Up
K. Tani (Japan)
3. Compressive Load at L5/S1 Spine Level as a Biomechanical Factor during Various Lifting Techniques
T. Leskinen, H. Stalhammar, I. Kuorinka, D. Troup (Finland)
4. Posture Optimization through Three-Dimensional Kinetic Biomechanical Modeling
A. Kumar, A. Mital (U.S.A.)
5. Physiological Load on the Back of Postmen during Letter Distribution in Urban Districts
K. Jorgensen, H. Christensen, E. Daltorn, T. Nicolaisen (Denmark)
6. The Musculoskeletal Status in Airport Transport Worker
K. Undeutsch, M.j. Karvonen, J. Mainzer (F.R.G.)
7. A Back-Care Program in the Building and Construction Industry in the Netherlands
E.A.P. Koningsveld (The Netherlands)

August 27 (Friday)

13:00 ~ 14:40

Room Hall E

Session 33: Working Environment

Chairman: S. Bagnara (Italy)
Co-Chairman: E. Takakuwa (Japan)

1. Studies on Subjective Sensations on Air Movement for Creating Comfort Indoor Climate
H. Kubota (Japan)
2. Passive Smoking at Work
A. Weber (Switzerland)
3. An Experimental Study on Irritations and Annoyance due to Passive Smoking
T. Muramatsu, A. Weber, S. Muramatsu, F. Akermann (Switzerland)
4. A Survey on the Effects of Involuntary Smoking and Attitude to Smoking among School Children and Students
S. Muramatsu, T. Muramatsu, A. Weber (Switzerland)
5. Effect of Physical Work Rate of Dispersal of Bacteria in the Air from Man
K. Terayama, H. Ohno, F. Hirata, T. Kawarabayashi (Japan)
6. Hazardous Materials Encountered in Human Factors Design Practice
D. Gloss (U.S.A.)
7. Solvent Mixtures Influence Dependent on the Working Process in the Wood Industry
R. Lödersdorf, G. Schäcke, B. Heydenreich-Adolff, A. Fuchs (F.R.G.)
8. The Aggregation Method of Heterogeneous Material Environment of Work Factors
L. Pacholski, A. Jasiak (Poland)

FAREWELL PARTY

August 26 (Thur.) 19:00 — 21:30

Akasaka Prince Hotel "Royal Hall" (Annex 5Fl.)

Those who wish to join a farewell party are requested to buy a ticket at the Information Desk by the noon, August 26.

You can enjoy Japanese Popular song, Folklore song and Dance.

CLOSING CEREMONY

August 27 (Fri.) 15:00 — 16:00

Nihon Toshi Center "Hall B"

This ceremony is scheduled to include an address by a representative from the next host country.

LADIES' PROGRAM

All Accompanying Persons registered can receive Ladies' Program tickets at Travel Information Desk (JTB Counter). They are invited to the Ladies' Programs, which will provide them with the opportunity to become familiar with the things of Japan.

LP-1: "Japanese Traditional Arts"
August 25 (Wed.) 9:00 — 16:20

LP-2: "Japanese Garden and Museum"
August 26 (Thur.) 8:40 — 12:30

TECHNICAL SITE VISITS

Following 6 courses are available to the limited number of participants.
Participants are required to go to the site on their own except for course 6.
Participants for course 6 are required to pay for bus transportation at the registration desk.

Those who wish to pay a visit are requested to make an application in advance and get information about courses at the Information Desk.

DATE: August 26 (Thur.)

Course 1: Japanese National Railways (Centralized Traffic Control Center)

Course 2: Metropolitan Police Headquarters

Course 3: Tokyo Fire Department

Course 4: Telecommunications Science Hall of Nippon Telegraph and Telephone Public Corporation.

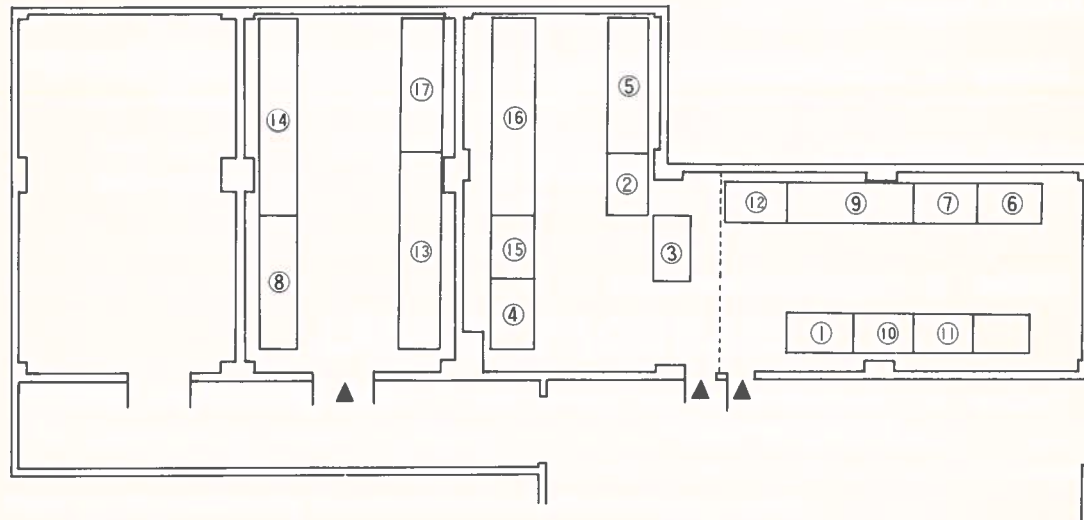
Course 5: The Federation of Bankers Association of Japan

Course 6: Nissan Motor Co., Ltd. — Zama Plant

EXHIBITION

The Organization Committee will hold IEA '82 Exhibition at Nihon Toshi Center from August 24 (Tues.) through August 27 (Fri.)

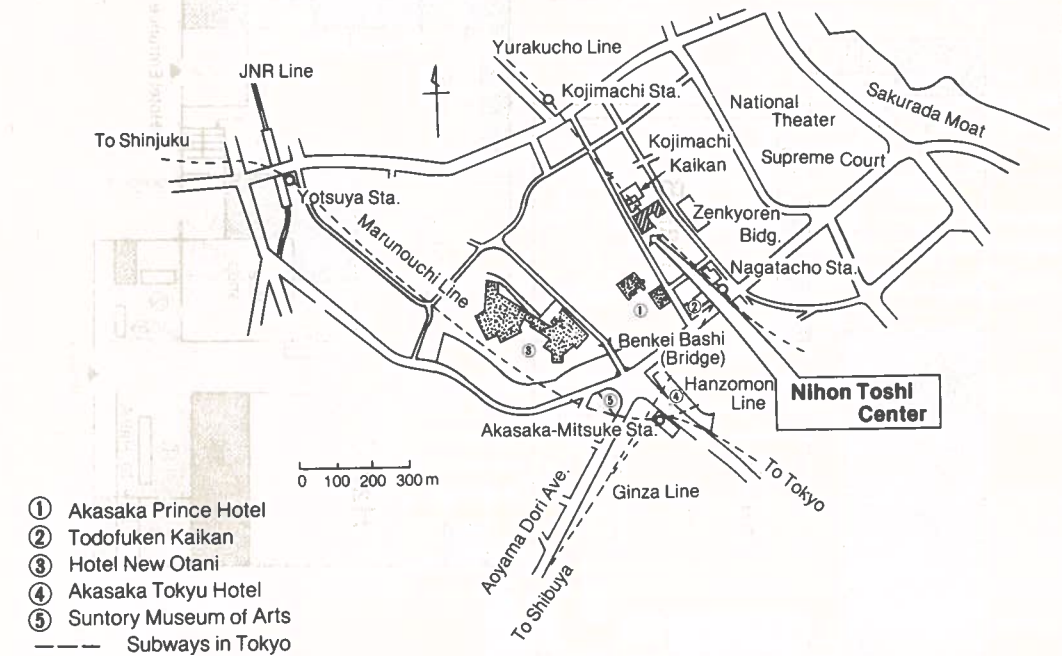
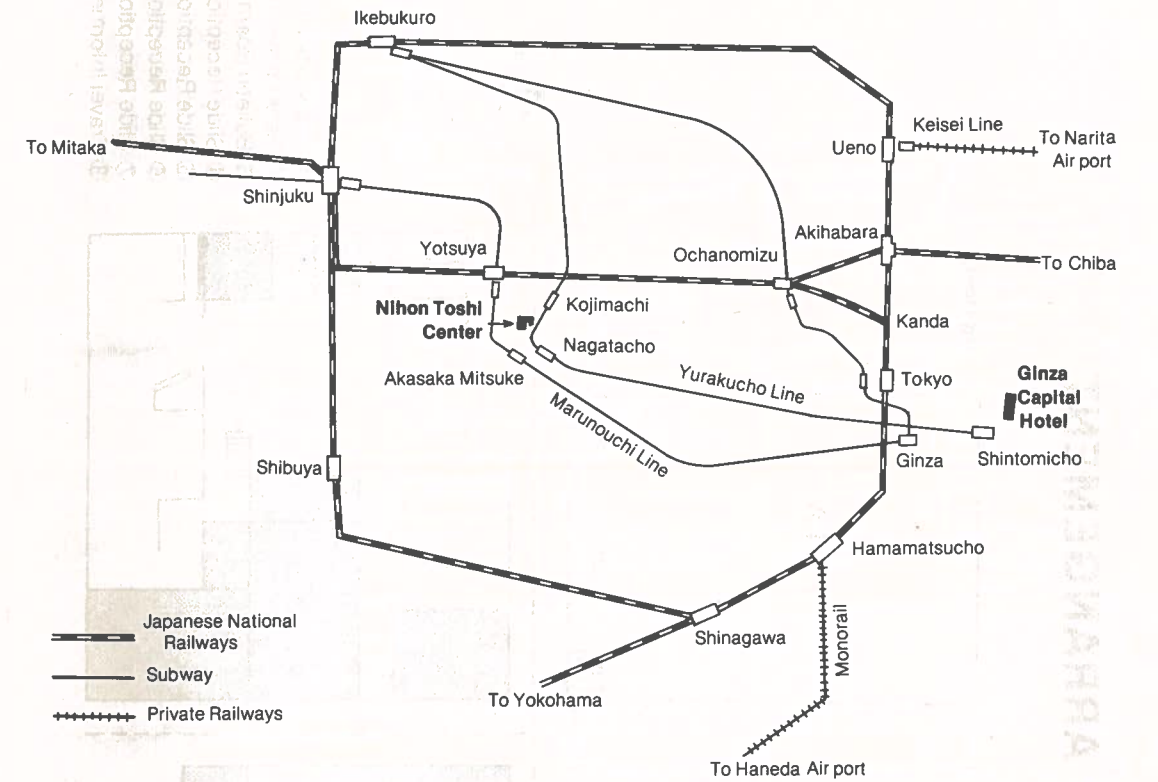
Date	Time
Aug. 24	13:00 — 17:00
25	9:00 — 17:00
26	9:00 — 17:00
27	9:00 — 12:00



Exhibitors

- | | |
|--|--|
| ① Aloca Co., Ltd. | ⑩ Nippon Telegraph and Telephone Public Corporation |
| ② Fuji Photo Optical Co., Ltd. | ⑪ Protech Incorporated |
| ③ Health Japan Center | ⑫ San-ei Instrument Co., Ltd. |
| ④ Hokushin Kaken Co., Ltd. | ⑬ Sony Corporation |
| ⑤ IBM Japan, LTD. | ⑭ Takei & Company, Ltd. |
| ⑥ Imasen Engineering Co., Ltd. | ⑮ TEAC Corporation |
| ⑦ Mitsubishi Electric Corporation, Central Research Laboratory | ⑯ Technology Research Association of Medical and Welfare Apparatus |
| ⑧ NAC Incorporated | ⑰ Yaesu Rehabili Co., Ltd. |
| ⑨ Nippon Electric Co., Ltd. | |

LOCATION MAP

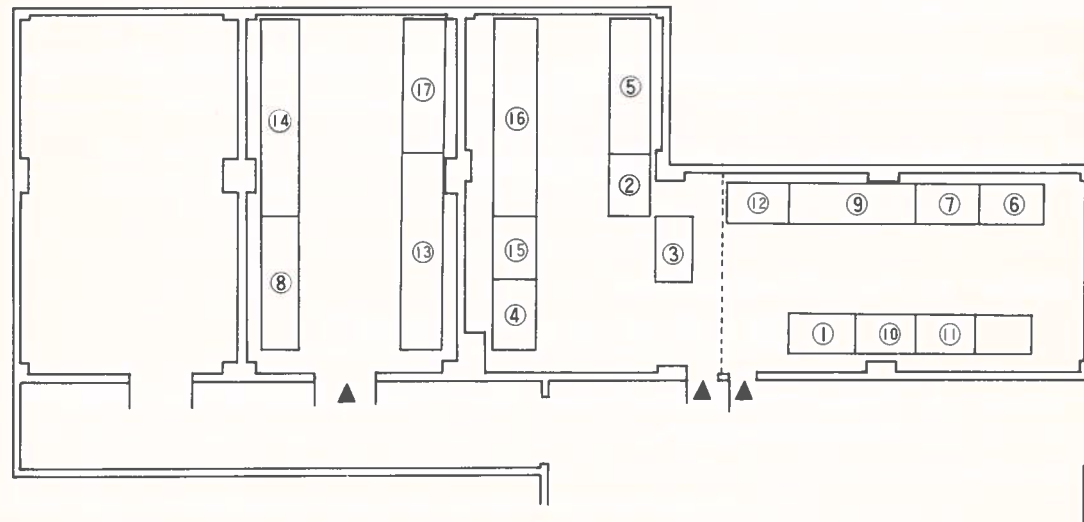


- ① Akasaka Prince Hotel
- ② Todofuken Kaikan
- ③ Hotel New Otani
- ④ Akasaka Tokyu Hotel
- ⑤ Suntory Museum of Arts
- Subways in Tokyo

EXHIBITION

The Organization Committee will hold IEA '82 Exhibition at Nihon Toshi Center from August 24 (Tues.) through August 27 (Fri.)

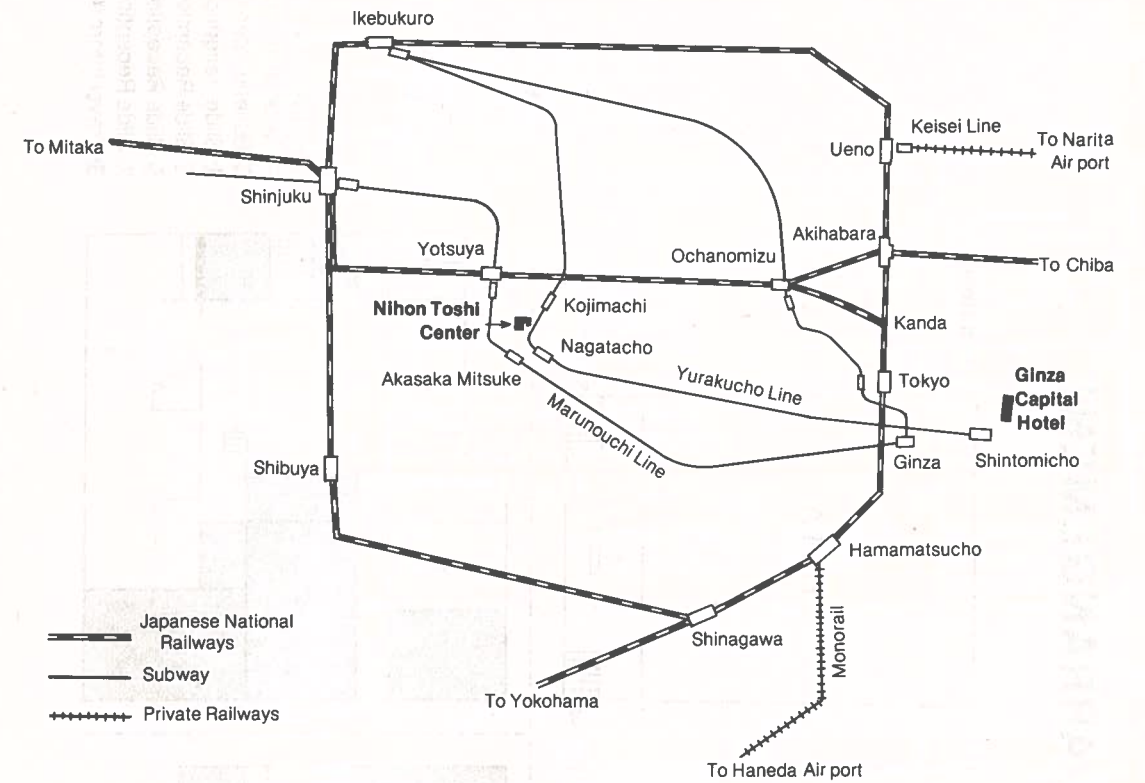
Date	Time
Aug. 24	13:00 — 17:00
25	9:00 — 17:00
26	9:00 — 17:00
27	9:00 — 12:00



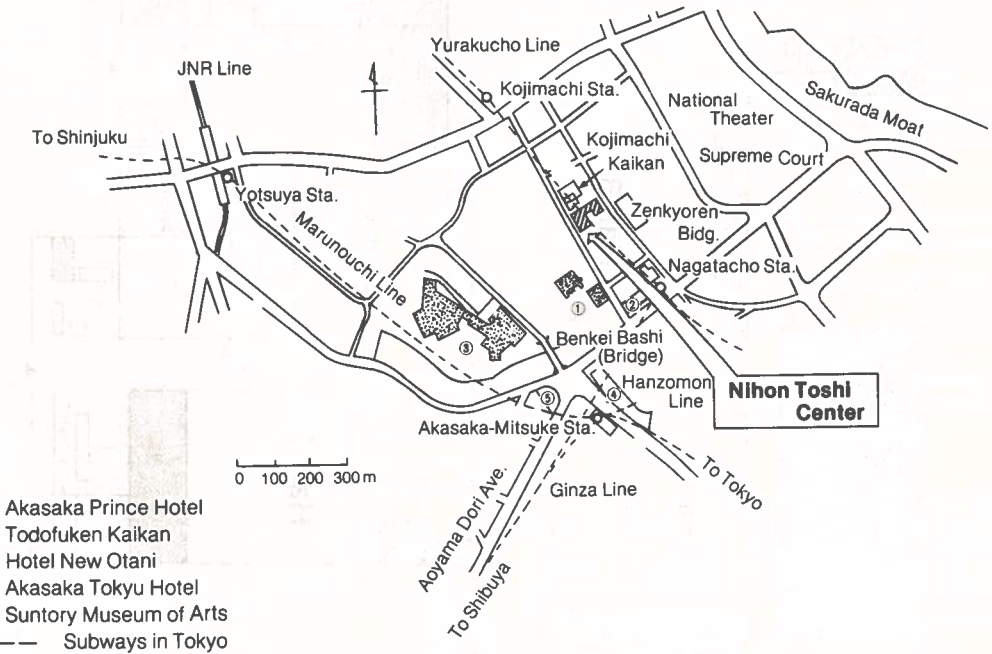
Exhibitors

- | | |
|--|--|
| ① Aloca Co., Ltd. | ⑩ Nippon Telegraph and Telephone Public Corporation |
| ② Fuji Photo Optical Co., Ltd. | ⑪ Protech Incorporated |
| ③ Health Japan Center | ⑫ San-ei Instrument Co., Ltd. |
| ④ Hokushin Kaken Co., Ltd. | ⑬ Sony Corporation |
| ⑤ IBM Japan, LTD. | ⑭ Takei & Company, Ltd. |
| ⑥ Imasen Engineering Co., Ltd. | ⑮ TEAC Corporation |
| ⑦ Mitsubishi Electric Corporation, Central Research Laboratory | ⑯ Technology Research Association of Medical and Welfare Apparatus |
| ⑧ NAC Incorporated | ⑰ Yaesu Rehabili Co., Ltd. |
| ⑨ Nippon Electric Co., Ltd. | |

LOCATION MAP



- Japanese National Railways
- Subway
- Private Railways



- ① Akasaka Prince Hotel
- ② Todofuken Kaikan
- ③ Hotel New Otani
- ④ Akasaka Tokyu Hotel
- ⑤ Suntory Museum of Arts
- Subways in Tokyo

400
1.870
1.130
7910
2260
20510

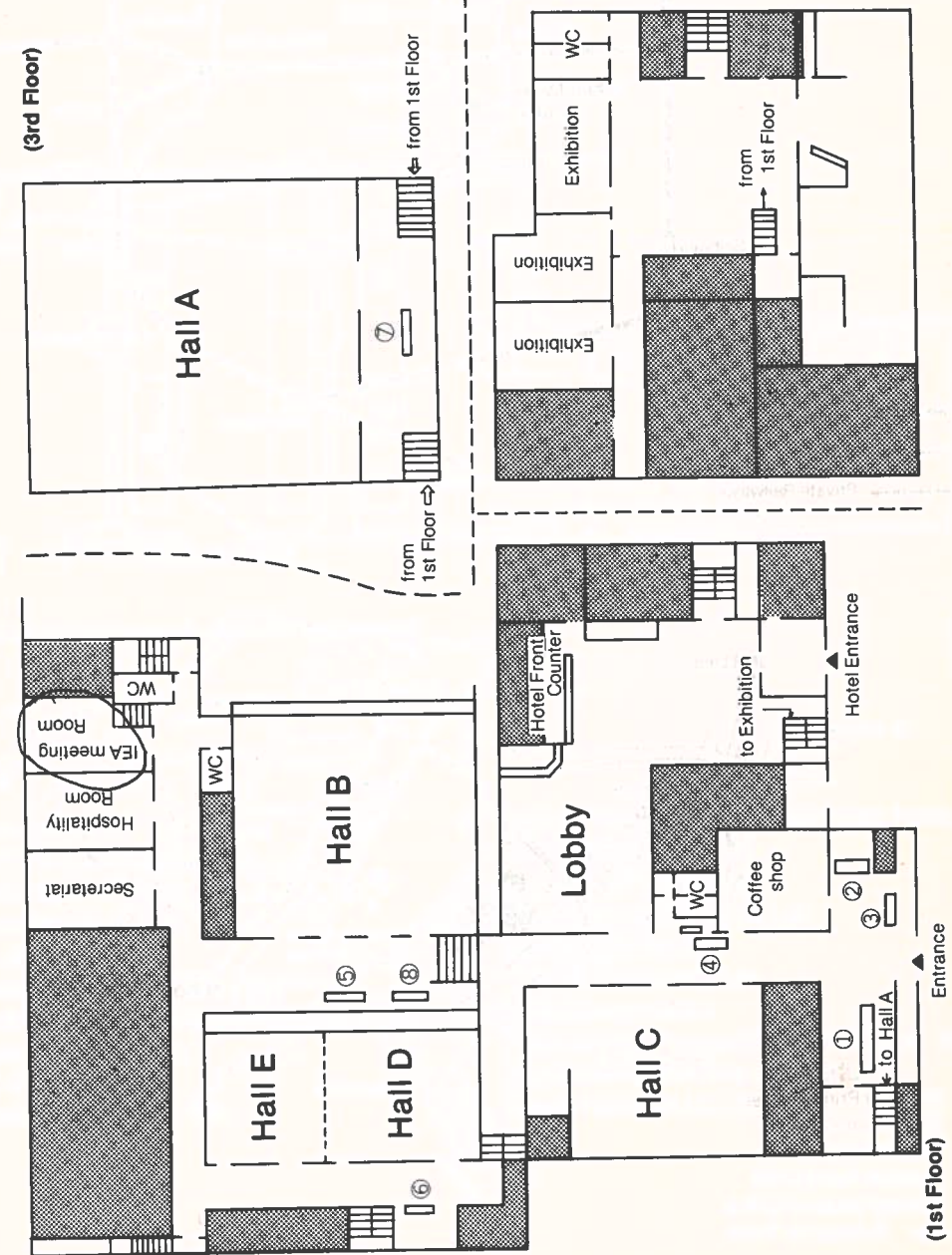
2.800
5.000
11.000

16 39

11.000
140
24
458

11.000
140
120
80
16
67
87
687

FLOOR ARRANGEMENT



- ① Registration Desks
- ② General Information Desk
- ③ Bulletin Board
- ④ Slide Reception for Hall C
- ⑤ Slide Reception for Hall B
- ⑥ Slide Reception for Hall D, E
- ⑦ Slide Reception for Hall A
- ⑧ Travel Information Desk

PROGRAM SCHEDULE

IEA

Welcome

Room	Hall A	Hall B	Hall C	Hall D	Hall E
Aug. 24 Tues.	9:00 Opening Ceremony				
	10:00-12:00 Special Lectures				
	13:00 <WORKSHOP I> Safety	Work Load: General	Systems Design I - Keyboard & Others	Anthropometry & Clothing	Quality of Working Life
	17:30 <WORKSHOP II> Human Error	Work Load: Industrial Applications	Circadian Rhythm & Shift Work	Motion & Gait	Environment: Noise & Vibration
25 Wed.	9:00 <WORKSHOP III> Productivity I - Automation & Robotization	Work Load: Muscle Activity	System Evaluation Methodology	Eye Movement	Environment: Temperature & Physiological Responses
	12:30 <WORKSHOP IV> VDU & Operator	Work Load: Physical	System Design Methodology	Education & Training	Environment: Heat Stress Evaluation
	14:00-15:00 General Assembly				
	15:00-16:00 Special Lecture				
26 Thur.	9:00 <WORKSHOP V> Productivity II - Humanization & Workplace	Architecture	Evaluation of Human Activities	Introduction of Ergonomics to Industry	Work Load: Visual
	12:30 Technical Site Visits	Work Load: Methodology	Systems Design II - Vehicle, Sign & Others	Ergonomics of Computer Systems	Visual Inspection & Vigilance
27 Fri.	9:00 <WORKSHOP VI> The Aged & Handicapped	Vehicle Driving	Introduction of Ergonomics to Social Systems	Posture	Perception & Recognition
	12:00-13:00 <Symposium> Past, Present & Future of Ergonomics		Work Performance	Work Load on the Back	Working Environment
	15:00-16:00 Closing Ceremony				

Circled numbers represent each Session Number.

Carnal

Ergonomics

*An international journal devoted to the scientific study of
human factors in relation to working environments and
equipment design*

VOLUME 25

NUMBER 6

JUNE 1982



**8th CONGRESS
INTERNATIONAL ERGONOMICS
ASSOCIATION**

Hosted by the Japan Ergonomics Research Society
Tokyo, 23-27 August 1982

The official publication of the
**ERGONOMICS SOCIETY
INTERNATIONAL ERGONOMICS ASSOCIATION**



Published by
TAYLOR & FRANCIS LTD
4 JOHN STREET LONDON WC1N 2ET

ERGONOMICS

General Editor
R. GOLDSMITH

Department of Physiology, Chelsea College,
Manresa Road, London SW3 6LX

Physiology Editor

J. M. PATRICK
Department of Physiology and
Pharmacology
University Medical School
Clifton Boulevard
Nottingham NG7 2UH

Applications Editor

E. M. FORDHAM
Department of Nursing Studies
Chelsea College
Manresa Road
London SW3 6LX

Psychology Editor

P. SHIPLEY
Department of Occupational Psychology
Birkbeck College
University of London
Malet Street
London WC1E 7HX

Book Reviews Editor

H. C. W. STOCKBRIDGE
Room 430, SP(N), A.B.S.
Old Admiralty Building
Spring Gardens
London SW1A 2BE

Editorial Board

- Australia:** Professor G. M. BUDD, Commonwealth Institute of Health, Environmental Health Subsection, University of Sydney, New South Wales, 2006.
Professor K. A. PROVINS, Department of Psychology, The University of Adelaide, Adelaide, 5001.
- Canada:** Professor T. M. FRASER, Director, Centre for Occupational Health and Safety, University of Waterloo, Waterloo, Ontario, N21 3G1.
Professor R. J. SHEPHARD, Department of Preventive Medicine and Biostatistics, University of Toronto, Toronto, M5S 1A8.
- Denmark:** Professor P. O. FANGER, Laboratory of Heating and Air Conditioning, Technical University of Denmark, Building 402 A, DK 2800 Lyngby.
- France:** Professor B. METZ, Centre d'Etudes Bioclimatiques (CNRS), 21 rue Becquerel, 67087 Strasbourg.
- Germany:** Professor Dr.-Ing. W. ROHMERT, Institut für Arbeitswissenschaft der Technischen Hochschule Darmstadt, Petersenstrasse 30, D-6100 Darmstadt.
- U.K.:** Dr. I. BROWN, MRC Applied Psychology Unit, 15 Chaucer Road, Cambridge CB2 2EF.
Dr. J. COTES, Respiration and Exercise Laboratory, University Department of Occupational Health and Hygiene, 24 Claremont Place, Newcastle upon Tyne NE2 4AA.
Professor P. R. DAVIS, Department of Human Biology and Health, University of Surrey, Guildford, Surrey GU2 5XH.
Dr. J. SPENCER, Department of Applied Psychology, University of Wales Institute of Science and Technology, Penylan, Cardiff CF3 7UX.
- Japan:** Professor M. OSHIMA, Institute of Medical Electronics, Faculty of Medicine, University of Tokyo, Hongo, 7-3-1 Bunkyo-ku, Tokyo.
Dr. Y. SUZUKI, Institute for Sports Science and Medicine, Amateur Sports Association of Japan, 1-1-1 Jinnan, Shibuya-ku, Tokyo.
- Netherlands:** Dr. F. VAN NES, Institute for Perception Research, P.O. Box 513, 5600 MB Eindhoven.
- Norway:** Dr. TARALD O. KVÅLSETH, Section of Industrial Management, University of Trondheim—Norwegian Institute of Technology, N-7304 Trondheim-NTH. (Temporary address: Department of Mechanical Engineering, University of Minnesota, 125 Mechanical Engineering, 111 Church Street SE, Minneapolis, Minnesota 55455, U.S.A.).
- Sweden:** Professor ULF ÅBERG, Royal Institute of Technology, S-100 44 Stockholm.
Dr. T. IVERGARD, Ergonomilaboratoriet AB, För forskning och konsultation, Renstiernas gata 12, S-11631 Stockholm.
- Switzerland:** Professor Dr. med. E. GRANDJEAN, Institut für Hygiene und Arbeitsphysiologie, ETH-Zentrum, CH-8082 Zurich.
- U.S.A.:** Professor A. LIND, School of Medicine, Department of Physiology, Saint Louis University, 1402 South Grand Boulevard, Saint Louis, Missouri 63104.
Dr. K. B. PANDOLF, Chief, Physiology Branch, Military Ergonomics Division, Department of the Army, U.S. Army Research Institute of Environmental Medicine, Natick, Massachusetts 01760.

Subscription Information

USA, Canada and Mexico (air freight): annual subscription (payable in advance), \$220.00; per part \$22.00 (surface post paid). Air freight and mailing in the USA by Publications Expediting Inc., 200 Meacham Avenue, Elmont, New York 11003. Second class postage paid at Jamaica, New York 11431. USA Postmaster: Send address changes to *Ergonomics*, Publications Expediting Inc., 200 Meacham Avenue, Elmont, New York 11003. US subscribers should send order and cheque (in favour of Taylor & Francis Ltd) to Account 04 810 879 Bankers Trust Company, P.O. Box 9137, Church Street Station, New York, N.Y. 10049.

Japan (accelerated surface post): apply to exclusive agents, Kinokuniya Company Ltd, Odakyu West-Shinjuku Building, 47-1 Hatsudai 1-chome, Shibuya-ku, Tokyo 151. Telex 2322535.

FR Germany (surface post): annual subscription (payable in advance), DM 341.00; per part DM 34.00. Subscribers in FR Germany should send order and cheque (in favour of Taylor & Francis Ltd) to Account No. 073-6686, Deutsche Bank AG, BLZ 500 700 10, Postfach 2623, Rossmarkt 18, 6000 Frankfurt/Main 1.

UK and the rest of the world (surface post): accelerated surface post to Australasia; air freight to India; annual subscription (payable in advance), £71.00; per part £8.00 (surface post paid).

Published monthly by Taylor & Francis Ltd, 4 John Street, London WC1N 2ET, UK. Telex 858540.

Printed by Taylor & Francis (Printers) Ltd, Rankine Road, Basingstoke, Hampshire RG24 0PR, UK.

© 1982 Taylor & Francis Ltd. ISSN 0014-0139.

ERGONOMICS, 1982, VOL. 25, NO. 6

Editorial

The 8th Congress of the International Ergonomics Association, Tokyo, August 1982 is the second of its kind to be held in a non-European nation, following the United States, and the first to be held in the Asia-Pacific region. Japan is far removed from Europe in language and culture, so that Japanese ergonomic research differs widely from that of Europe in concepts and problem-solving approaches. These differences make clear understanding between Japanese and European investigators difficult. Many ergonomic studies by European investigators have been introduced to Japan through *Ergonomics* and other journals, but work carried out by Japanese investigators has rarely been introduced to Europe. Taking the opportunity to correct this imbalance, the holding of the congress has stimulated Japanese ergonomists, who have submitted a total of over 180 abstracts for presentation at the congress.

Abstracts from ergonomic workers in 28 foreign countries have exceeded 170. It is rare for this type of international meeting that the number of reports from the host country approximately equals that of reports from the other countries. Thus the host country's contributions are neatly balanced against those of the rest of the world, presaging active exchange between East and West.

The abstracts received cover an extremely wide range of topics, including subjects that have aroused new interest in the past few years. Readers will notice that the abstracts tell them about recent trends of ergonomic research in the world, among other things views of ergonomists and methods of ergonomic research.

This special issue first divides the abstracts into two broad groups of fundamentals and applications, and then subdivides them into more detailed research fields. This classification is very systematic and is different from the sequence of the technical sessions and workshops at the congress. The special issue is edited in this way, bearing in mind that it will also be referred to after the congress.

As Congress Editor, I would like to thank many people for their help in compiling this issue. Professor R. Goldsmith, General Editor, has shown me an extremely deep understanding and has given me apt suggestions through several meetings and communications. I also thank Mr. S. A. Lewis, Managing Director of Taylor & Francis Ltd, for his business acumen and great enthusiasm for international scientific exchange and finally, Mr. Shuhei Hattori of Kinokuniya Co. Ltd who has painstakingly supported me in my work in Japan and has played a major role in bringing this issue to completion.

KAGEYU NORO

Congress Issue Editor

Note from the General Editor

The world knows that Japanese industry has had unprecedented success in capturing markets, at the same time maintaining peace and tranquility among those who actually make the products. The 8th Congress of the International Ergonomics Association will shed some light on the contributions that Ergonomics and ergonomists have made to this achievement. This issue, so ably edited by Professor Noro, will be the permanent record from which new contacts between the cultures of East and West, through the scientific research, will be established. If within its pages language is sometimes obscure or difficult, blame not the hard-working editors but reflect that communication across the cultures is difficult, and we are still only at the beginning of true conversations. Our aim is to make but a small contribution; practitioners and researchers in Ergonomics must do the real work.

R. GOLDSMITH

CONGRESS PROGRAMME

Room	Hall A	Hall B	Hall C	Hall D	Hall E
Date	9.00	Opening Ceremony			
	10.00				
	10.30				
Aug. 24 Tues.	12.00	< WORKSHOP I > Safety	Work Load: General	Systems Design I —Keyboard & Others	Anthropometry & Clothing
	13.00				
	17.30				
25 Wed.	9.00	< WORKSHOP II > Human Error	Work Load: Industrial Applications	Circadian Rhythm & Shift Work	Motion & Gait
	12.30				
	13.00				
26 Thur.	9.00	< WORKSHOP III > Productivity I — Automation & Robotization	Work Load: Muscle Activity	System Evaluation Methodology	Eye Movement
	12.30				
	14.00				
27 Fri.	9.00	< WORKSHOP IV > VDU & Operator	Work Load: Physical	System Design Methodology	Education & Training
	12.30				
	14.00				
28 Sat.	9.00	General Assembly			
	12.30				
	15.00				
29 Sun.	9.00	Special Lecture			
	12.30				
	15.00				
30 Mon.	9.00	< WORKSHOP V > Productivity II — Humanization & Workplace	Architecture	Evaluation of Human Activities	Introduction of Ergonomics to Industry
	12.30				
	15.00				
31 Tue.	9.00	Work Load: Methodology	Systems Design II —Vehicle, Sign & Others	Ergonomics of Computer Systems	Visual Inspection & Vigilance
	12.30				
	15.00				
1 Wed.	9.00	Technical Site Visits	Technical Site Visits		
	12.30				
	15.00				
2 Thu.	9.00	< WORKSHOP VI > The Aged & Handicapped	Vehicle Driving	Introduction of Ergonomics to Social Systems	Posture Work Load: Lifting
	12.00				
	13.00				
3 Fri.	13.00	< Symposium > Past, Present & Future of Ergonomics	Work Performance	Work Load on the Back	Working Environment
	15.00				
	15.00				
4 Sat.	15.00	Closing Ceremony			
	16.00				
	16.00				

Ergonomics in Japan

By MASAMITSU OSHIMA

The Medical Information System Development Centre,
Tokyo, Japan

The Japan Ergonomic Research Society was established on 1 December 1964. The present situation of the society is as follows:

- (1) The society has seven regional branches as listed in table 1.
- (2) Six journals are published in each year.
- (3) The annual meeting and general assembly are held each year.
- (4) Six special research committees are active for research and development in the area of ergonomics, these are shown in table 2.
- (5) The members of the society are classified by profession; the largest number of members is in the area of engineering, followed by medicine, housekeeping and psychology (figure 1).

The characteristic of ergonomics in Japan is thought to depend on the concept of the human being. The following items are listed for the understanding of the human being.

Man system: Man is observed to be a man system, because man has the conditions of a system; that is to say, (a) man has various kinds of components, (b) man has the relation between each component, and (c) man has purpose as the man system, which may be living and social activities. Man system is called from the standpoint of many kinds of concepts, these are shown in table 3.

Man systems have many kinds of characteristics, which are called system functions instead of human functions. Table 4 shows the system functions, only one item is explained in detail.

Table 1. Regional branches of the society.

- (1) Hokkaido branch
- (2) Tohoku branch
- (3) Kanto branch
- (4) Tokai branch
- (5) Kansai branch
- (6) Chu-shikoku branch
- (7) Kyushu branch

Table 2. Research committees of the society.

- (1) Committee for clothing
- (2) Committee for aviation ergonomics
- (3) Committee for the environment of cities
- (4) Committee for ergonomics of nursing
- (5) Committee for rehabilitation
- (6) Committee for inspection and measurement
- (7) Committee for production systems

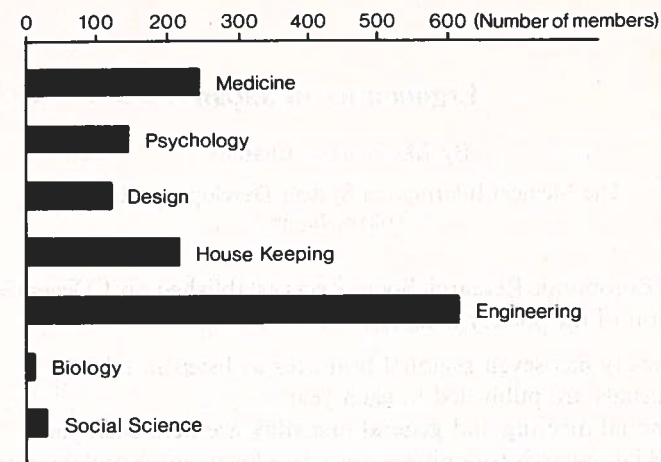


Figure 1. Number of members in specific professions including the inactive members.

Table 3. So-called kinds of man systems.

- (1) Open system
- (2) Facilitation system
- (3) Facilitation-inhibition system
- (4) Adaptive control system
- (5) Output-input system (cybernetical system)
- (6) Homeostasis system
- (7) Self-fuelling system
- (8) Self-repairing system
- (9) Self-procreation system
- (10) Closed loop system
- (11) Organized system
- (12) Information processing system
- (13) Self-optimization system
- (14) Others

Table 4. Characteristics of the man system.

- (1) Homeostasis, constancy
- (2) Double control system
- (3) Double feedback system
- (4) Adaptation, acclimatization
- (5) Antagonism
- (6) Syntonization, synchronization (24-hour physiological rhythm)
- (7) Open system → Man system (i.e. Man-machine system)
- (8) Control of attention level, tension level and consciousness level
- (9) System balancing function
- (10) Possibility of disorganization, dysfunction
- (11) Effects of motivation and emotion on system function
- (12) Inertia
- (13) Redundancy
- (14) Illusion and error
- (15) Language system

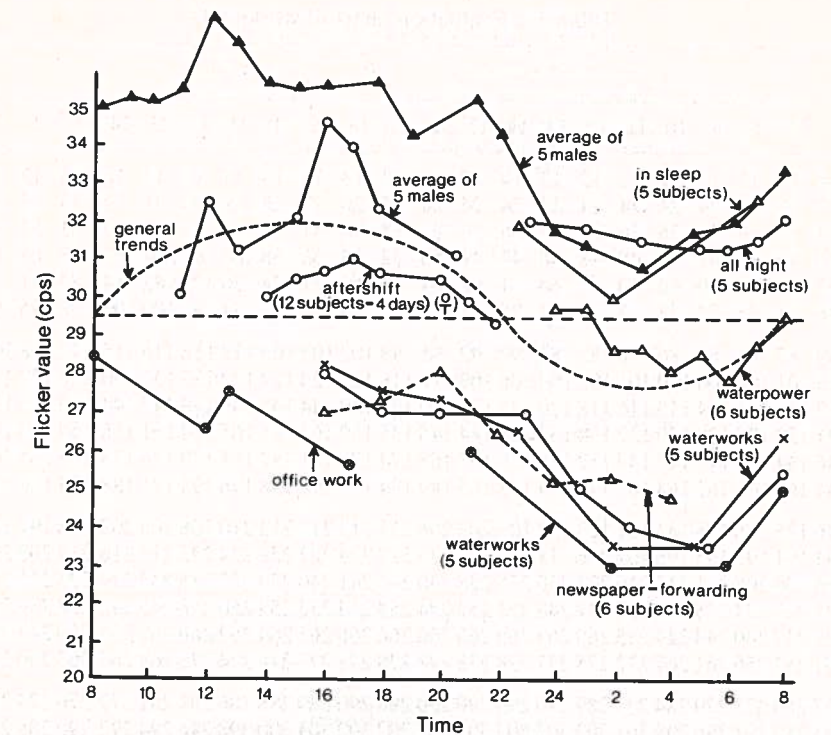


Figure 2. The course of flicker value in 1 day.

Figure 2 shows the 24-hour physiological rhythm, which includes the results of numerous research by flicker value, the average shows the fine 24-hour rhythm. This curve shows the higher phase during the day and the lower phase at night. The higher phase corresponds to the active stage which requires the alternation of functions, and the lower phase corresponds to the rest stage, which requires the rest of all functions.

From this physiological 24-hour rhythm, we obtain the evaluation values of the effect of workload and sleep. Tables 5 and 6 show the two evaluation charts, which are available for the evaluation of life from the standpoint of time.

On the other hand, the concept of the system expands to wider areas. Figure 3 shows this situation, and we have to expand the area of ergonomics. Man expands from man only to man-machine systems, to ecological man-machine systems and to social systems or international systems. So ergonomics has to expand and research the development of social systems. Social systems have to have some support system as shown in figure 4. Advancing, monitoring, advisory, maintenance, and check systems, which are mainly constructed by men, are necessary for man-machine systems.

Ergonomics has to be promoted through man assessment, principle between man and object, principle of availability and welfare of social systems. As an example, the principle of visibility is shown in table 7. Of course, concentration is also important, and another example of the practice of ergonomics, the dimension of steps from the standpoint of ergonomics, is shown in figure 5. The optimum height of the rise and length of the tread is shown. The best angle of step gradient was 26° .

Table 8 shows that at last ergonomics has developed the technology to back-up the human being.

Table 5. Evaluation chart of workload.

		B																							
		6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	1	2	3	4	5
A	1	14	13	12	12	12	12	12	12	12	12	12	12	13	13	14	14	15	15	16	16	17	18	17	15
	2	27	25	24	24	24	24	24	24	24	24	24	25	26	27	28	29	30	31	32	33	35	35	32	29
	3	39	37	36	36	36	36	36	36	36	37	38	40	41	43	44	46	47	49	51	52	50	46	42	
	4	51	49	48	48	48	48	48	49	50	52	54	56	58	60	62	64	67	68	67	64	59	54		
	5	63	61	60	60	60	60	61	62	64	66	69	71	74	76	79	82	84	83	81	77	71	66		
	6	76	74	73	73	73	73	74	75	77	79	82	85	88	91	94	98	100	100	98	95	90	84	79	
	7	89	87	86	86	86	87	88	90	92	95	98	102	105	109	113	116	116	115	112	108	103	97	92	
	8	103	101	100	100	100	101	102	104	106	109	112	116	120	124	129	132	133	132	130	126	122	117	111	106
	9	117	115	114	114	115	116	118	120	123	126	130	134	139	144	148	149	149	147	144	140	136	131	125	120
	10	131	129	128	129	130	132	134	137	140	144	148	151	159	163	165	165	164	161	158	154	150	145	139	134
	11	146	144	144	145	147	149	152	155	159	163	168	174	179	181	182	181	179	176	173	169	165	160	154	149
	12	161	160	160	162	164	167	170	174	178	183	189	194	197	198	198	196	194	191	188	184	180	175	169	164
	13	176	175	176	178	181	181	183	192	197	203	208	211	213	213	212	210	208	205	202	198	194	189	183	178
	14	191	191	192	195	198	202	206	211	217	222	225	227	228	227	226	224	222	219	216	212	208	203	197	193
	15	206	206	208	211	215	219	224	230	235	238	240	241	241	240	239	237	235	232	229	225	221	216	211	207
	16	221	222	224	228	232	237	243	248	251	253	254	254	253	252	250	248	245	242	238	234	230	225	222	
	17	236	237	240	244	249	255	269	263	265	266	266	266	266	265	264	262	260	257	254	250	247	243	239	236
	18	251	253	256	261	267	272	275	277	278	278	278	278	277	276	274	272	269	266	263	260	257	253	251	
	19	267	269	273	279	284	287	289	290	290	290	290	290	289	288	286	284	281	279	276	274	271	268	266	
	20	283	286	291	296	299	301	302	302	302	302	302	301	300	298	296	294	292	290	288	286	283	282		
	21	300	304	308	311	313	314	314	314	314	314	314	314	313	312	310	309	307	306	304	303	301	299	298	
	22	318	321	323	325	326	326	326	326	326	326	326	326	325	324	323	322	321	320	319	318	317	316	315	
	23	335	336	337	338	338	338	338	338	338	338	338	338	337	337	336	336	335	335	334	334	333	332	333	
	24	350	350	350	350	350	350	350	350	350	350	350	350	350	350	350	350	350	350	350	350	350	350	350	

A, restraint working time; B, starting time (Association of Industrial Hygiene).

Table 6. Evaluation chart of the effect of sleep.

		B																							
		8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	1	2	3	4	5	6	7
A	1	9	8	8	8	8	8	8	8	8	9	9	9	10	10	11	12	12	12	12	12	11	11	10	
	2	19	18	18	18	18	18	18	19	20	20	21	22	22	25	26	26	26	26	26	25	24	24	21	
	3	29	28	28	28	28	28	29	30	31	32	33	35	37	39	40	40	40	40	39	38	36	36	31	
	4	39	38	38	38	38	39	40	41	43	44	46	49	51	53	54	54	54	53	52	50	47	47	41	
	5	48	47	47	47	47	48	49	50	52	54	56	59	62	64	66	67	67	66	65	63	60	56	53	50
	6	56	55	55	55	56	57	58	60	62	65	68	71	74	75	78	79	78	77	75	72	68	64	58	
	7	64	63	63	64	65	66	68	70	73	77	80	83	86	88	90	90	89	87	84	80	76	72	69	66
	8	71	70	71	72	73	75	77	80	84	88	91	94	97	99	100	100	98	95	91	87	83	79	76	73
	9	77	77	78	79	81	83	86	90	94	98	101	104	107	108	109	108	105	101	97	93	89	85	82	79
	10	84	84	85	87	89	92	96	100	104	108	111	114	116	117	117	115	111	107	103	99	95	91	88	86
	11	91	91	93	95	98	102	106	110	114	118	121	123	125	125	124	121	117	113	109	105	101	97	94	92
	12	98	99	101	104	108	112	116	120	124	128	130	132	133	132	130	127	123	119	115	111	107	103	101	99
	13	106	107	110	114	118	122	126	130	134	137	139	140	140	138	136	133	129	125	121	117	113	110	108	106

A, sleeping time; B, bedtime (Association of Industrial Hygiene).

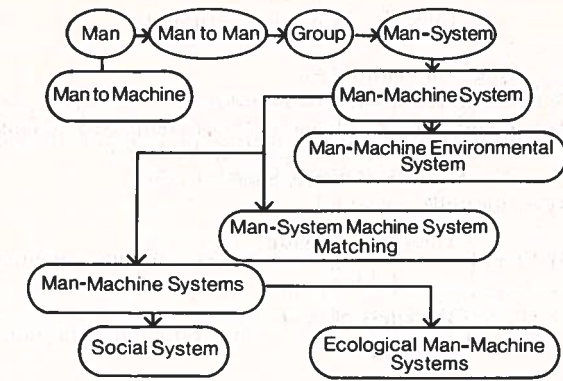


Figure 3. Development of the concept of systems.

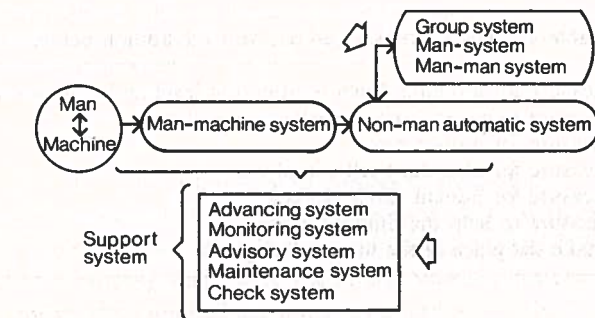


Figure 4. System which is necessary to the man-machine system.

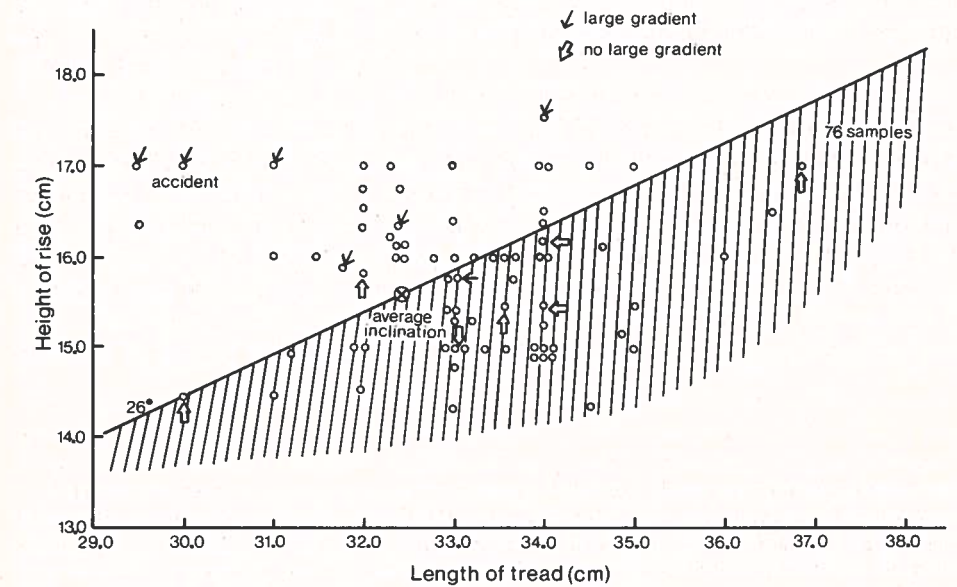


Figure 5. Dimension of steps (76 examples).

Table 7. Principle of visibility.

(1)	Visibility = $a \log(\text{illumination}) + b$
(2)	Visibility = $a' \log(\text{difference of value}) + b'$
(3)	Visibility = $a'' - b''$ (number of characters or complexity of figure) = $a''' + b'''$ (size of figure, $a + b/2$, diameter) = $a'''' + b''''$ (size of figure, area)
(4)	Visibility = $c \log(\text{reflectance}) + d$
(5)	Visibility = $e + f \left(\frac{\text{Thickness of figure}}{a + b/2}, \text{ under optimum condition} \right)$ = $g - h \left(\frac{\text{thickness of figure}}{a + b/2}, \text{ over optimum condition} \right)$ or $\frac{\text{area of figure only}}{a \times b} (\%)$

Table 8. The technology to back-up the human being.

(1)	Countermeasure for levelling down of attention level and consciousness level
(2)	Countermeasure to cover forecast performance of man
(3)	Countermeasure for human error
(4)	Countermeasure for abundant self-confidence
(5)	Countermeasure for human carelessness
(6)	Countermeasure to help the thinking power
(7)	Robot to take the place of the human being

Human-computer communications with special reference to technological developments, occupational stress and educational needs*

By GAVRIEL SALVENDY

Human Factors Program, School of Industrial Engineering,
Purdue University, West Lafayette, Indiana 47907, U.S.A.

The rapid development of computer technology is reviewed and its impact on employment and on the gross national product is mentioned. The process of designing an effective human-computer communication system is outlined, the role of job satisfaction is mentioned and methods which can be utilized to minimize (or optimize) occupational stress in human-computer communication work environment is discussed. The impact of utilizing high technology on the educational needs of ergonomists are outlined.

1. The emergence of computer technology

The information processing industry as we know it today, with revenues exceeding \$100 U.S. billion and effects on virtually every part of our national life, had its origin in a few powerful ideas. Among them were the binary number system, Boolean algebra, the mechanical adder, the punched card, the Jacquard loom, the Hollerith tabulator, the stored program, and the concept of a high-level programming language. Complex technological and social forces accelerated the development of these ideas and led to the modern computer, but the most influential force by far was economic demand. The computer made it possible to do the same work for less money. As the cost decreased and the function increased, use of the computer was rapidly extended to new and different kinds of work (Opel 1981).

Figure 1 illustrates that in the past 30 years the price per one second of instruction has decreased drastically such that a computation which now costs \$1 would have cost about \$30,000 in 1950. If the automobile industry had incorporated equivalent cost reductions, one could now buy a new car for less than \$1. This marked reduction in the cost of calculations was closely associated with significant increases in memory product density (figure 2). In effect, during the past 15 years the memory product density has increased such that an area which in 1965 could accommodate only one bit, now, the same area, can accommodate over 1000 bits. These technological innovations of increases in density of bits per unit area and decrease in cost of computations were

* This work was supported by control number 210800034 from the National Institute of Occupational Health and Safety (NIOSH), John Etherton, program manager. The author is indebted to Professor Masamitsu Oshima, General Chairman of the Eighth International Ergonomics Congress, for inviting him to present this paper. The author is indebted to Dr. Bruce Rupp, Coordinator of Ergonomics and Scheduling, IBM Corporation, for bringing to his attention the 25th Anniversary Issue of the *IBM Journal of Research and Development*.

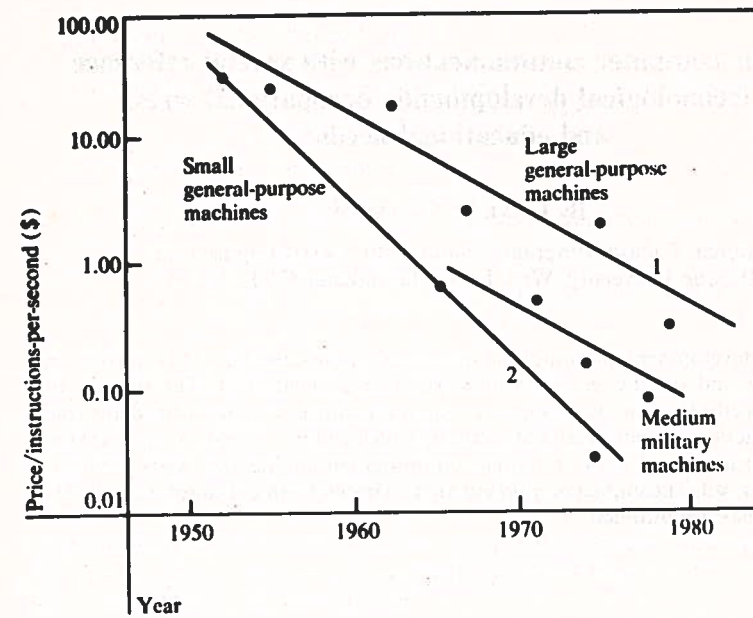


Figure 1. Computer price-performance trends. Curve 1 represents an average improvement for large general-purpose machines of 15% per year; Curve 2 represents an average improvement for small general-purpose machines of 25% per year. (After Olsen and Orrange 1981.)

largely responsible for the emergence and rapid growth of the micro-computers for business and personal use. The fact that circuit reliability has also increased 1000 fold (figure 3) has contributed to the wider acceptance and use of computer technology such that in 1980 \$355 was spent in the United States per capita on data processing which accounted to 5.2% of the gross national products. It is predicted that by the year 1995 these figures for the United States will be respectively \$2,400 and 21% (figure 4).

Although there are no accurate figures on the number of people who interact with computers at the workplace, various estimates suggest that close to 10 million people are working on Visual Display Terminals (VDT) in the United States and that this figure is likely to increase to 25 million by 1990. By the year 2000, as figure 5 illustrates, we can expect the widespread use of VDTs in all occupational settings including an office systems network (figure 6). In view of the above, it is no wonder that the fastest growing jobs are in the computer-related fields (table 1) and that by the year 2000 the blue collar jobs will account only for a fraction of total employment (table 2). However, for some years to come, humans will be working adjacent to robotized and automated work environment which will create many human problems (Nof *et al.* 1980, Kamali *et al.* 1982); most significant of which would be the social and psychological consequences of isolation of work and workers' safety in computer-controlled work environment and its work pacing consequences on job satisfaction and occupational stress (Salvendy and Smith 1981, Salvendy 1982).

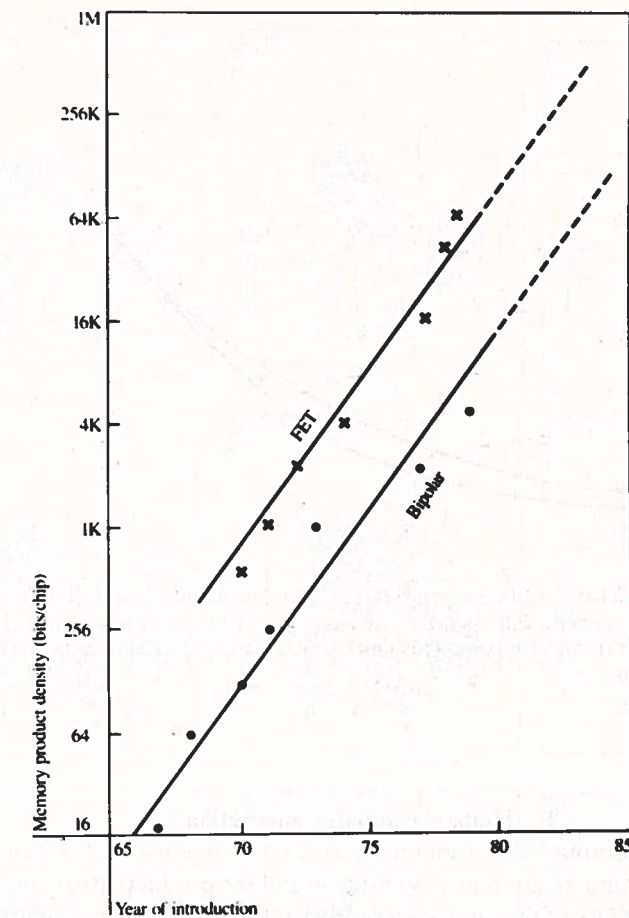


Figure 2. Productivity growth for bipolar and FET memory chips. The dots and crosses mark actual products. (After Harding 1981.)

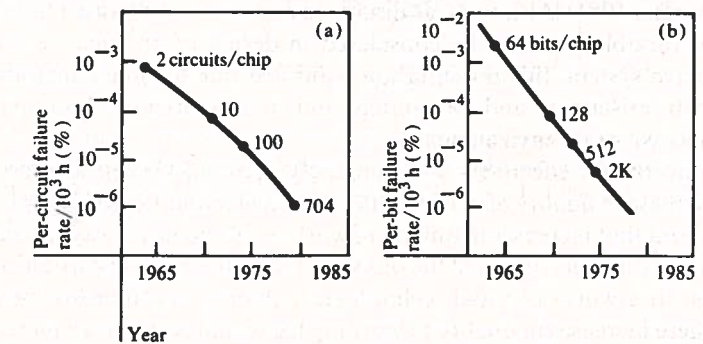


Figure 3. Intrinsic failure rate improvement trends for IBM technology. (a) Logic circuit reliability, where the per-circuit per cent failure rate is given per 10^3 hours. The numbers noted on the curve refer to the number of circuits per chip. (b) Bipolar memory reliability, where the per-bit per cent failure rate is given per 10^3 hours and the numbers noted on the line refer to the number of bits per chip ($K=1024$). (After Hsiao *et al.* 1981.)

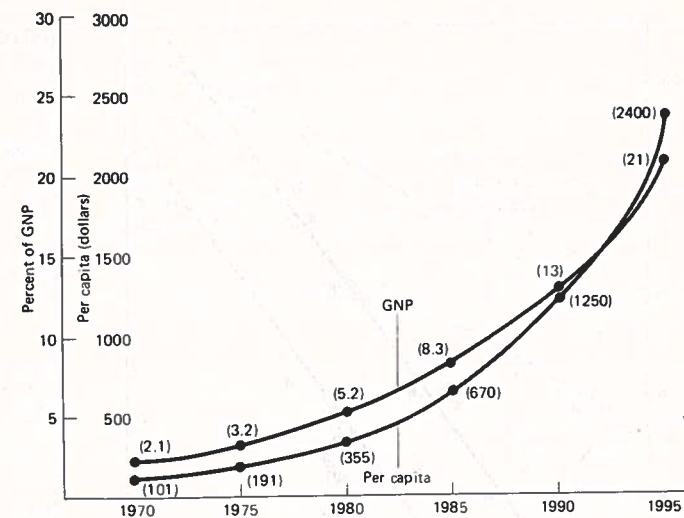


Figure 4. Forecast of United States spending on data processing. Users of data processing equipment and services will spend an amount that will increase to 21% of the gross national product (GNP) by 1995. This amount will equal \$2,400 per person. (After Gore and Stubbe 1979.)

2. Human-computer interaction

Working with computerized technology ergonomists must ensure not only the health, safety, social and psychological well-being and the productivity of the operators but also the productivity of the human-computer interactive system (e.g. Seppala and Salvendy 1982). The ergonomist must also evaluate worker aptitude, skills and knowledge to assess trainability for computer technology related jobs (Borman and Peterson 1982). These effects of technological change on human well-being have been effectively covered in two recent union publications (Channot and Baggett 1979, Channot and Dymmel 1981). Although, as discussed above and illustrated in figure 7, many ergonomic variables have to be considered in design of an effective human-computer interactive system, this presentation is limited due to time constraints, to brief referral to job satisfaction and job content and to a discussion of occupational stress in computerized work environment.

The above concerns for effectively and humanely accommodating workers leads generally to an increase in quality of working life. But Lawler and Ledford (1981-1982) are quick to point out that increases in quality of working life do not always necessarily lead to increase in productivity; much of the outcome for such a relationship depends on situational forces. In a world of rapid technological change, ergonomists must first focus on areas where increases in quality of working life would result in an increase, or at least the maintenance of *status quo* regarding productivity improvements. We definitely cannot afford a quality of working life paradigm which results in decreased productivity. In this regard one feels compelled to point out that job enrichment does not always lead to increased job satisfaction and productivity. Based on experimental evidence, Salvendy (1978) points out that equal numbers of people are more satisfied,

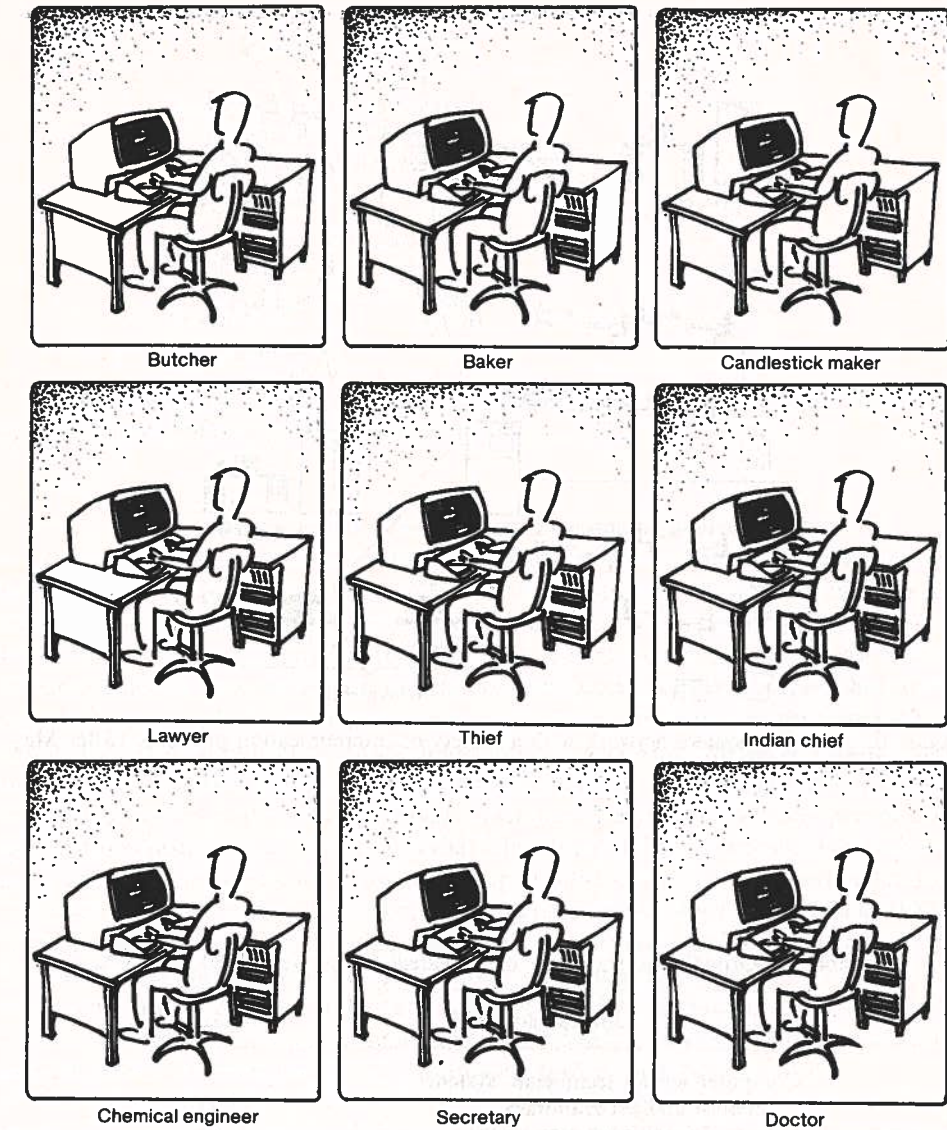


Figure 5. Computer technology will impact on virtually every occupational area and thus the need for designing flexible human-computer interactive systems will increase. (Figure drawn by Robert Karasek and Laurie Beck of Columbia University. Idea by Gunilla Bradley of Sweden.)

productive and prefer to work at simplified jobs as prefer to work at enriched jobs at which they are more productive and satisfied. About 10% of the labour force does not like any work. Usually the young and more educated people preferred enriched jobs whereas the older workers with less years of formal schooling preferred simplified jobs. This has broad implications for job allocation between computers and humans.

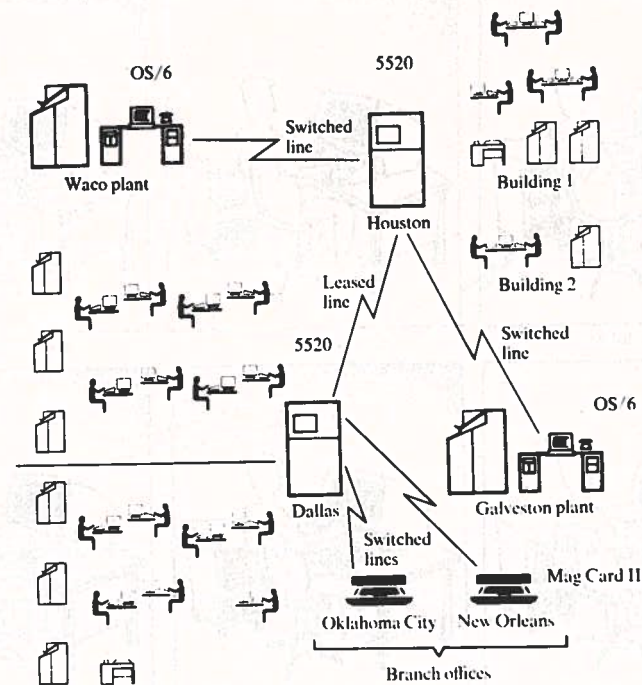


Figure 6. An office system network with a variety of communication products. (After May 1981.)

Table 1. Growth and shrinkage of job categories between 1980 to 2000*.

Job categories	Index
Computer service technician; systems analyst and programmers	100
Industrial machinery repairman	60
Occupational therapists	50
Dental hygienists	40
Postal clerks	-25
Secondary school teachers	-40
Private household workers	-70
Merchant marine sailors	-90
Railroad station agents	-140

* Data interpolated from: 1980, *Occupational Projections and Training Data*, Bureau of Labor Statistics, Bulletin 2058, Washington, D.C.

Table 2. Predicted most common jobs in the United States in the year 2000*

Job category	Index
Clerical and secretarial workers	100
Retail trade sales workers	70
Nurses (registered and aides)	60
Building custodians	50
Cashiers	30
Local truck drivers	30
Engineers	25
Blue collar worker supervisors	25
Bookkeepers	20
Industrial assemblers	15

* Data interpolated from: 1980, *Occupational Projections and Training Data*, Bureau of Labor Statistics Bulletin in 2058, Washington, D.C.

3. Occupational stress in human-computer interaction

As indicated above, because of time and space constraints much of the discussion below focuses on occupational stress. Occupational stress is suspected to be a major cause for cardiac and stomach disorders. Stress affects all segments of our society—both leisure and work activities. Selye (1975) has argued (figure 8) that the stress level is the same whether the experience is pleasant or unpleasant. Selye also argued that stress cannot be decreased to zero since we always experience some stress. Stress is frequently associated with attention, arousal, information processing, decision making and uncertainty. The new technologies of human-computer interaction require, during task performance, high attention modes since under certain conditions people can perform two tasks at once. The things that affect their ability to perform, two tasks at once, are such as uncertainty of signals, compatibility of input and output codes, the amount of practice, and similarity between the components of the tasks (Posner 1982). In making effective decision making the storing of information in long-term memory is critical (Posner and McLeod 1982). In human-computer interactive work one may be called only infrequently to make decisions, the fact that the human must store task relevant information in long-term memory may indicate an increase in mental loading and subsequently stress during the monitoring part of task performance.

Salvendy *et al.* (1982) evaluated the impact of new technology on human stress by comparing two-hand push-button actuators on power presses with optically sensed and electronically controlled self-tripping actuators. As a result of a statistically balanced industrial study in which heart rate and blood pressure data were unobtrusively monitored during the entire work day, the data indicated that although the productivity output was 30% higher for the self-tripping than for the two-hand control, there were no statistically significant or clinically meaningful differences in the stress levels between using the two actuators. Interestingly there was no significant relationship between stress and production output for the self-tripping system whereas a significant 0.53 correlation was present between heart rate data and production output for the two-hand control. Yet personality measures assessed by the Eysenck Personality Inventory indicated that for the two-hand control there was no relationship between stress levels and operators' personality make-ups. However, for the self-tripping system, extroverted operators had higher stress level ($r=0.81$; $p<0.05$). This

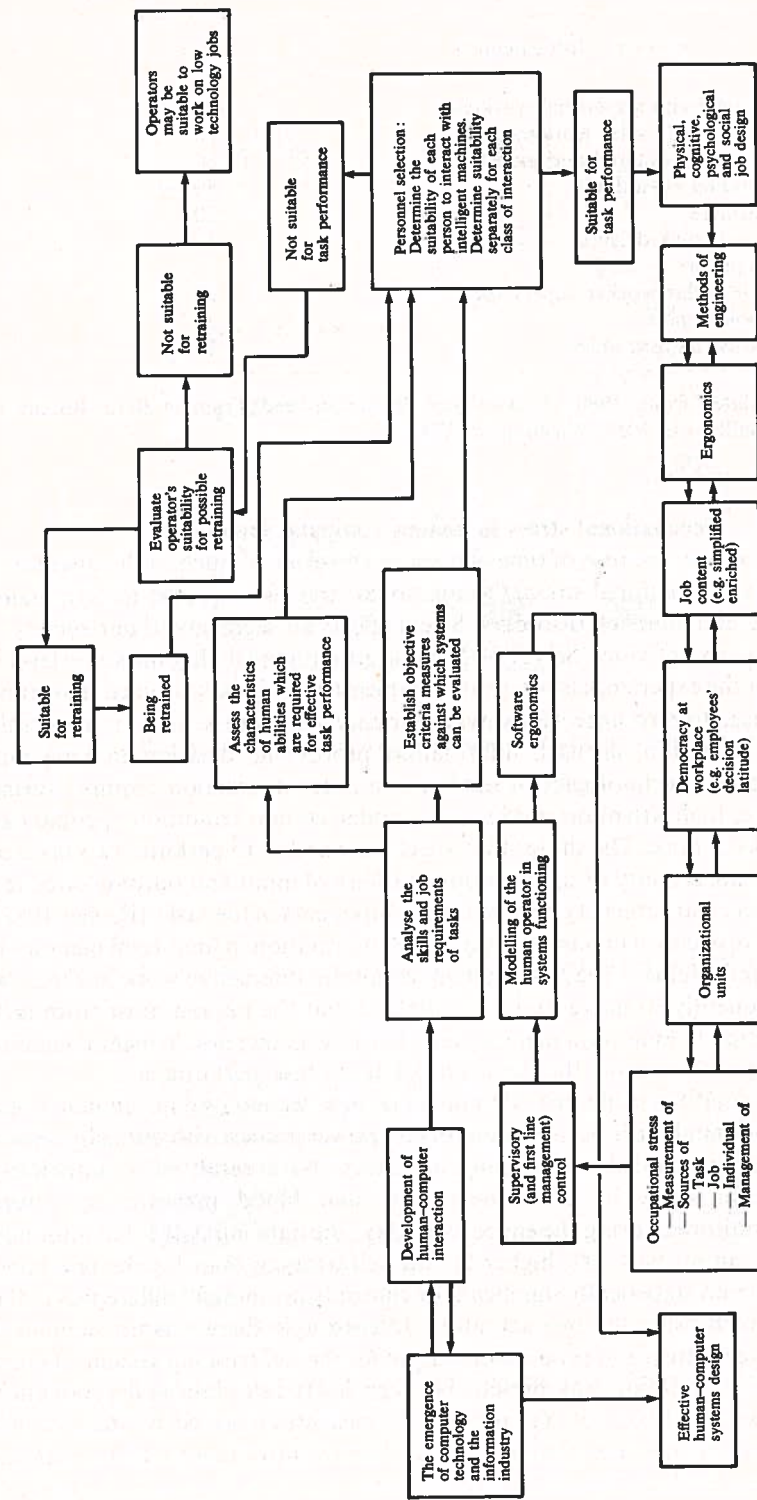


Figure 7. Schematic presentation of the process of designing an effective human-computer interactive work environment. Note that a variety of conventional and contemporary methodologies are needed to be utilized in order to design effectively a human-computer interactive work environment.

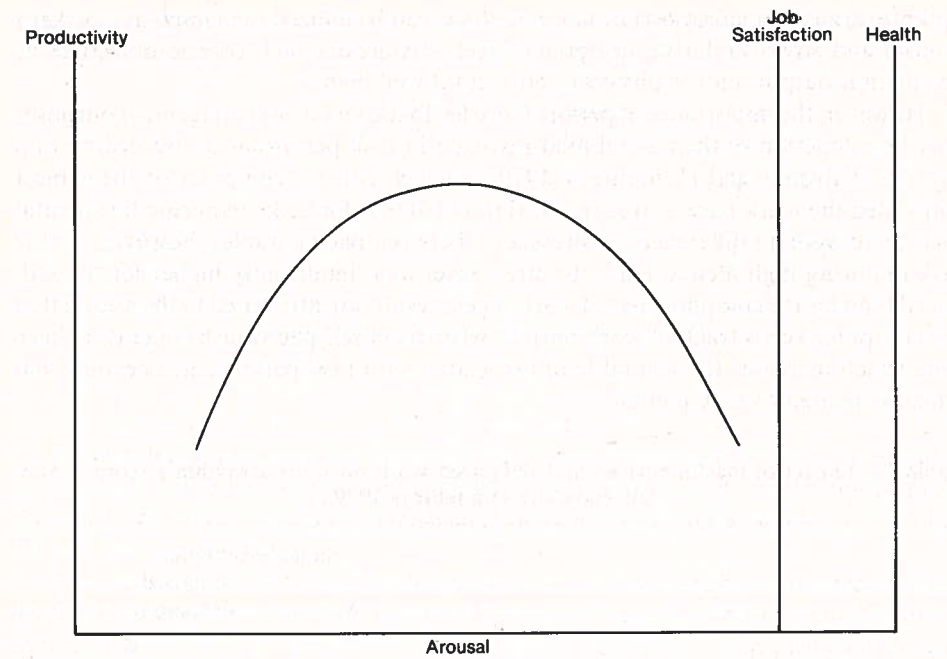


Figure 8. Too much or too little arousal for task performance results in low productivity, job satisfaction and worker's health. There is an optimal region of arousal needed for maximizing productivity, job satisfaction and worker's health. This optimal region may vary depending on the criterion to be optimized.

may have broad implications for the assignment of people to high technology jobs and for the design of human and intelligent machine interactions.

The notion that immediate performance feedback accelerates the training process (Holding 1981) and improves worker motivation (Ilgen *et al.* 1979) is well known. Performance feedback has another useful function, Knight and Salvendy (1981) demonstrated (table 3) that as the performance feedback is made more exact, the worker's stress decreases. When the same subjects performed the same task under different modes of performance feedback, it is apparent that when no performance feedback is provided the subject's stress level was nearly twice as high as when the subjects received exact performance feedback. As figure 8 illustrates, since we want to

Table 3. Effects of performance feedback on stress. (After Knight and Salvendy 1981.)

Work condition	Stress index*
Self-paced	
No feedback	100
Cycle feedback	90
Time feedback	86
Combined time and cycle feedback	57
Machine-paced	62

* A difference in the stress index of six or more units is statistically significant at 5% level.

optimize arousal or stress, performance feedback can be utilized to manipulate worker's arousal and stress to derive an optimal level maximizing such criteria objectives as production output and/or physical and mental well-being.

However, the importance of performance feedback for stress management purposes may be a function of the mental load involved in task performance. According to a study by Salvendy and Humphreys (1979) in which either a computer or the subject controlled the work pace, it was revealed (table 4) that for tasks requiring low mental load there were no differences in stress level between pacing modes; however, for the task requiring high mental load, the stress level was significantly higher for the self-paced than for the computer-paced work. These results are attributed to the notion that the computer keeps track of work output; whereas in self-paced tasks operators keep time which increases the mental load associated with task performance beyond that which is related to task content.

Table 4. Impact of machine-paced and self-paced work on sinus arrhythmia scores. (After Salvendy and Humphreys 1979.)

	Sinus arrhythmia	
	Mean	Standard deviation
Task with low perceptual level		
Machine-paced	0.66	0.15
Self-paced	0.69	0.13
Task with high perceptual level		
Machine-paced	0.90	0.18
Self-paced	0.55	0.16

During the workshop, following the International Conference on Machine-Pacing and Occupational Stress (Salvendy and Smith 1981), it was suggested by the participating scientists that the most critical variable effecting stress on paced work is the length of the cycle time associated with a job. This notion was tested in a pilot experimentation (Salvendy *et al.* 1982) suggesting the possibility that for both machine-paced and self-paced tasks stress decreases as cycle time increases. In this case, as in real-world industrial work situations, short and longer cycle times are confounded with simplified and enlarged jobs; hence, it is not feasible to assess whether it is the length of cycle or changes in the job content which cause this possible significant interaction.

Another variable, affecting occupational stress, in human-computer interaction is anticipation of systems delays lasting a few seconds. In this connection, one question is its impact on stress. Sharit and Salvendy (1982) answered these questions (table 5) by pinpointing that when the task performed prior to or after systems delay requires external attention (e.g. visual detection), the stress level during the anticipatory systems delay was significantly lower than for tasks requiring internal attention (e.g. arrhythmic problems).

Together with the significant pacing effect these results suggest that when a computer system is shared with more than one class of task activities, then from a human stress point of view, system delays should occur for those tasks that are self-paced (rather than computer-paced) and require external (rather than internal) attention.

Table 5. Acceleration and deceleration in heartbeats (per minute) as a function of job content, job design and the nature of financial incentive. Data after Sharit and Salvendy (1982).

	No financial incentive		Financial incentive	
	M/P	S/P	M/P	S/P
External attention	66	63	68	62
Internal attention	71	69	75	72

Mean starting heartbeat 72 beats per minute.

4. Implication

Accelerated application and use of human-computer communications has major implications for training and employment of ergonomists and for development of effective research methodologies which could enhance significantly quality of working life and standard of living.

As a result of rapid technological developments, especially in computer technology, the field of ergonomics matured to a level that is no longer feasible to train effectively general ergonomists. In such fields as engineering, psychology, and medicine, people are trained in specialty areas because it is not possible to train 'general engineers. Although there is only one ergonomist for every 350 engineers in the United States, the reasons for urgent need for specialty training in ergonomics emerges due to the following:

- (1) The technology with which humans interact has reached a high level of technical sophistication for which the ergonomist must possess not only behavioural but also technological skills and knowledge. When technology was relatively simple, ergonomists substituted good common sense for technological know-how. But this no longer derives an effective design for high-technology utilization.
- (2) The behavioural basis of ergonomics has also been broadened to include greater emphasis on computer technology and applied mathematics (especially mathematical modelling) in addition to the conventional methodologies.
- (3) Based on this it appears that increased emphasis should be in the following three areas:
 - (a) *Software ergonomics*. Since computer software determines the structure of a job, ergonomists must be trained as computer systems analysts so that the newly developed software is ergonomically based.
 - (b) *Systems ergonomics*. While the process of developing a new body of knowledge in each of the areas which make up a systems functioning continues, a conceptual methodology integrating separate components into unified systems ergonomics is essential.
 - (c) *Mathematical ergonomics*. When individual components are conceptually integrated to systems functioning, the role of each variable in systems effectiveness is operationally identified and quantitatively measured. But mathematical ergonomics is in its infancy because, (1) many ergonomists, presumably due to prior training (or the lack of it), shy away from mathematical ergonomics; (2) in many instances lack of ergonomic data on

individual variables increases the difficulty of mathematically quantifying them; and (3) many assumptions underlined in mathematical modelling, especially in stochastic processes, cannot be met in real-world situations.

Cet article fait le point sur le développement rapide de la technologie des calculateurs et de ses conséquences sur l'emploi et le produit national brut. On souligne quel devrait être le processus pour la conception d'un système efficace de communication Homme-calculateur, l'impact sur la satisfaction au travail et on indique quelles techniques pourraient être utilisées pour minimiser (ou optimiser) l'astreinte liée au travail dans une situation de communication Homme-calculateur. On souligne également l'impact de l'utilisation d'une haute technologie sur les besoins de formation des ergonomes.

Die rasche Entwicklung der Computertechnik wird hinsichtlich ihres Einflusses auf Beschäftigung und Bruttosozialprodukt untersucht. Der Gestaltungsprozeß für ein leistungsfähiges Mensch-Rechner-Kommunikationssystem wird beschrieben und die Bedeutung der Arbeitszufriedenheit erwähnt. Ferner werden Methoden beschrieben, deren Einsatz den aus dem System der Mensch-Rechner-Kommunikation resultierenden Berufsstress minimieren (oder optimieren) soll. Die Auswirkungen hochtechnisierter Verfahren auf die Ausbildungsbedürfnisse von Ergonomen werden aufgezeigt.

References

- BORMAN, W. C., and PETERSON, N. G., 1982, 'Selection and training of personnel.' In *Handbook of Industrial Engineering* (Edited by G. SALVENDY) (New York: JOHN WILEY & SONS).
- CHANNOT, D., and BAGGETT, J. M. (Editors), 1979, 'Silicon, satellites and robots.' *The Impact of Technological Change on the Workplace* (Department of Professional Employees, AFL-CIO, Washington, AFL-CIO, Washington, D.C.).
- CHANNOT, D., and DYMME, M. D. (Editors), 1981, *Cooperation of Conflict: European Experiences with Technological Change at the Workplace* (Department of Professional Employees, AFL-CIO, Washington, D.C.).
- GORE, M. R., and STUBBE, J. W., 1979, *Computers and Data Processing* (New York: MCGRAW-HILL BOOK COMPANY).
- HARDING, W. E., 1981, Semiconductor manufacturing in IBM, 1957 to the present: A perspective. *IBM Journal of Research and Development*, **25**, 647-658.
- HOLDING, D. H., 1981, *Human Skills* (New York: John Wiley & Sons).
- HSIAO, M. Y., CARTER, W. C., THOMAS, J. W., and STRINGFELLOW, W. R., 1981, Reliability, availability, and serviceability of IBM computer systems: A quarter century of progress. *IBM Journal of Research and Development*, **25**, 453-465.
- ILGEN, D. R., FISHER, C. D., and TAYLOR, M. S., 1979, Consequences of individual feedback on behavior in organization. *Journal of Applied Psychology*, **64**, 349-371.
- KAMALI, J., MOODIE, C. L., and SALVENDY, G., 1982, A framework for integrated assembly systems: humans, automation and robots. *International Journal of Production Research*, **20**, 431-448.
- KNIGHT, J. L., and SALVENDY, G., 1981, Effects of task feedback and stringency of external pacing on mental load and work performance. *Ergonomics*, **24**, 757-764.
- LAWLER III, E. E., and LEDFORD, G. E. Jr., 1981-1982, Productivity and the quality of work life (National Productivity Review). *The Journal of Productivity Management*, **1**, 23-36.
- MAY, F. T., 1981, IBM word processing developments. *IBM Journal of Research and Development*, **25**, 741-753.
- NOF, S., KNIGHT, J., and SALVENDY, G., 1980, Effective utilization of industrial robots: A job and skills analysis approach. *A.I.I.E. Transactions*, **12**, 216-225.
- OLSEN, P. F., and ORRANGE, R. J., 1981, Real-time systems for federal applications: A review of significant technological developments. *IBM Journal of Research and Development*, **25**, 405-416.
- OPEL, J. R., 1981, Message from the President and Chief Executive Officer. *IBM Journal of Research and Development* (25th Anniversary Issue), **25**, front page.
- POSNER, M. I., 1982, Cumulative development of attentional theory *American Psychologist*, **37**, 168-179.
- POSNER, M. I., and MCLEOD, P., 1982, Information processing models—in search of elementary operations *Annual Review of Psychology*, **33**, 477-514.
- SALVENDY, G., 1978, An industrial engineering dilemma: Simplified versus enlarged jobs. In *Production and Industrial Systems: Future Development and the Role of Industrial and Production Engineering* (Edited by R. MURAMATSU and N. A. DUDLEY (London: TAYLOR & FRANCIS, LTD)).
- SALVENDY, G., 1982, Occupational stress: A significant contributor to effective utilization of technology. *International Journal of Production Research*, **20**, 409-416.
- SALVENDY, G., EVANS, R., and UPTON, D., 1982, Impact of stringency in job design on the stress associated with computer-paced and self-paced work. A Pilot Study, Unpublished Report, Human Factors Program, School of Industrial Engineering, Purdue University, West Lafayette, Indiana 47907.
- SALVENDY, G., and HUMPHREYS, A. P., 1979, Effects of personality, perceptual difficulty and pacing of a task on productivity job satisfaction and psychological stress. *Perceptual and Motor Skills*, **49**, 219-222.
- SALVENDY, G., SHODJA, S., ETHELTON, J., and SHARIT, J., 1982, Stress implications of working on self-tripping and two-hand control actuators in power press operations. Unpublished Report, Human Factors Program, School of Industrial Engineering, Purdue University, West Lafayette, Indiana 47907.
- SALVENDY, G., and SMITH, M. J. (Editors), *Machine Pacing and Occupational Stress* (London: TAYLOR & FRANCIS LTD).
- SELYE, H., 1975, Confusion and controversy in the stress field. *Journal of Human Stress*, June, **1**, 37-44.
- SEPPALA, P., and SALVENDY, G., 1982, Decision making styles and productivity of first-line managers in computerized flexible manufacturing systems. Unpublished Report, Human Factors Program, School of Industrial Engineering, Purdue University, West Lafayette, Indiana 47907.
- SHARIT, J., and SALVENDY, G., 1982, Occupational Stress: Review and reappraisal. *Human Factors*, **24**, 129-162.

Abstract

Modelling of human performance in complex systems with emphasis on nuclear power plant operations and probabilistic risk assessment

By A. D. SWAIN

Sandia National Laboratories, Albuquerque, New Mexico 87185, U.S.A.

Human activities in many complex systems are required for various maintenance, calibration, testing, and other normal operations as well as for coping with unusual events that place a system at risk. In general, each human in the system must perceive information (from displays or from written or oral instructions) about the state of that part of the system for which he has some responsibility. He must then process that information to determine what actions, if any, he should take. Then he must take the appropriate actions. While there can be general agreement with this rather gross qualitative description of the role of the human in a complex system, the details of human interaction with a system are less easy to understand or describe. This problem is increased by the fact that for many important system functions, especially those called on in response to unusual events, the interaction of two or more people is required.

These difficulties are somewhat lessened, though they are still formidable, if the requirement is to model the role of the human only for the purpose of probabilistic risk assessment. In this case, some of the detailed human response mechanisms can be represented by more general statements, and these statements can be presented in the form of estimates of human error probabilities as a function of the time available to respond appropriately to system events. This lecture presents a general qualitative model of human performance and some specific quantitative models to assess the probabilities of human errors in nuclear power plants in responding to system events requiring cognitive behaviour (i.e. interpretation and decision-making) and for assessing the dependence among different people in the system and/or within the actions performed by one person. These and other models have been used in recent probabilistic risk assessments of nuclear power plants in the United States.

A. BASIC STUDY OF HUMAN CHARACTER

A 1. Work Load and Performance of Muscular Work

An Ergonomic Evaluation of Working Postures in Manual Weight Lifting

By M. MORIOKA, A. KIMURA, K. KISHIDA, S. HORINO and M. SAITO

Department of Hygiene, Nihon University School of Medicine,
30 Ohyaguchi-Kamimachi, Itabashi-ku, Tokyo 173, Japan

Two kinds of weight lifting postures are frequently used by industrial workers; lifting with the knees bent and the spine stretched (KB) and lifting with the knees stretched and the spine bent (KS). The former has been recommended as a desirable posture to prevent back lesions, but the latter is rather prevalent in industrial workshops. The energy metabolism and the electromyograms of active muscles were compared between the two postures. The muscle load of the KB posture proved to be larger than the KS posture, which would be a reason why many workers are reluctant to take that posture. The larger displacement of the centre of gravity in the KB posture would also be relevant. When we compared efficiency of lifting between various weight and height differences, we came to the conclusion that the weight of lifting should not be more than 20 kg in the case of a lifting height of less than 1 m. This economically desirable weight should be reduced to 10-15 kg in the case of a lifting height of 1.2-1.8 m. From the point of view of preventing low back pain, the emphasis of preventive measures should be placed on the aspect of work organization, i.e. setting up the upper limit of the total amount of weights lifted per day and arranging the most appropriate work-rest schedules as well as adjusting the weight of a single load and the handling frequency in relation to the individual physical capacities of the workers.

Compressive Load at L₅/S₁ Spine Level as a Biomechanical Factor During Various Lifting Techniques

By T. P. J. LESKINEN, H. R. STÅLHAMMAR and I. KUORINKA

Back Laboratory, Department of Physiology, Institute of Occupational Health, Laajaniityntie 1,
SF-01620 Vantaa 62, Helsinki, Finland

J. D. G. TROUP

The Department of Orthopaedic and Accident Surgery, University of Liverpool, Liverpool, England

The relative severity of lifting techniques and differences in lifting methods can be precisely evaluated when all elements of a lifting task are applied. Relevant biomechanical parameters for the body and its segments must be considered to achieve a better evaluation of the stress imposed on the spine.

The compressive load on the lumbosacral disc was computed by the dynamic biomechanical model which includes the effects of acceleration on the body and the load. Each of the 20, healthy men used four lifting techniques: the back lift, the leg lift, the box kinetic lift and the body kinetic lift. By using back and leg lifts the box, which weighed 15 kg, was lifted without preliminary movement of the body. These two kinetic lifts made use of the kinetic energy of the box and the body.

The data were obtained from a 60 × 60 cm force-plate, from which the force applied to the ground by the feet was recorded, 'The Selspot System', which recorded the displacements of the body segments and the accelerometers by which the accelerations of the box were recorded.

Preliminary comparisons between the maximums of the calculated compressive load at the L₅/S₁ level in various lifts showed slight differences between the 'non-kinetic' lifts. The kinetic lifts seemed to create greater loads on the spine. Presumably the kinetic energy transfers from the body to the object to be lifted may be more strenuous when lifting occurs in narrow space.

Recommended Work Rates and Container Configuration for Manual Lifting and Lowering Activities

By A. MITAL

Department of Mechanical and Industrial Engineering, University of Cincinnati, Cincinnati, Ohio 45221, U.S.A.

S. S. ASFOUR

Department of Industrial Engineering, University of Miami, Coral Gables, Florida 33124, U.S.A.

and M. M. AYOUB

Department of Industrial Engineering, Texas Technical University, Lubbock, Texas 79409, U.S.A.

To avoid injuries resulting from manual materials handling, it is essential to define the capacity limits of individuals and operate within them. One approach to determine the working capacity of individuals has been to study the amount of weight people are willing to handle (psychophysical) at different frequencies and heights of lift. Another approach has been to screen the jobs based on a physical work capacity limit of 5 kcal/min (physiological) for an 8-hour continuous work period. It has been suggested that manual activities requiring more than 33% of the maximum aerobic power (15–16 kcal/min) for an 8-hour continuous work period should be considered as fatigue generating activities.

There have been several studies in the past in which researchers have measured the metabolic energy expenditure rate of individuals performing manual materials handling activities to get an estimate of the imposed stress. The purpose of this work was: (1) to compare the data generated in the studies by Mital (1980), Asfour (1980) and Mital and Ayoub (1981) with the metabolic energy expenditure rates measured in the past studies (Aquilano 1968, Hamilton and Chase 1969, Garg and Saxena 1979) and the metabolic energy expenditure rate predicted by various models (Garg 1976); (2) to compare the psychophysical and the physiological approaches; (3) to determine the optimal container configuration for lifting and lowering activities based upon the physiological approach and (4) to recommend work rates (combinations of load, frequency and vertical height) which meet the physiological approach ceiling of 5 kcal/min.

It appears that within a narrow frequency range (4 and 6 kcal/min), the psychophysical and the physiological approaches are in agreement. The two approaches also agree with the conclusion that between the load and the work rate, work rate is relatively much more important. Based on the available data and recent studies, recommendations are made for the optimal container configuration and work rates.

Guidelines for Permissible Limits for One-handed Lifts by Women

By A. GARG

Industrial and Systems Engineering, P.O. Box 784, University of Wisconsin, Milwaukee, Wisconsin 53201, U.S.A.

This research was initiated to develop guidelines for permissible limits for one-handed lifts in the horizontal plane by female workers based on object weight, reach distance and frequency of lifts. Several anthropometric measurements were made on ten female volunteers to characterize the population. Twelve different combinations of load, reach distance and frequency were used for one-handed lifting. The subjects were trained on one-handed lifting tasks for a period of 8 weeks. Several physiological measurements were made at different time intervals while the subjects performed one-handed lifting for a period of 1 hour.

Oxygen uptake, blood pressure (systolic and diastolic) and grip strength showed little change with an increase in work intensity. Statistical analysis showed that the maximum oxygen uptake rates for one-handed lifting (0.54–0.82 l/min) were significantly lower than those observed for arm and bicycle ergometer ($p < 0.05$). Heart rate and EMG amplitude for isometric exertion measured at 30 and 60 min from the beginning of work were higher than those measured at the beginning of work. Discomfort from one-handed lift perceived on Borg Scale was maximum for shoulder and back. Maximum frequencies acceptable to the subjects were 51% of the maximum frequency that they could maintain for a period of 4 min.

Effects of training, load and reach distance on work capacity are discussed. Effects of load and distance on maximum frequency acceptable to the subjects and the resulting heart rate and rating of perceived exertion are also discussed. General recommendations are proposed for the design of workplace layout and tasks involving arm work.

An Ergonomic Approach to Reduce Hazards of Lifting Tasks

By M. M. AYOUB

Department of Industrial Engineering, Texas Technical University, P.O. Box 4130, Lubbock, Texas 79409, U.S.A.

A psychophysical approach has been utilized to determine the lifting capabilities of the U.S. industrial population to lift loads under varied task variables. The specific task variables selected in these studies were: the height of lift, the frequency of lift and the container or load size. Based on the data generated, 'capacity' distributions were estimated. In addition several psychophysically-based models to predict this capacity were developed and validated. The development of the capacity data and the predictive models are presented and discussed. This paper also discusses the development of the Job Severity Index (JSI) which is used to identify demanding tasks taking into account the level of risk management is willing to tolerate. Finally the use of JSI to select personnel prior to employment will be presented. Industrial data will be used to provide examples of the applications.

Energy Cost of Lifting in Sagittal and Lateral Planes by Different Techniques

By S. KUMAR and D. MAGEE

Department of Physical Therapy, 210 Corbett Hall, Edmonton, Alberta T6G 2G4, Canada

Six young normal males (mean age 24.16 years, mean weight 75.4 kg and mean height 176.63 cm) and six young normal females (mean age 20 years, mean weight 59.81 kg and mean height 162.67 cm) were asked to lift and lower a weight of 10 kg to a height of 91 cm at three-quarter reach. All three lifting techniques, that is, stoop lift, squat lift and free style lifting, were used to manipulate the weight in midsagittal, 30° lateral and 60° lateral planes. Six complete cycle of task (six lifting and six lowering) were performed per minute for a period of 6 min. The energy consumption of these subjects was measured during rest and activity by monitoring inspired volume through gasometer and fractions of oxygen and carbon dioxide by rapox and capnographs in expired gas sampled from the mixing chamber. Prior to measuring these variables in activity the basal metabolic rate (BMR) of each subject was established for a period of 5 min. The values of last 2 min were taken and averaged to determine BMR. Similarly, the values of the last 2 min of activity were taken to determine the metabolic cost of the relevant activity.

Descriptive statistics along with two-way ANOVA for both sexes separately and a least-squared regression analysis was performed to develop predictive models. Of the nine tasks stoop lifting in sagittal plane was metabolically least expensive and squat lifting in 30° lateral plane most expensive for both sexes. The three techniques of lifting were significantly different from each other in oxygen uptake at 0.01 level. The three planes did not differ significantly for oxygen uptake. Six predictive models for gross and net oxygen uptake and caloric expenditure are developed.

Trunk Muscle Activity During Dynamic Forward Bending and Straightening Up

By K. TANII

Human Factors Engineering Department, Industrial Products Research Institute, 1-1-4, Yatabe-Machi Higashi, Tsukuba-Gun, Ibaraki 305, Japan

Manual handling work has been extensively associated with low back injuries and much concern has been expressed about how to prevent this in the industrial field and in schools of handicapped children. This study was designed to investigate muscular load of the low back muscle region during bending and straightening up movements in sagittal plane with static muscular fatigue of the lumbar region.

Normal males with no history of spinal pathology were used for the study. Dynamic forward bending and straightening up was performed at a fairly low speed with and without static muscular fatigue of the lumbar region. Then an additional load of 10 kg was suspended by both hands of the subject with the feet fixed and the knees straight. Electromyograms of the *erectores spinae* at lumbar 4 level, the *rectus abdominis* and the external obliques were bipolarly led with a time constant of 0.03 s. The angle of forward bending and inclination of the pelvis were measured.

Electromyographic activity of the *erectores spinae* during dynamic forward bending and straightening up with static fatigue of low back muscle differed from its activity without low back muscle fatigue. Local muscle pain of the low back muscle region developed during the two different movements. Other trunk muscle activities are also reported and discussed.

Posture Optimization Through Three-dimensional Kinetic Biomechanical Modelling

By A. KUMER and A. MITAL

Department of Mechanical and Aerospace Engineering, University of Delaware, Newark, Delaware 19711, U.S.A.

Manual materials handling is a primary source of overexertion injuries in the industrial workforce in the United States. In order to improve the efficiency of the human operator and reduce injury hazards, it is essential to understand the stresses imposed upon a worker, while performing a particular activity. Both the inertia force of body segments and external forces imposed by the job must be considered.

This paper describes a three-dimensional kinetic biomechanical model which can be used to analyse manual handling jobs. The model requires position, velocity and acceleration profile of hand and the position of ankles during the activity and determines shear and compressive forces in the intervertebral column (L5/S1 joint). The model yields a number of feasible postures between the two extreme positions, stoop and squat.

An optimization problem is posed to minimize the mechanical stresses at L5/S1 joint to arrive at an optimum posture between stoop and squat positions. This posture, between stoop and squat, is called a free style posture. Physiological studies, using the metabolic energy expenditure criterion, have already established that a free style posture is the most efficient one for manual lifting activities. This present work corroborates that conclusion.

The model uses data collected by E.-Bassoussi (1974) and Chaffin (1977) for validation purposes.

Dynamic Loading of Static Trunk

By S. KUMAR, P. R. DAVIS and D. P. CURRIER

Department of Physical Therapy, 210 Corbett Hall, Edmonton, Alberta T6G 2G4, Canada

The quantitative pattern of gradual increase and decrease of stress as measured by EMG of erector spinae and intra-abdominal pressure due to continuous and steady progressive loading and unloading in static stooping posture was studied and compared with that of stoop lifting of the same weight.

Eight normal young males participated in the study. EMG activity of the erector spinae muscles was monitored from T12 and L3 levels. The intra-abdominal pressure was measured by radio telemetry and heart rate was recorded using chest electrodes. For steady dynamic loading and unloading two plastic tanks filled with 25 kg of water with a tap opening at the bottom fitted with flexible uniform bore hoses were used. The hose from the tap of one container was connected to the mouth of the other. For water transfer gravity feeding method was used. The subjects stood either on the floor or on table-top holding the container in stooping posture for progressive loading or unloading. They also performed stoop lifting with weights of 15 and 25 kg. The results were statistically analysed and compared.

In dynamic loading the mean EMG at T12 was 50% of the L3 level for peaks as well as plateaus. For dynamic loading it was reduced to 33%. The level of electromyographic activity at T12 for loading was not significantly different for unloading. At L3, however, the magnitude increased significantly at unloading. The EMG and intra-abdominal pressure responses of static posture were between 33 and 50% of the corresponding phases during stoop lifting of the same weight. Heart rate increases from resting were similar for all activities. A quantitative relationship between static and dynamic components of these responses in lifting activities is delineated.

Mechanism of Microvibration and the Application of Fatigue in Work of Lifting of Weights and Typing

By T. USUI, K. SAKAMOTO, K. SEKI and A. IWASAKI

The University of Electro-Communications, 1-5-1, Chofu-ga-oka, Chofu-Shi, Tokyo 182, Japan

Although the uniform interpretation for the generation of microvibration (MV) or minor tremor (MT), which is mechanical vibration on the body surface, has not yet been given the important theories for the mechanism were already proposed by Rohrer (1955, thermoregulatory autonomic nervous system), Sugano and Inanaga (1960, reflex of spinal cord by γ motor system) and Ozaki *et al.* (1969, ballistocardiogram by heart beat). In this paper, the relationship between MV in the eyelid and EEG in awakening and sleeping was studied in order to elucidate the contribution of the central nervous system on MV. The close correlation between MV and EEG was recognized in the higher level of consciousness (i.e. awakening and sleep stages 1 and REM). There existed not only a physiological effect but also a psychological one on MV.

These results of MV were applied to the study of fatigue in the work of lifting of weights, as heavy work, and typing work, as higher restrained work. The former work could be examined by various procedures (e.g. EMG, ECG and $\dot{V}O_2$, etc), but in the latter work, which was lower energy consumption work, fatigue was

generally difficult to detect psychophysically. Comparison of the wave analysis of MV before and after the work showed the features of fatigue in the respective works. For example, in the work of lifting a heavy load, not only the large change of MV but also the component of shivering of the whole body was found. In the typing work, the change of frequency component in the power spectrum was recognized as fatigue proceeded.

Mechanical Efficiency in Relation to Pedalling Rate During Bicycle Ergometer Work

By Y. FUKUBA, Y. KOYA, S. WATANUKI and K. FUJIE

Department of Ergonomics, Kyushu Institute for Design Research, 226 Shiobaru, Minami-ku, Fukuoka 815, Japan

The effect of pedalling rate on mechanical efficiency at a constant load during ergometer work was studied in eight young male subjects. Each subject performed four works at a load of 60% $\dot{V}O_2$ max by bicycle ergometer while pedalling at 30, 50, 70 and 90 r.p.m. From data on oxygen uptake during work and recovery, mechanical, gross (no base-line correction) and net (resting level as base-line correction), and work (unloaded cycling as base-line correction) efficiencies were computed. The relation of each efficiency to pedalling rate is a quadratic equation, and optimum pedalling rates were about 50, 50 and 60 r.p.m. in gross, net and work efficiencies, respectively.

As the usual method of calculation of efficiency is made from oxygen uptake of the last few minutes of exercise, gross, net and work efficiencies were calculated with 5th min O_2 cost. Gross and net efficiencies with 5th min O_2 cost were quadratic equations similar to efficiencies with total O_2 cost, but work efficiency linearly increased with increments in pedalling rate. At 30, 70 and 90 r.p.m. efficiencies with 5th min O_2 cost were significantly higher than those with total O_2 cost. At 50 r.p.m. gross and net efficiencies were equal in comparison with total O_2 cost and 5th min O_2 cost, and work efficiency with 5th min O_2 cost was slightly lower than that with total O_2 cost. Due to these results, work efficiency with 5th min O_2 cost might be linear in relation to pedalling rate. It is difficult to measure the oxygen cost of unloaded cycling, as the work efficiency definition proved difficult to apply.

Optimum Speed of Up-hill Cycling With Special Reference to Slope Gradients and Gear Ratio

By A. KIMURA, M. MORIOKA, S. HORINO, K. KISHIDA and K. UCHIDA

Department of Industrial Engineering, Faculty of Technology, Kanagawa University, 3-27-1 Rokkakubashi, Kanagawa-ku, Yokohama-shi 221, Japan

The optimum speed of up-hill cycling was determined by measuring the energy metabolism at different slope gradients, gear ratios and speeds. The results were compared with practical speeds applied by cycling people. Six subjects pedalled a bicycle at either the low or normal gear-ratio on six different slopes of 2-10% at different speeds. A distinct tendency was seen that the optimum speed was higher at 10-15 km/h on low-gradient slopes compared with that of 8-10 km/h on slopes of higher gradients. But the optimum speed was not apparently associated with the gear-ratio level due to large variations of data resulting from various wind effects and road frictions which could not be controlled in the experimental field conditions. These results were consistent with our experimental optimum speeds determined using a bicycle ergometer. When the optimum speed was examined comparing the oxygen consumption at five loadlevels of 30-360 W and at five speeds of 20-120 r.p.m., it corresponded to the pedalling frequency of 30 r.p.m. at 60 W and 60-80 r.p.m. at 180-360 W. This implied that the optimum speed should be 5-8 km/h on 8-10% slopes and 12-18 km/h on less steep or flat roads, the oxygen requirement being remarkably smaller for the latter (400-700 ml/100 m) than for the former (about 2000 ml/100 m). The practically chosen speed tends to be faster than the optimum speed on the flat road or on low-gradient slopes and slower on steep slopes.

Critical Power as a Measure of Muscular Fatigue and Anaerobic Threshold

By A. NAGATA and M. MURO

Faculty of Science, Tokyo Metropolitan University, 1-1-1 Yagumo, Meguro-ku, Tokyo 152, Japan

Earlier ergographic experiments showed that there was a linear relationship between maximal work (W_{lim}) and maximal time (T_{lim}) over which it was performed until the onset of local muscular exhaustion. According to Monod and Scherrer (1965), this linear relationship could be expressed by the equation $W_{lim} = a + bT_{lim}$, where W_{lim} was thought to result from the use of an energy reserve a and an energy reconstitution whose maximal rate was b .

It was the purpose of this study to extend this concept to total body work (bicycle ergometer) and to test the hypothesis that anaerobic threshold (AT) might be closely associated with the maximal rate of energy reconstitution b . Eight male and eight female students underwent exercise tests at 400, 350, 300, 275 and 300, 250, 200, 175 W, respectively, to the onset of fatigue. Results indicated that b was correlated with the onset of AT as determined by the gas exchange method ($r=0.928$, $p<0.001$). Furthermore, our empirical data revealed that the arbitrary sum of a and b (energy reserve and maximal energy reconstruction rate) was correlated with maximal oxygen uptake ($r=0.956$, $p<0.001$) and therefore the obtained regression equation might be used to predict one's physical work capacity with the standard error or the estimate of 0.24 l/min.

Electromyographic analysis indicated that neuromuscular fatigue as estimated by the rate of rise in the IEMG/force as a function of time (IEMG slope coefficient) showed a close relationship with T_{lim} in an exponential fashion. In other words, the longer T_{lim} (less fatigable) for a given power output, the smaller the IEMG slope coefficient becomes with an accelerated rate.

The Effect of Body Postural Change on Anaerobic Threshold

By T. FUKUNAGA, H. YATA and S. IKEGAWA

College of General Education, University of Tokyo, 3-8-1, Komaba, Meguro, Tokyo, Japan

The purpose of this study is to observe the effect of body posture on anaerobic threshold in pedalling exercise. The postural positions used in this study were the sitting and horizontal supine positions. Four male subjects performed pedalling exercise in each body position with stepwise incremental loading of 0.25 kp until exhaustion. Oxygen consumption was measured each 30 s during exercise by means of Ergo Oxyscreen (EAGER). For the measure of lactic acid concentration venous blood was taken by teflon catheter inserted deep into the antecubital vein. At a given work load, lower V_{O_2} , V_E and H_R were observed in the horizontal supine position than in the sitting position. Maximum oxygen consumption measured in the supine position was 27% lower than that in the sitting position. Lactic acid concentration at a given workload was higher in the supine position than in the sitting position. At the point where lactic acid concentration was 4 mM/l, anaerobic threshold (AT), oxygen consumption was 1.44 l/min in the supine position and 1.98 l/min in the sitting position. However, as expressed by the ratio to maximum oxygen consumption it was equivalent to 60% V_{O_2} , max independent of body posture. It turns out that lower H_R , V_E and V_{O_2} , and higher lactic acid concentration in the horizontal supine position, that those in the sitting posture is due to hemodynamic change, however, % V_{O_2} , max at anaerobic threshold is not affected by posture exercise body.

The Effect of Additional Weight on External Mechanical Energy in Running

By A. MATSUO, T. HIRATA, N. TSUNODA and T. FUKUNAGA

University of Tokyo, College of General Education, Department of Health and Physical Education, 3-8-1, Komaba, Meguro-ku, Tokyo, Japan

The purpose of this study is to observe the effect of additional weight on the external mechanical work in running. Six male runners were requested to run with an additional weight of 5 and 10 kg attached to the body, using a belt or jacket. The external mechanical work of the body was estimated from the external force measured by Kistler force platforms, which were inserted in the experimental running track. The average running velocity passing over three force platforms was determined by electric signals from photo cells placed 3 m apart in front of and behind the force platform. The maximum velocity of running was decreased from 7.81 to 7.45 m/s by an additional weight of 10 kg without change in step frequency. The external work per step at the maximum velocity increased progressively from 131 to 154 J with increments of additional weights. However, the external power per step indicated, approximately, the constant values of 2100–2200 W. Therefore, it is concluded that in running the additional weight attached to the body induced the decrements of step length and velocity, however, it did not affect the mechanical power exerted by the muscle.

Evaluation of Local Muscle Fatigue in Dynamic Muscular Work by Isometric Test Contraction

By S. KIRA, K. YAMASAKI and H. SATO

Department of Ergonomics, Kyushu Institute for Design Research, 226 Shiobaru, Minami-ku, Fukuoka 815, Japan

Dynamic work was accomplished by repeated concentric and eccentric contractions of the biceps brachii against various loads (3, 4, 5 and 6 kg) given at the wrist. Work duration was 1, 2, 3, 4 and 5 min for 3 kg, 1 and 2 min for 4 kg and 1 min for 5 and 6 kg. Work continued until exhaustion in each load.

Test contraction, isometric contraction of the biceps at less than 10% MVC for 20 s, was performed before and immediately after each dynamic work. Bipolar surface EMG was taken from the biceps during test contraction and power spectral analysis was made on the EMG.

The ratio of power in the frequency components 9.3–18.6 Hz to the total power in the EMG (RP_L) of the test contraction increased after dynamic work when compared with the ratio prior to work.

In general, the longer the work time and the heavier the workload, the larger RP_L increased in the test contraction. In work where the work time was short or the load was light, however, RP_L did not show obvious changes correlating to increased load or work time.

There was significant positive correlation between the increase in RP_L and work duration expressed in percentage of maximal work duration ($p<0.01$, $r=0.620$).

A Biotechnological Study of Hang Glider Crewmen

By N. ANDO and others

The Faculty of Engineering, Hosei University, 3-7-2 Kajinocho, Koganei-shi, Tokyo, Japan

Hang gliding has become a popular sport in recent years, but so many serious accidents have occurred that it is now considered a social problem in Japan. We have undertaken a biotechnological study of hang gliders and have been studying the problem of the crewmen's security and accident prevention.

Studies concern (1) the structure of hang gliders and (2) hang glider crewmen. Many studies have been reported concerning hang glider structure and structure has been greatly improved recently. As to the studies of crewmen, no biotechnological studies except ours have been conducted. There continue to be many unknown problems about the security of crewmen, therefore we have been conducting studies on crewmen for nearly 5 years, and we reported some of our first studies and experiments at the 10th and 11th Kanto Workshops of the Japanese Society of Human Engineering and at the 10th and 11th Workshops of the Japanese Society of EEG and EMG in 1980 and 1981, respectively.

In our present studies, we have conducted repeated experiments on crewmen's mental and physical condition in flight, by using a telemeter and an electroencephalograph, to find a key to accident prevention. In flight some crewmen had α and θ waves. It is known that similar brain waves appear when Zen sect priests sit in religious meditation (*zazen*). We have pursued a comparative study of these two cases. We have also studied crewmen's eye-movement, respiration, heart rate, etc. Our report includes all these biotechnological studies on hang glider crewmen.

Pulling and Pushing Forces as a Function of Elbow Flexion

By Y. IKEDA

Department of Industrial Engineering, Aichi Institute of Technology, 1247 Yachigusa Yagusa-cho, Toyota 470-03, Japan

'Pulling' or 'pushing', is one of the fundamental motions for a worker to operate a machine or hand tool. Data about muscular strength capability of pulling and pushing has shown that the hands can push more powerfully than they can pull when sitting down. However, recently published data showed the opposite result to above when either sitting down or standing. In view of the knowledge that muscles can exert greatest force (with the exception of the lever systems effect) when the working muscle is fully extended, it seemed that the former information was not necessarily always true, i.e. pulling or pushing force exerted might depend upon position of the upper- and fore-arms. Experiments were conducted to investigate muscular forces as a function of elbow angles using the MVC method, and to compare them between pulling and pushing. The present study observed that muscular forces exerted depend on the positions of the arms, and supported the view that the hands can pull more powerfully than they can push when the best of each is compared.

Psychophysiological Studies of Physical Performance

By G. BORG

Department of Psychology, Box 5602, S-11486 Stockholm, Sweden

In the evaluation of physical stress and strain, to understand man at work, it is important to try to incorporate measurements from the three main effort continua: the performance continuum, the physiological and the subjective-perceptual continuum.

During the last 25 years we have done many studies in all these three areas. The performance studies concern determination of maximal performance for both work of an aerobic and an anaerobic character. Work and fatigue curves for intermittent performance have also been determined and new methods been constructed for the evaluation of these variables.

Physiological responses of importance both for prediction of performance and perceptual responses have been studied. During the last year we have devoted our interest especially to studies on the variation of muscle and blood lactate. In most of our studies we found the same monotonously increasing function to describe the lactation variation. The best equation is a power function with an exponent of about 2 for the blood lactate variation and with an exponent of about 3 for the muscle lactate.

The perceptual studies concern both theoretical psychophysical ones and applied studies with different category scales. One scale for ratings of perceived exertion which has been very generally recognized and applied is the RPE-scale according to Borg (1970). This scale has the advantage of giving ratings increasing linearly with workload and heart rate. A new category scale with ratio properties has been developed, with which general psychophysical functions may be obtained but at the same time as 'level-measurements' for differential comparisons.

The theoretical studies in this field concern models for direct inter-process comparisons (e.g. between psychological and physiological variables). Most applications are done in clinical exercise tests and cardiac rehabilitation but also in industrial settings.

What Do We Neglect When Evaluating Muscle Fatigue

By N. G. GANTCHEV

Institute of Physiology, Bulgarian Academy of Sciences, G. Bontchev str.bl.1, Sofia 1113, Bulgaria

The problem of muscle fatigue is still an important problem for occupational physiology and ergonomics, because many professional activities are connected with repetitive small movements and static effort which leads to neuromuscular fatigue.

Neuromuscular fatigue can be determined by measurements of muscle force and endurance, some parameters of the movements while performing motor tasks, but as a rule EMG data are used for this purpose. We tried to propose some criteria for evaluation of neuromuscular fatigue on the basis of our data on this problem.

It is well known that overloading the locomotor system causes occupational diseases of the connective tissue organs, tendons, ligaments, bursas, etc., and rarely of the muscles. Our studies under laboratory conditions and observations in industry showed that after prolonged motor activity complaints of discomfort, fatigue and ache appeared, to a larger extent, in joints than in muscles. Therefore, evaluation of muscle fatigue and recommendations for the prevention of locomotor systems overload should be based not only on EMG studies but also on investigations of functional changes in the whole locomotor system. Now we underestimate the role of connective tissue formations in establishing the working capacity of the whole system.

The approach for solving this problem and some examples are presented in the report.

A Three-level Computer-assisted System for the Evaluation of Physiological Changes During Work, Before and After Ergonomical Intervention

By J. FORMÁNEK

Czechoslovak Medical Society JEP, Society of Biomedical Engineering,
c/o Institute of Hygiene and Epidemiology, 100 42 Praha 10, Šrobárova 48, ČSSR

A three-level hierarchical system based on the computers JPR 12 (Hewlett-Packard 2116/2100) or JPR 12R (EG 1040) makes it possible to control the measurement of basic physiological data (heart rate, EEG, EMG) and to perform the subsequent preprocessing and processing of these data. New algorithms and programs were developed for the statistical testing of hypotheses concerning the averages of the spectral power densities (may be used for EEG, EMG, biological rhythms, etc.) and for the extraction of essential information from multiple time series of physiological, psychological and ergonomical data, the latter being based on the principal component model. A special digital cardiometer was designed for the purposes of on-line as well as off-line evaluation of beat-to-beat as well as average heart rate. For reliable off-line evaluation of tape-recorded EGG, EEG, EMG and other signals, a special time code generator and reader was developed which provides a precise synchronization of the tape record, graphical record and computer-processed data. Examples of the practical use of the system are presented. With the use of this system, it is also possible to quantitatively estimate the practical ergonomical intervention.

A 2. Muscular Stress and Physical Response

Assessment of Physiological Cost in Dynamic Muscular Work by Oxygen Cost and Cardiac Cost

By H. SATO

Department of Ergonomics, Kyushu Institute for Design Research, 226 Shiobaru, Minami-ku, Fukuoka 815, Japan

A method of assessing physiological cost of work by oxygen uptake and heart rate was studied experimentally on male students by varying the type of work (bicycle ergometer work or treadmill work), workload (0-900 kg/min or 0-15° slope), duration of work (4-15 min) and thermal environment (15°C 50% RH, 20°C 50% RH, 35°C 30% RH and 35°C 80% RH).

Total oxygen cost, which was the sum of oxygen uptake above the resting level during work and recovery, was calculated. Oxygen cost per min was derived by dividing the total oxygen cost by the duration of work. Likewise, cardiac cost per min was calculated from the data on heart rate during work and recovery.

Oxygen cost per min was almost the same at the same workload regardless of different durations of work, and so was cardiac cost per min. In ergometer work, oxygen cost per min per kg of body weight did not lessen the individual variations (coefficient of variation) as compared with oxygen cost per min.

Oxygen cost above zero was calculated by adding resting oxygen uptake rate to oxygen cost per min. A linear relation was found between oxygen uptake rate at the 1st min of work and oxygen cost above zero. Heart rate at the last min of work was lower than cardiac cost above zero, which was cardiac cost per min plus resting heart rate, above about 100 beats/min of heart rate.

Cardiac cost per min varied according to workload and thermal condition, while oxygen cost per min varied with workload only. The relation between oxygen cost per min and cardiac cost per min was affected by the type of work, thermal condition and subject. Therefore, oxygen cost per min and cardiac cost per min could be used to evaluate the physiological cost of dynamic muscular work.

Several Aspects of the Prediction Method of Local Muscle Energy Metabolic Rate

By S. YOKOYAMA and K. YOSHIDA

Department of Sanitary Engineering, Faculty of Engineering, Hokkaido University, Sapporo 060, Japan

A prediction method of local muscle energy metabolic rate was presented by one of the authors (Yokoyama 1980). It requires the measurements of total metabolic rate and integrated surface electromyograms during different exercise items and the solution of simultaneous equations. The experimental procedures and the solving procedures of the equations have been improved upon (Yokoyama *et al.* 1981).

According to our prediction method, the main seven local muscle energy metabolic rates were determined in different static working and resting postures for 21 Japanese young healthy males. The seven muscle groups were (1) muscles of the anterior abdominal wall; (2) muscles erector spinae; (3) muscles of the buttock; (4) posterior femoral muscles; (5) anterior femoral muscles; (6) posterior crural muscles and (7) anterior crural muscles. If integrated surface electromyograms were converted into ratios of maximum voluntary contraction strength (MVC), the maximum local energy metabolic rates could be determined with the above method. The prediction of the maximum local energy metabolic rates concerning the above seven muscle groups was performed for 17 Japanese young healthy males.

The quantitative results of local muscle energy metabolic rate in the present study confirmed a number of findings, with reference to human static postures, by the previous investigators, mainly from the viewpoint of electromyography. The results of the predicted maximum local energy metabolic rates disclosed individual differences caused by daily muscle activities. By using local muscle metabolic rates of the anterior and the posterior femoral muscle groups during different exercise items, the human femoral thermal systems was studied. For that purpose a mathematical model of the human thermal system was developed.

Occupational Muscular Strain Indicated by Serum Creatine Kinase

By M. HAGBERG

National Board of Occupational Safety and Health, Medical Division, Box 6104, S-900 06 Umeå, Sweden

The creatine kinase is a muscle enzyme concentrated in skeletal muscle fibres. If the muscle fibres are damaged, an increased muscle enzyme efflux to the blood is noted. The aim of the present investigation was to evaluate serum creatine kinase (S-Ck) as an indicator of local muscular strain.

Methods. Experimental study: S-Ck was measured before and after (24 and 48 hours) exposure to two types of dynamic work in ten subjects. Bicycle ergometry produced a high general dynamic load and lifting boxes produced a high local load on the shoulder-neck. In a field study S-Ck analysis was done before work after 2 days rest and after 3-4 days of work. The occupational groups consisted of welders, assemblers, controllers, fork-truck drivers and cash-register operators.

Results. An increase of S-Ck was seen after the lifting work as well as discomfort and pain from the shoulder-neck. After the bicycle ergometry no increase of S-Ck or discomfort was noted. Welding, assembling and cash-register operating having a high local load on the shoulder-neck produced an increase of S-Ck during the work week. Controllers and fork-truck drivers revealed no increase of S-Ck during the work week.

Conclusion. Evaluation of S-Ck is a new ergonomic approach for detection of work tasks producing local muscular strain.

The Effect of Arm Elevation on Muscle Circulation

By H. YATA, T. FUKUNAGA and A. MATSUO

Department of Physical Education, Wako University, 2160 Kanai, Machida, Tokyo, Japan

When the position of an arm or leg is altered in a vertical plane, the blood circulation in the extremity may be affected by the change of hydrostatic pressure. The purpose of this study is to observe the effect of arm elevation on forearm muscle circulation. Four healthy men, aged 22-28 years, volunteered to act as experimental subjects. The upper extremity of the subject, who sat on the specially designed apparatus, was elevated every 30° from the dependent position to directly overhead. At each arm position dynamic hand grip contractions were performed by raising a weight of 5 kg 2 cm five times at a rate of once every 2 s. Forearm blood flow, blood pressure, p_{O_2} , p_{CO_2} and pH in venous blood were determined during 10 min rest and immediately after the exercise. Systolic blood pressure and blood flow in forearm decreased with arm elevation by about 20 mmHg and 1.5 ml/100 ml min, respectively. Significantly, at positive correlation coefficient of 0.667 was observed between resting blood flow and blood pressure. Blood flow and venous oxygen pressure after exercise also decreased with arm elevation by about 4 ml/100 ml min and 5 mmHg, respectively. It may be considered from these results that with arm elevation the decrement of hydrostatic pressure in forearm vessels cause decreases of blood pressure and also of blood flow.

Effects of Hot Dry and Hot Humid Environment in Continuous Work Performance in Man

By J. SEN GUPTA

Defence Institute of Physiology and Applied Sciences, Delhi Cantt 110010, India

Rise in body temperature during work is generally considered to represent a failure on the part of the thermoregulatory system. A progressive increase in climatic stresses will result in physiological strains on the body sufficient enough to lead to incapacitation. Most of the limited information available relating to this subjects has been conducted on unacclimatized human beings. Studies have, therefore, been conducted on prolonged continuous moderately heavy and heavy physical work (400, 500 and 600 kg/min) on naturally heat-adapted Indians in a climatic chamber. Studies were conducted on four sets of environmental conditions: comfortable, very hot and extremely hot with high humidity and very hot with low humidity. Duration in continuous work, rectal temperature, mean skin temperature from various points, sweat loss, O_2 consumption, pulmonary ventilation and cardiac frequency were all noted during rest and every 10 min during exercise.

Results indicated that above the critical air temperature of 30°C, body temperature rises to a new higher steady level and in extremely hot conditions, the deep body temperature continued to rise to a target of 38.8°C, when work was discontinued. Of various physiological indices, cardiac frequency seemed to be a good guide for assessing the effect of heat on work capacity. Attempts have also been made to predict the capacity for prolonged work in hot dry and humid conditions by giving combined weight to various physiological functions.

Effects of Specific Dynamic Action on Metabolism at Rest

By K. YAMASAKI, S. WATANUKI and S. KIRA

Department of Ergonomics, Kyushu Institute for Design Research, 226 Shiobaru, Minami-ku, Fukuoka 815, Japan

The specific dynamic action of food is not a negligible factor when resting metabolic rate is measured. The purpose of the present study was to observe the change of metabolism at rest when subjects have ordinary meals and have meals by instalments.

The subjects were three healthy men aged 24-28 years. Meals were taken as follows: (1) only lunch, (2) breakfast and lunch, (3) five meals, (4) nine meals and (5) abstention from food. Breakfast contained 540 cal (protein: 22 g, fat: 23 g, carbohydrate: 59 g) and lunch in (1) and (2) contained 785 cal (protein: 36 g, fat: 18 g, carbohydrate: 118 g) and 869 cal (protein: 42 g, fat: 21 g, carbohydrate: 124 g), respectively. The total calories and constitution of the nutritive elements in (2), (3) and (4) were approximately mutually equal. Oxygen consumption, heart rate and temperature of the axilla were measured from 07.00 to 17.00 hours in a sitting position.

After breakfast and lunch oxygen consumption began to increase immediately, 2 hours later meal oxygen consumption increased 20 and 25% to the value before meal ingestion, respectively. Thereafter oxygen consumption began to decrease gradually, 5 hours later lunch oxygen consumption was about 10% as high as the value before meal ingestion. In (3), (4) and (5) transition of oxygen consumption was generally flat. The change of heart rate was similar to oxygen consumption, the value of difference between 2 hours after the meal and before the meal was about 5 beats/min. The temperature of the axilla was not affected by meal ingestion.

Creatinine Excretion Under Physical Exercise and Hypokinesia

By Y. ZORBAS, V. PETROVSKIY and Y. KOICHI

Life Sciences Division, European Institute of Environmental Cybernetics, Athens 514/1, Greece

The elimination of creatinine in urine was examined under 94 days of hypokinesia (HK) on six physically healthy men ranging in age from 18 to 24 years. They were divided into two groups with three men in each. The group of men submitted to pure HK and the second group subjected to combined HK and physical exercise (PE) with energy expenditure of 250 cal/day. Food intake was measured throughout the investigation. Creatinine was determined in the daily urine by conventional methods. The results prior to HK served as control. The obtained data was processed statistically according to the criterion of Students' *t*-test. An increase in the elimination of creatinine was observed under these experimental conditions. It can be concluded that PE did not decrease but increase creatinine excretion, exerting a normalizing effect on the metabolism.

To ensure maximum restriction of motor activity all men of both groups were kept under rigorous bedrest regime.

A 3. Heat/Cold

Relationships Between Physique and Increase in Body Temperature During Exercise at Different Ambient Temperatures

By T. KATSUURA

Department of Ergonomics, Chiba University, 1-33 Yayoi-cho, Chiba 260, Japan

The relationships between physique and increase in rectal temperature during exercise were studied at three different ambient temperature conditions. Six male adults, aged 22-31, participated in this study. Skinfold thickness were measured at six sites, i.e. triceps, chest, abdomen, iliac, subscapula and thigh. Mean skinfold thickness was calculated according to Hori *et al.* (1974). Body density was determined using the equation of Nagamine and Suzuki (1964), and body fat percentage was calculated according to Brozek *et al.* (1963). Body surface area was determined according to Fujimoto *et al.* (1968).

The subjects wore only shorts and exercised on a bicycle ergometer for 32 min at the two work loads, i.e. 300 and 600 kg/min. The experiments were carried out in a climatic chamber. The ambient temperatures used were 20, 30 and 40°C. The relative humidity was kept at about 50% in all conditions.

Rectal temperature was recorded with a thermister inserted 10 cm into the rectum. Skin temperature was measured with copper-constantan thermocouples on the chest, upper arm, thigh and lower leg. Mean skin temperature was calculated according to Ramanathan (1964). Sweat rate was determined from the weight loss during the test. Oxygen uptake was determined with the Douglas bag method. The order of exposure to three air temperature conditions was randomized for each of the subjects.

The effects of physique on the increase in body temperature were analysed by multiple regression analysis.

Effect of Ambient Temperature on Physical Work Capacity

By M. T. LAZAR and J. SEN GUPTA

Defence Institute of Physiology and Allied Sciences, Delhi Cantt-110010, India

Studies were carried out in 12 young (20–28 years of age) healthy human volunteers to evaluate the effect of variation in the ambient temperatures on physical work capacity. Their physiological responses to exercise were studied in a laboratory maintained at 10, 15, 20, 30 and 35°C with the relative humidity varying from 50–60%. Their responses to submaximal and maximal exercise were measured on a bicycle ergometer by continuously monitoring heart rate, ventilation and oxygen consumption under testing, during exercise and recovery periods. The exercise-induced heat load was studied by measuring rectal and mean skin temperatures before and after the exercise, as well as during recovery periods. The results showed that the $\dot{V}O_2$ max was not significantly different in any of the above ambient conditions. Details of the results and their implications will be discussed.

The Effects of Work Rates and Ambient Temperature on Transient Physiological Responses

By Y. TAKASAKI

Institute of Balneotherapeutics, Kyushu University, Tsurumihara 4645, Beppu, Japan

The present study deals with transient physiological responses of man to various work rates in thermal environments and describes the effects of work rates and ambient temperature on responses. Subjects were five college males, from 18 to 20 years old, screened for cardiopulmonary disease. They exercised on an electrically braked bicycle ergometer at five work rates of 25, 50, 75, 100 and 125 W in a controlled climatic chamber at 20 and 30°C. At each work rate, the test consisted of a rest period followed by 15 min cycling at 50 r.p.m., performed once or twice a day per subject. During these tests, the subjects breathed through a gas mask connected to the gas analysing system developed by Ichimaru and were monitored by electrocardiography to provide heart rates of the subjects. The time course of responses to the transition of various conditions were discussed.

Cardiovascular and Metabolic Reactions to Work in Different Ambient Temperatures

By T. NARIAI, Y. FUKUBA, J. OHASHI and Y. IZUMITANI

Department of Ergonomics, Kyushu Institute for Design Research, 226 Shiobaru, Minami-ku, Fukuoka-City, 815 Japan

The cardiovascular and metabolic response of five male Japanese students, 21–23 years of age, were studied at rest and at various levels of work up to the individual's maximum when they were exposed to ambient temperatures of 12, 26 and 40°C. Oxygen consumption was linearly related to workloads without effect of ambient temperatures.

In a 40°C environment, the major change in cardiovascular function was an increase in heart rate with an associated fall in stroke volume. Cardiac output, estimated by the CO_2 rebreathing method, was relatively increased within the range of approximately 40–60% $\dot{V}O_2$ max and was reduced throughout the higher range of % $\dot{V}O_2$ max when compared with the values obtained in a 26°C environment. In the latter range of % $\dot{V}O_2$ max, a relative increase in arterio-venous oxygen difference accounted for the ultimate rise in oxygen

consumption. During moderate work in 40°C the decrease in total peripheral resistance might indicate a larger portion of the blood flows away from the contracting muscles to the skin than in 26°C. However in heavier work the value was the same as that obtained in 26°C.

In a 12°C environment, while a slight decrease in heart rate and a slight increase in stroke volume were found, no difference was found in cardiac output, arterio-venous oxygen difference or total peripheral resistance when compared with the values observed in 26°C.

Consequently, in a 12°C environment, we could not find any major changes of cardiovascular or metabolic reactions at various levels of oxygen consumption. However, in 40°C, some important changes were found. Especially during heavy work in 40°C, cardiac output was still lower than values obtained in 26°C, although total peripheral resistance was the same value as seen in 26°C.

Influence of Age on Circulatory Responses to Exercise at Different Air Temperature Conditions

By Y. KIKUCHI, T. KATSUURA and A. OKADA

Department of Industrial Design, Faculty of Engineering, Chiba University, 1-33 Yayoi-cho, Chiba 260, Japan

This study was planned to investigate whether circulatory responses to exercise at different air conditions were significantly different in older compared with younger subjects.

Cardiac output, heart rate, stroke volume and oxygen uptake were measured in young and middle-aged men during submaximal exercise. The subjects exercised on a bicycle ergometer at two kinds of workload, i.e. 300 and 600 kg/min, under three air temperature conditions: 20, 30 and 40°C. Heart rate was measured between the 5th and 7th min of exercise from the recordings of an electrocardiograph. Expired gas was collected by Douglas bag through a gas mask for 2 min after the 5th min of exercise. The ventilatory volume was measured with a dry gas meter. The sample of expired gas was analysed by the Respilyzer. After the gas collection, cardiac output was determined by the CO_2 rebreathing method. The partial pressure of CO_2 in the mixed venous blood was determined from the CO_2 rebreathing curve, according to principles set by Defares (1958) and using calculations described by Jernerus *et al.* (1963). The partial pressure of CO_2 in arterial blood was assumed to be the same as in the end-tidal air. A CO_2 dissociation curve for oxygenated blood was used to determine the CO_2 content of both arterial and mixed venous blood. For the CO_2 analysis a rapid infrared CO_2 meter was used. Stroke volume was calculated from the values of cardiac output and heart rate.

The results were analysed by computing the analysis of variance, which was performed with respect to age, air temperature, work load and different individuals.

A Study on Seasonal Variations of Circulatory and Metabolic Responses During Prolonged Exercise

By A. OKADA

2nd Department of Anatomy, Nihon University School of Medicine, 23-17, Toyoda 2-chome, Hino-shi, Tokyo 191, Japan

Relatively few studies have been made of circulatory and metabolic response under the several thermal conditions in the different seasons.

The purpose of the present study was to investigate the changes of oxygen consumption, cardiac output, heart rate, rectal temperature and stroke volume during prolonged exercise under cool conditions and under warm conditions in the different seasons.

As the first investigation in the series of the study, the experiments were carried out in late autumn, in early spring and in summer. The ambient temperatures were 20 and 30°C in a climatic chamber in autumn and spring, and about 30°C under natural thermal conditions in summer.

The subjects were Japanese normal males, 22–31 years of age. They worked for 32 min at 300 and 600 kg/min on a bicycle ergometer.

Oxygen consumption was determined with the Douglas bag method, and heart rate was measured with an electrocardiograph, at rest and during 5–7 and 30–32 min after the start of exercise. Cardiac output was determined with the CO₂ rebreathing method at rest and after 7, 17 and 32 min of exercise. Stroke volume was calculated from the values of cardiac output and heart rate.

These results were analysed and discussed with respect to seasons, ambient temperatures, exercise times and levels of load.

Evaluation of Cardiac Output by Electrical Impedance Method Under Different Ambient Temperatures

By T. AZUMA, T. KATSUURA, A. OKADA and Y. KIKUCHI

Faculty of Engineering, Chiba University, 1-33 Yayoi-cho, Chiba 260, Japan

Electrical impedance method (EIM) has been used as a simple and non-invasive method to estimate stroke volume and cardiac output. But, it is not clear that EIM is also applicable in other temperatures. So, we try to investigate its reliability.

Subjects were six male adults aged 22–31 years. All six subjects were familiar with measurement procedures. The subjects wore only shorts, and exercised on a bicycle ergometer for 34 min at two workloads, i.e. 300 and 600 kg/min. The experiments were carried out in a climatic chamber, under three ambient temperatures: 20, 30 and 40°C (R.H. 50%, respectively). Expired gas was collected by Douglas bags through a gas mask for 2 min after 8 min of the resting period and after each 10, 15 and 30 min of exercise. Ventilatory volume was measured with a dry gas meter. The sample of expired gas was analysed by Respilyzer. After gas collection, cardiac output was determined with EIM and CO₂ rebreathing method.

Thoracic impedance data were obtained using an impedance cardiograph (AI-600G, Nihon Koden Co. Ltd.) with four disposable aluminized strip electrodes. Stroke volume (SV) was calculated as follows,

$$SV = \delta(L^2/Z_0^2)(dZ/dt)_m T,$$

δ is the resistivity of blood (135 Ω m), L is the mean distance (cm) between the inner pair of electrodes, Z is the basal thoracic impedance (Ω), $(dZ/dt)_m$ is the maximum rate of the change of impedance (Ω /s) and T is the ventricular ejection time (s). Cardiac output was computed from the value of SV and heart rate.

Results and discussion are shown in the full text.

Change in Pulmonary Diffusing Capacity for CO under Various Conditions of Temperature Combined with Hypobaric Hypoxia

By A. YASUKOUCHI, K. IWANAGA, Y. KOYA and M. SATO

Department of Ergonomics, Kyushu Institute for Design Research, 226 Shiobaru, Minami-ku, Fukuoka 815, Japan

The change in pulmonary diffusing capacity for CO (D_L) was studied in ten normal human subjects using a breath-holding method. The experiments consisted of two series. One series (Series I) was performed in five subjects at ambient temperatures of 16, 20, 24 and 28°C (RH 50%, respectively) each at simulated altitude of 0, 2000 and 4000 m. In another series (Series II) the remaining subjects were exposed to ambient temperatures of 12, 20, 28 and 36°C (RH 50%, respectively) for about 2 hours. The purpose of this study was to observe the characteristics of the change in D_L induced by the various thermal conditions combined with hypobaric hypoxia and to investigate a physiological parameter which indicates the change in D_L .

In Series I, the change in D_L was not significant within the range 16–28°C at sea-level but was significant at altitudes of 2000 ($P < 0.05$) and 4000 m ($P < 0.01$). The differences of D_L in the corresponding temperature between 0 and 4000 m were larger at lower temperatures than in the neutral condition. The physiological parameter which showed significant correlation with D_L at each altitude was oxygen intake, however, the first order correlation between D_L and O₂-pulse holding the influence of oxygen intake statistically constant was significant at 0 and 2000 m. The change in D_L with ambient temperature was significant when the variation of ambient temperature condition was widely controlled as in Series II. Pulmonary capillary blood volume obtained in Series II by Roughton and Forster's technique was highly correlated with D_L ($r = 0.928$, $P < 0.001$). Since O₂-pulse was well related to stroke volume ($r = 0.939$, $P < 0.001$), computing the second order partial correlation between pulmonary capillary blood volume and stroke volume holding both oxygen intake and cardiac output statistically constant resulted in a correlation of $r = 0.688$ ($P < 0.05$). It seems reasonable to conclude that the D_L variation with ambient temperature primarily depends on the alteration of pulmonary capillary blood volume which may be able to be predicted from the relative change in stroke volume or O₂-pulse at both 0 and 2000 m.

The Effects of Exercise, Ambient Temperature and Season on Estimation of Maximal Oxygen Intake

By S. WATANUKI, K. YAMASAKI and Y. KOYA

Department of Ergonomics, Kyushu Institute for Design Research, 226 Shiobaru, Minami-ku, Fukuoka City, 815 Japan

The data were collected on 16 males, ranging in age from 19 to 27 years. The subjects were given submaximal works by a bicycle ergometer exercise and a step exercise in a warm (26.8°C) and a cool environment (8.0°C) in summer and winter.

Both exercises lasted 10 min. In a bicycle ergometer exercise, the subjects rode at workloads of 450 kg/min during the first 7 min and then 750 kg/min for 3 min. In a step exercise, the subjects stepped up and down on a 40 cm high wooden bench at a rate of 15 and 25 steps/min for 7 min and 3 min, respectively.

In summer, autumn and winter, maximal oxygen intake was measured by performing an exhausting series of treadmill walks at a speed of 95.0 m/min at a grade beginning at 13–15% and, until exhaustion, the grade was increased by 2% per min.

Prediction equations of maximal oxygen intake examined in this study were those of Astrand and Ryhming (1954), Margaria *et al.* (1965) and Sato *et al.* (1976, 1980).

The difference with respect to exercise, ambient temperature and season between observed and predicted maximal oxygen intake was examined with respect to exercise, ambient temperature and season.

It was concluded that the estimation oxygen intake from the prediction equation by Astrand and Ryhming (1954), Margaria *et al.* (1965) and Sato *et al.* (1976) was not sufficient compared with that from the prediction equation by Sato *et al.* (1980) in all cases.

Sensitivity Analysis Supports Simplified Heat Stress Rules

By J. D. RAMSEY and C. P. CHAI

Texas Technical University, P.O. Box 4130, Lubbock, Texas 79409, U.S.A.

There currently exist many decision rules which help define hot working environments through the use of heat threshold values, or onset points for increasing risk of heat strain. Typically, such rules are based upon environmental measurements and on estimates of the metabolic workload of the worker. Abbreviated guidelines, which represent a simplified procedure for including factors in addition to workload that are important in heat strain, have also been proposed.

The approach used in this paper was to evaluate threshold wet bulb globe temperature (WBGT) values by comparing them to the values of calculated human heat exchange using the generally accepted equations developed as the Belding-Hatch Heat Stress Index (HSI). Several levels of metabolic workload, clothing, radiant heat, wet bulb temperature, air temperature and air velocity were used as input to a computer model for generating the corresponding HSI and WBGT. This iterative procedure provided the ability to look at the specific work, clothing and environmental components that yield an HSI of 75, and then to identify the corresponding WBGT for that set of components. This procedure served as a basis for validating the abbreviated guideline rules and for conducting the sensitivity analysis.

Findings of this analysis indicate: a high variability in threshold WBGT values when metabolic workload must be estimated; and, difference in air velocity and clothing levels have substantial effects on WBGT threshold values, although these factors are not normally included in decision rules.

This paper supports the appropriateness of abbreviated guideline rules relating to air velocity and clothing. Further, it suggests that the sensitivity level of the entire measurement and estimation process greatly reduces the overall precision and confidence in any set of decision rules. Simplified rules, when combined with appropriate administrative and work practices, should yield protection to the worker that is comparable to the use of seemingly more precise methods.

Effects of Body Build and Sweat Rate on Rectal Temperature During Acute Heat Exposure in Man

By K. IWANAGA, A. YASUKOUCHI, K. YAMASAKI, H. SATO and M. SATO

Department of Ergonomics, Kyushu Institute for Design Research, 226 Shiobaru, Minami-ku, Fukuoka-City, 815 Japan

The present study was conducted to examine the effects of body build and sweat rate on rectal temperature during acute heat exposure. Nine healthy male students volunteered as subjects. After staying for 30 min in a climatic chamber at a temperature of 28°C with 50% relative humidity, the physiological

responses to heat exposure at rest were examined in another climatic chamber at a temperature of 45 or 50°C with 50% relative humidity for 61 min. Rectal temperature was measured at the end of the period at 28°C and during heat exposure at 45 or 50°C. Sweat rate (mg/10 min) in the chest was obtained using the filter paper method. Skin-fold thickness and body density were measured. Body weight was measured prior to and after the experiment and the volume of sweat during exposure was obtained. Moreover, expired gas collection, ECG recording and skin temperature measurement were performed.

Sweat rate had a negative linear correlation with the absolute value of rectal temperature. Skin-fold thickness of upper arm and body weight had a negative linear correlation with the increase of rectal temperature during exposure.

In conclusion, sweat rate is affected by the absolute value of rectal temperature, and body build affects the increase of rectal temperature.

Analytical Determination of Heat Stresses

By J. J. VOGT, V. CANDAS and J.-P. LIBERT

Centre d'Etudes Bioclimatiques du C.N.R.S., 21 Rue Becquerel, 67087 Strasbourg, Cédex, France

This paper describes an analytical method for assessing heat stress, recently adopted as a national standard by the French Standard Institution (AFNOR). This method sets Heat Tolerance Limits (HTL) and Safe Exposure Times (SET) on a psychrometric chart for any situation in which air movement, mean radiant temperature, metabolic heat production and clothing insulation are specified. These assessments are based on the following criteria: maximal sweating rate, maximal skin wetness, maximal heat storage and maximal dehydration. Good agreement is found between HTL and SET assessed through this analytical method and corresponding data established experimentally by other authors.

Physical Work Capacity of Young Competitive Swimmers in Water at Three Different Temperatures

By T. NOMURA

Institute of Sports Science, University of Tsukuba, Sakura-mura, Niihari-gun, Ibaraki 305, Japan

Maximal oxygen uptake ($\dot{V}O_2$ max) was studied at three different water temperatures (18.0, 22.0 and 26.0°C) using an underwater bicycle ergometer. Subjects consisted of three girl and six boy competitive swimmers aged 10–12 years. There was no significant difference in $\dot{V}O_2$ max at the three water temperatures. Higher pulmonary ventilation (\dot{V}_E) in 18°C water (79.8 ± 6.9 l/min) than 22°C (65.7 ± 15.7 l/min) and 26°C (63.5 ± 6.7 l/min) was observed. However maximal heart rate (HR_{max}) in 18°C was about 6 beats/min lower than 26°C water. Blood lactate concentrations after maximal exercise was 6.61 mmol/l in 18°C, 6.10 mmol/l in 22°C and 5.36 mmol/l in 16°C. In 18°C water five subjects' core temperature dropped (0.2–0.6°C) during 10–16 min exercise. Present results showed that young swimmers responded similarly to adult results previously reported.

Effects of Repeated Cold Exposures on Thermal Responses of Men

By Y. TOCHIHARA

Department of Hygiene, School of Medicine, Showa University,
1-5-8 Hatanodai, Shinagawa-ku, Tokyo 142, Japan

Recently, the number of artificial cold working environments (e.g. cold-storage plant) increased, and air temperature in these environments became lower. Work in such severe cold environments has produced some medical problems. The effects of cold exposure on physiological responses and performances have been frequently studied, but investigations on effects of repeated cold exposures are limited. This paper describes some experiments with effects of repeated cold exposures on thermal responses of men wearing cold-protective clothing.

Four healthy male students wearing cold-protective clothing (total clothing weight was 5.2 kg) served as subjects for a total of 24 tests. After 20-min rest at neutral air temperature (22–25°C), subjects were exposed to cold environments (–5, –20 or –35°C) for 30 min. This pattern was repeated three times, and so total cold exposure time was 90 min for a test. In each cold environment, subjects were rested in sitting position (rest) or loaded with step exercise (work). Oxygen consumption, rectal temperature, skin temperatures at 12 sites, heart rate and thermal sensations were measured.

Heart rate at rest in cold environments kept lower than that in neutral air temperature, but heart rate increased when shivering occurred. The change of rectal temperature was observed by repeated cold exposure. At the end of the third cold exposure to air temperature at –5, –20 and –35°C, rectal temperatures at rest were 36.75, 36.48 and 36.55°C, respectively, then rectal temperatures during work were 37.10, 36.80 and 36.43°C, respectively. Skin temperatures fell due to repeated cold exposures and there were many complaints of coldness and pain particularly at fingers.

Thermal Effects and Finger Strength Changes in Cold Water Immersion with a Survival Suit

By K. KIMOTSUKI

Institute for Science of Labour, 1544 Sugao, Takatsu-ku, Kawasaki 213, Japan

The thermal resistance of two kinds of survival suits for cold sea-water immersion was tested by examining changes in body and skin temperatures, heart rate, finger strength and other items. Each of four male subjects was kept immersed, wearing a survival suit, in a cold water pool for 3 hours. The water and room temperatures were kept constant at 0, 3 or 6°C. Body temperature decreased more markedly during immersion in water of lower temperature. Finger strength, which was measured separately for fingers II–V of both hands by means of a finger dynamometer, paralleled the decrease of body temperature.

Body temperature and heart rate showed fluctuating variations in accordance with shivering and while the subjects endured immersion they felt chilled pains in their extremities. Finger strength declined consistently to about two-thirds of the pre-immersion level. The finger strength level was considered a good indication of the peripheral efficiency of the thermally resistant suits.

Further improvement of such suits was found necessary, in particular with respect to hand and finger movements and peripheral thermal efficiency.

Heat Protection in Respiratory Channels

By Y. LE MASSON

LAMA, 19 rue du Gord, 91580 Etrechy, France

In deep water diving (150 to 300 m), the gases breathed out under high absolute pressure convey a large quantity of heat. If the gases breathed in are cold, heat loss by the respiratory channels becomes important and places the life of the diver in danger. Closed circuit breathing apparatus can maintain the temperature of recycled gas at the correct levels. On-going studies including simulation in caissons illustrate this phenomenon and confirm the interest in closed circuits in deep sea diving.

Telecontrol of Breathing Apparatus in a Lock out Breathing System for Deep Sea Diving

By Y. LE MASSON

LAMA, 19 rue du Gord, 91580 Etrechy, France

Liberating the diver of all respiratory preoccupations by transferring the regulation and control of these parameters to qualified personnel onboard the underwater vessel from which the diver has come out of, is the outcome of an ergonomics study to such a problem. A lock out breathing system (L.B.S.) is proposed, characterized by a reading of a continuous sample of gas breathed out in a closed circuit by the diver, which takes place in the underwater vessel. This sample is analysed and the values of the partial pressure of the oxygen measured determine the oxygen necessary to maintain optimum conditions of the mixture breathed. Continuous recording memorizes the development of the diving.

A 4. Hyperbaric Environment

Convective Heat Transfer Coefficient of the Human Body in a Hyperbaric Helium-Oxygen Mixed Gas Environment

By H. NAKAYAMA

Department of Hyperbaric Medicine, School of Medicine, University of Occupational and Environmental Health, 1-1 Iseigaoka, Yahata-nishi-ku, Kita-Kyushu-shi 807, Japan

There is a significant increase in heatloss from body surfaces when a man is exposed to a hyperbaric helium-oxygen mixed gas environment essential for a saturation dive.

Increasing heatloss induces significant diuresis and lower performance if there is no attempt to control ambient temperature and humidity. In addition, with the decrease of evaporative heat transfer, heat stroke may be induced more easily in the case of deviation of ambient temperature to a higher range. It is, therefore, very important to quantitatively understand the body convective heat transfer coefficient as a parameter in providing the life-support system.

This paper reports on the convective heat transfer coefficient of resting and working subjects at normal and high ventilated conditions when the Japanese Marine Science and Technology Centre (JAMSTEC) carried out saturation dive experiments at 26-31 ATA in 1978 and 1979.

At the thermal comfort zone skin and rectal temperatures, metabolic rates and decreasing rates of body weight of subjects who were resting and at exercise, by bicycle-ergometer at two different ventilated conditions, were measured.

From the above data various factors of body heat balance were calculated by equations.

The Influence of a Hyperbaric Environment (11-31 ATA, He-O₂) on Disturbed Human Sleep

By K. SEKI

Japanese Marine Science and Technology Centre, 2-15, Natsushima-cho, Yokosuka-shi 237, Japan

Since the investigations of Naitoh *et al.* (1971), Rostain and Regesta (1973), Wilcox *et al.* (1976), Townsend and Hall (1978), Seki and Nakayama (1978, 1979, 1980, 1981), it is well known that a hyperbaric heliox environment affects the sleep profile of divers. That the modification of sleep relates to fatigue and decreased performance under a hyperbaric heliox environment has been especially thoroughly investigated. Seki (1976) also showed by a psychophysiological study, that modified sleep caused altered vigilance and increased fatigue.

This study consisted of four simulated dives (11-31 ATA, $P_{O_2}=0.4$ bar, $P_{N_2}=0.79$ bar) to investigate the electrophysiology of sleep in four professional divers. The compression rate followed 10 and 25 mph (1-26 ATA). The experimental schedules were as follows, pre-dive (1 ATA air and 2 ATA He-O₂) of 3-4 days, saturation of 7-14 days, decompression of 5-12 days.

The results were as follows;

- (1) Sleep stages REM and NREM III and IV develops (absolute and relative figures) for all divers but decreased on the first night after compression from 1 to 11, 21, 26 ATA.
- (2) During saturation periods (11, 21, 31 ATA) the ratio of AWAKE time, NREM sleep stage (I + II) to total sleep time increased, then the ratio of time of NREM sleep stage (III + IV) to total sleep time decreased.
- (3) Skin temperature and respiration rate also decreased, but heart rate and rectal temperature do not change at such depth (31 ATA).
- (4) Remarkably enough, urination volume and episodes at night significantly increased at 11, 21, 31 ATA.

Conclusion: Under a hyperbaric environment in a dry caisson, sleep in man undergoes essential (not only circumstantial) modification.

The Influence of a Hyperbaric Environment on Fatigue in Human Deep Dives

By Y. TAYA and N. KUWABARA

Japanese Marine Sciences and Technology Centre, 2-15 Natsushima-cho, Yokosuka-shi 237, Japan

It is well known that when man is exposed to pressures greater than 16 atmospheres absolute (ATA) He-O₂, signs and symptoms of the high pressure nervous syndrome (HPNS) begin to appear. These are primarily characterized by disorientation, nausea, dizziness and tremors of the hands and arms.

This study was about fatigue of divers exposed to 21 and 31 ATA He-O₂ environments. Measurements were made of subjective symptoms of fatigue, psychomotor performance (tapping test and manual dexterity test) and critical flicker frequency test (CFF). Four subjects (commercial divers) were exposed to each experiment at 21 ATA for 26 days and 31 ATA for 34 days. The diver's daily activity schedule inside the chamber was as follows: 07.00 (rise, subjective appreciation of fatigue), 08.00 (breakfast), 09.00 (underwater activity or physical exercise), 17.00 (tapping test, manual dexterity test), 18.00 (supper, subjective appreciation of fatigue), 19.00 (bathing), 23.00 (retire).

Psychomotor performance improved during experiments except on compression day to 26 and 31 ATA. Symptoms of HPNS occurred during the first 24 hours of compression to 26 and 31 ATA, but disappeared 24 hours later. The results of subjective symptoms of fatigue showed that there were more claims both about physical and mental fatigue in the morning than in the evening throughout the experiments. CFF results showed little change and were normal as for a usual industrial society.

A 5. Noise and Vibration

Responses of a Sympathetic Nervous System to Hand-induced Vibration

By T. SAKURAI

Department of Environment Health, Kurume University School of Medicine, 67 Asahi-machi, Kurume-shi, Fukuoka-ken, Japan

Responses of a sympathetic nervous system to hand-induced vibration were observed by electrocardiograph on a chest, photo-plethysmograph on a left middle finger, mercury-plethysmograph on a middle finger of the right side and galvanic skin reflex on a left palm on nine healthy male subjects.

Sinusoidal vibration was given to the right hand of a subject, who gripped a handle set on a electrodynamic shaker. Room temperature varied at 10 or 25°C. In these experiments factors concerning vibration (vibration magnitude, vibration frequency, vibration exposure time) and room temperature were examined by using the experimental design method.

It was concluded that the responses of a sympathetic nervous system on the above-mentioned marks were affected by vibration and environmental temperature as stress factors. The contours of equal reaction on these marks were obtained.

TTS of Vibratory Sensation Induced by Exposure to Intermittent Vibration

By Y. FUKUCHI and S. WATANABE

Department of Preventive Medicine, Shiga University of Medical Science, Seta-Tsukinowa cho, Ohtsu 520-21, Japan

The temporary threshold shifts of vibratory sensation (TTSv) after intermittent exposure to vibration transmitted to the hand were measured in order to obtain basic information for the hygienic permissible time-limitation in using vibratory tools.

The subjects were six 22-30-year-old male students. Vibration was applied to the left hand through a handle attached to an electro-dynamic vibration generator for 4, 8 and 16 min, repeating 8, 4, and 2 times, respectively, i.e. totalling 32-min exposure, with intervals of 2, 4, 8, 16 or 32 min rest (unexposed to vibration).

The threshold of 125 Hz vibratory sensation was measured in 2.5 dB steps at left forefinger-tip before exposure, and every minute after cessation of exposure.

The cumulative effects of intermittent exposure to TTSv, i.e. the growth of TTSv and delay in recovery, were recognized in some combinations of the exposure time and unexposed interval.

Individual Protection Against Noise

By J. DUCROCQ

ERGOS: Société d'Etudes et Réalisations en Ergonomie, B.P. 42, 77201 Marne-La-Vallee, France

Of all the means for dealing with noise, individual protection has been one of the most frequently employed methods because of its ease of use and excellent effectiveness.

Such a method must protect against noise but must not completely audially isolate the user from his environment. The improvement of individual protection is possible using 'active' systems which permit the ear to hear a large range of sounds while assuring the protection needed.

Two solutions are possible: an electronic system with progressive saturation and an electronic system with constant gain. The first solution has made its commercial debut and has elicited an interest in 'active' protection. It seems, after trials, that future development will be oriented towards the constant gain solution which permits a better dosage of the quantity of energy provided by the electronic system. This technology seems to be the only way to give a noticeable improvement in individual protection against noise.

Effects of Psychic Load on the Growth of Temporary Thresholds of Hearing During Exposure to Combination of Stable Noise and Sinusoidal vs. Stochastic Low-frequency Vibration at a Dry-bulb Temperature of 20°C

By O. MANNINEN

Faculty of Medicine, University of Tampere, Box 607, SF-33101 Tampere 10, Finland

The purpose of this study was to characterize the single and combined effects of noise and vibration on TTS values when a psychic load caused by competition was added to the mutual exposure combinations of stable noise and stochastic or sinusoidal whole-body vibration.

The study was carried out as a factorial experiment which was voluntarily participated by 54 healthy male students. The age of the subjects ranged from 17 to 26 years of age. The exposure period consisted of three successive 16-min exposure cycles. The dry-bulb temperature of the exposure chamber was maintained at 20°C during the part of the test in question. The subjects were randomly divided into two groups, those competing and those not. The competitor achieving the fastest reaction time with least faults could win FIM 2,000, whereas those not competing were allowed to freely operate at the speed they considered best without any possibility of receiving a financial reward. A-weighted white noise with cutoff frequencies of 0.2 and 16 kHz and intensity of 90 dB was used. The noise classes and the psychic load mixed with them were as follows: (1) no noise, no competition; (2) noise of 90 dB(A), no competition and (3) noise of 90 dB(A) and competition. Each subject was exposed to vibration (z axis) using either sinusoidal vibration of 5 Hz or stochastic vibration of 2.8–11.2 Hz, acceleration being set at 2.12 m/s² in both cases. The values for hearing thresholds were calculated using a pure tone audiometer 2 min after the termination of each exposure (i.e. TTS₂). The results indicate that the hearing threshold averages in the audio range of 4 kHz of those persons participating in the competition and being simultaneously exposed to noise of 90 dB(A) were considerably higher than of those who were only exposed to noise of 90 dB(A). When the persons were subject, simultaneously with noise, to either vibration of 5 Hz or vibration of 2.8–11.2 Hz, the hearing threshold averages in the audio range of 4 kHz were now higher ($p < 0.10-0.05$) than when the subjects were exposed to the noise of 90 dB(A) only. A psychic load of competition type did not, however, seem to raise the hearing threshold to any noteworthy extent during a paired simultaneous combination of noise and vibration. Hearing threshold averages in the audio ranges of 4 and 6 kHz differed from each other most when the exposure combination included stochastic vibration.

The Influence of Environmental Noises on the Performance of a Repetitive Task

By T. K. TAKATA

Toyota Technical College, 2-1, Eisei-cho, Toyota-shi, 471, Japan

Modern production technology has increased productivity by specializing tasks which then became repetitive with a short time cycle. This type of work is monotonous. The performance of a repetitive task is affected by many factors such as climate, noise and psychosensory activity.

One of the aims of this study is to find out what kinds of physiological reactions, such as heart rate variability, are associated with repetitive tasks under an imposed environmental noise.

The experiment consisted in performing a repetitive task which was an exercise with measurements of reaction times. The task was characterized by different noise conditions. Twenty healthy male and female students participated in this study.

Recordings of the repetitive reaction time, noise level, respiration and ECG were made during the exercise. Heart rate variability signals were derived from the recorded ECG.

To determine the relationship between reaction time and heart rate variability, cross-correlation technique and time series analysis were employed.

Spectral analysis of reaction time, heart rate and respiration variability revealed the existence of several frequency components.

The frequency components and reaction times were affected by environmental noise levels and several kinds of noises. The period of repetitive tasks also influence the performance of repetitive tasks.

Despite possible disturbances by other influencing factors, the results seem to be reliable enough for fundamental data of working environments.

Human Response to Infrasound Below Hearing Threshold

By O. OKAI

Department of Physiology, Kyorin University, School of Health Science, Miyashita 476, Hachioji City, Tokyo 192, Japan

We investigated human response to infrasound below their hearing threshold. Subjects were placed in an environment exposed to infrasound at levels of 70, 80, 90 and 100 dB of 8–20 Hz during 1 hour. Hearing threshold for infrasound draws a curve on 100 dB for 10 Hz, 87 dB for 20 Hz and 76 dB for 50 Hz in normal subjects. However, a few subjects, sensitive to infrasound, had a lower threshold, suggesting that sensitive subjects may be audible to infrasound at a lower level and lower frequency than normal subjects. Heart rate and respiration increased in response to infrasound. At the same time the standard deviations of blinking decreased from 70 to 80 dB. Only one subject indicated a rare wave form of respiration. These responses may be attributable to vestibular reflexes. Namely, infrasound pressure, augmented at the sound transporting system of the hearing organ, stimulates the vestibular organ directly and causes such reflexes to take place as vestibulo-ocular, vestibulo-autonomic and vestibulo-spinal reflexes.

Studies on the Influence of Infrasound to the Human Body—Physiological Effects of Long-term Exposure to Infrasound in the Case of Rabbits

By N. MACHIDA, Y. YOSHIDA, H. ITOW

Nihon University, College of Science and Technology, 24-1, 7-chome Narashinodai, Funabashi, Chiba-ken 274, Japan

The term infrasound refers to ultra-low frequency (20 Hz or below) air vibration inaudible to humans. In this study, the physiological effects on animals of long-term exposure to infrasound were investigated experimentally. The experimental animal was a rabbit. The responses of the autonomic nervous system and of the endocrine system (changes in hormone levels) were taken as indices of these effects.

The infrasound was generated by an electrodynamic loudspeaker with a diameter of 46 cm. The experimental conditions were:

infrasound frequency	16 Hz (sinusoidal)
infrasound pressure level	100 dB, 110 dB
exposure period of infrasound	4 weeks (whole-body exposure)

Experimental number of the rabbits were:

exposure level of infrasound pressure	100 dB ♂ 8 (body weight 2.5–3.0 kg)
exposure level of infrasound pressure	100 dB ♀ 1 (body weight 2.5 kg)
exposure level of infrasound pressure	110 dB ♂ 1 (body weight 2.9 kg)
control (non-exposure to infrasound)	♂ 4 (body weight 2.5–3.0 kg)

Physiological function was gauged from electrocardiograms, serum K and Ca values, leucocyte counts, changes in the number of stomach movements and from urinary adrenalin, noradrenalin, corticoid (17-OHCS) and steroid (17-KS) levels.

These items were measured for 6 weeks, including 1 week each of pre- and post-exposure rest periods.

The results showed decreases in stomach movement and increases in the serum K and urinary 17-ketosteroid values.

It is thought that changes in the sound pressure of the infrasound caused stress in the bodies of the subjects.

We concluded that long-term exposure to infrasound affects both the autonomic nervous system and the endocrine system of living bodies.

Studies on the Influence of Low Frequency Vibration to the Human Body— Vertical Vibration

By Y. YOSHIDA, N. MACHIDA and R. MIKI

College of Science and Technology, Nihon University, 24-1, 7-chome Narashinodai, Funabashi,
Chiba-ken 274, Japan

We often receive vibratory stimuli in our normal living environment.

In 1974, the ISO (International Organization for Standardization) established ISO 2631, *Guide for the Evaluation of Exposure to Whole Body Vibration*, to assess the effects of exposure to whole-body vibration. This standard covers a vibration frequency range of 1–80 Hz. The guide for evaluating exposure to vibration less than 1 Hz in frequency was proposed and is now under deliberation as Addendum 2 to the standard. The important factors which govern the human perception of vibration are the physiological reactions which result from the vibration transmitted to the body and the psychological reactions which are the sensations of comfort and discomfort. No systematic methods are developed yet which can evaluate these reactions collectively.

This study experimentally investigated the effects on the human body of low-frequency whole-body vibration, including ultralow-frequency vibration of less than 1 Hz.

The subject was given vertical vibration on a body vibrator and the resultant physiological and psychological (subjective) reactions were measured to evaluate comprehensively the effects of the vibration on the body. The frequencies ranged from 0.2 to 2 Hz, and the amplitudes were 2, 5, 7 and 10 mm (the acceleration was approximately 1.02×10^{-3} to 0.2 G). The duration of exposure to the vibration was 15 min. Changes in the subject's cardiac function (heart rate), respiratory function (frequency of respiration) and salivary function (amount of secreted saliva) were measured to observe the effects of the vibration on the automatic nervous system. The subject was then asked to grade the vibration on a five-point scale ranging from 'comfortable' to 'uncomfortable', and his psychological reactions were evaluated from his subjective ratings of the vibration. Under these experimental conditions, the physiological reactions and subjective ratings were comparatively studied.

As a result, it was found that the heart rate and the amount of secreted saliva tended to decrease as compared with those before the subject was exposed to the vibratory stimulus. The vibration which the subject psychologically perceived as 'pleasant' did not necessarily produce a good physiological reaction.

Noise Emissions From Industrial Plants and Annoyance in the Neighbourhood

By S. GYR and E. GRANDJEAN

Institut für Hygiene und Arbeitsphysiol, Clausiusstrasse 21, 8092 ETH-Zürich, Schweiz

Noise emissions were measured in the surroundings of five industrial plants and people were asked by questionnaire about the effects caused by industrial noise. The questionnaires of 1498 people were analysed. The noise measuring points were situated near dwellings and on balconies. The Leq (level of average noise intensity) of the total noise (industrial noise and non-industrial noise) was measured (in dB(A)) for a measuring time of 1000 s; the Leq was measured repeatedly (on different days, on the same day) at most noise measuring points and from that an average Leq was calculated. The average Leq is known for industrial noise in the surroundings of all five industrial plants.

The context between the average Leq for industrial noise and (i) strength of annoyance and (ii) frequency of specific disturbances and reactions caused by industrial noise, was investigated separately for daytime and night-time. Limits for noise emissions caused by industrial plants in residential areas are discussed.

A 6. Load and Performance of Mental Activity

Cumulative Fatigue Symptoms and Conditions of Work

By R. KOSUGO

Institute for Science of Labour, 1544 Sugao, Takatsu-ku, Kawasaki 213, Japan

Chronic fatigue was studied on various groups of workers using a questionnaire about cumulative fatigue symptoms. The factor analysis of the results have established that there are six underlying factors of these symptoms: general tiredness physical disorder, weakness, irritability, anxiety and lowered motivation. The

mean percentage of works having symptoms of each factor differed greatly between the 32 different jobs studied.

The profile of the mean frequencies of those six factors showed patterns specific to each group of jobs having similar job characteristics. Works with load-handling tasks such as transport workers showed higher weight of general tiredness and physical disorder. Whereas vigilance and mental task workers such as air traffic controllers showed predominance of chronic weakness and irritability. Nurses, teachers of disabled children and others with complicated dense physical and mental tasks tended to have high scores for both physical and weakness-irritability factors. Nurses were featured by higher frequencies of anxiety symptoms. The cumulative fatigue profiles are thus useful to indicate workload characteristics as a basis for ergonomics considerations.

The Validity of Japanese Fatigue Feeling Scale

By Y. SAITO

Department of Psychology, Chuo University, Higashi-nakano, Hachioji, Tokyo, Japan

The validity of the Fatigue Feeling Scale proposed by the Industrial Fatigue Research Committee of the Japanese Association of Industrial Health was examined on the data of an industrial survey of 121 locomotive drivers. The scale is comprised of 30 fatigue complaints of physical, mental and sensory symptoms, every 10 of which are factor-analytically classified to three scales, i.e. 1st, weakened activation, 2nd, weakened motivation and 3rd projected physical fatigue. The drivers were asked to answer each of the items by Yes or No before and after driving, the number of 'Yes' answers being the score on each scale.

Drivers showed an increase in scores of the 1st scale on the condition of more than 3 hours driving than of less than 3 hours. The rates of decrease in the 1st score during the rest time they took at their destination were clearly different among conditions of 5 or less hours, 5–6.5 hours and more than 6.5 hours, indicating that longer rest time causes the 1st score to lower. These results demonstrate that the change in score may explicitly express the level of driving fatigue and the extent of recovery.

It was shown that with daytime driving the regression coefficient of the 1st score on the 2nd one was quite different from that of the 2nd score on the 1st one. However, the two coefficients became similar on data during night driving. It suggests that at night subjective complaints on the 2nd scale become dependent on a decreased level of activation which manifest itself on the 1st score.

It is concluded that in vigilance work such as locomotive driving the proposed Fatigue Feeling Scale may be a valid measure to show the nature and level of subjective fatigue caused by the work.

Factorial Analysis of Fatigue

By S. KONDO and M. OSHIMA

2-3-13, Asahi-cho, Nerima-ku, Tokyo 176, Japan

When a man judges himself to be in excellent condition or weary, it is not usually clear to himself or a third party how valid the judgement is. It is the object of this present paper to examine the validity of subjective judgement of the degree of one's fatigue, from the relation of degree of fatigue (in excellent condition, ordinary, somewhat fatigued, extremely fatigued) to several relatively concrete and objective categories of daily life, which are considered to be related to fatigue, by positioning distances between the two factors in multidimensional space. To show how our idea has worked, we picked two cases from the subjects of our studies. Both cases concern people of middle age. One is a male subject (S), who is a salaried engineer of managerial class, and the other a housewife (K), who is also working as a paramedical technician.

We obtained the distance between the degree of fatigue as judged by the above two cases and other categories of their daily life, which had been investigated by the questionnaire method from the factorial analysis by Hayashi's Quantification Theory III. The results show that in the case of S, his 'excellent' condition is surrounded (or near in distance) by such categories as holiday, lying down for a rest, slept enough, the 'ordinary condition' is surrounded by fine weather, rain, daily office work, going outdoors, etc., which represent the ordinary daily life. The 'somewhat fatigued' condition and 'fatigued' have a cluster of items like sleepy, unstable weather, night-time work, etc., which are usually considered to be related to fatigue. The case was similar with subject K. The flicker fusion device and other methods have hitherto been used as a measure of fatigue, but our study results suggest that common subjective observations of conditions from daily life factors, might prove reliable enough judgements.

Measurement of Critical Fusion Frequency by Liquid Crystal

By R. HOSAKA

Faculty of Medicine, University of Tokyo, 7-3-1 Hongon, Bunkyo-ku, Tokyo 113, Japan

A new device to measure critical fusion frequency (CFF) is developed. In the conventional method a light source is set against a proper background and switched on and off either mechanically or electrically. Measurement during work is difficult using this type of equipment since the examinee has to look into a box.

In the proposed equipment, natural light is used as a light source and is modulated by a liquid crystal. The liquid crystal used has a response time of approximately 1 ms, which is short enough compared with the usual CFF value below 50 Hz. The CFF value changes by luminous intensity of the central spot and background. In this equipment, contrast of the liquid crystal is always held at a constant level by control of its driving voltage.

This method makes the measurement of CFF during work possible. Some applications are being studied with the object of making the device small and easy to handle.

Workload Studied by Multi-point Critical Fusion Frequency (MCFF)

By H. OSAKI, S. KIKUCHI and M. OGATA

School of Engineering, Okayama University, 1-1 Naka 3-chome, Tsushima, Okayama 700, Japan

Recently it has become clear that performance of the cerebrum is divided between two hemispheres. The dominant hemisphere takes charge of analytical, verbal, arithmetical and computer-like performances, whereas the minor hemisphere takes charge of musical, pattern-sense, synthetic, geometrical and spatial performances. Therefore the level of excitement of each hemisphere possibly differs in accordance with its work content. Measurement of the level of excitement in each hemisphere by CFF would help decide whether this is indeed so.

The nervous tissue of the retina is divided into four parts by horizontal (temporal, nasal) and vertical (superior, inferior) lines. These tissues pass to the different visual areas through the optic nerve.

Multi-point flicker apparatus controlled by a microcomputer was developed to measure the CFF at the fovea centralis when both eyes were being used and when each eye was being used separately—at points located in each eye of the quadrants of the visual field and at a visual angle of 6° in each eye. This apparatus could measure eleven CFFs (MCFF) consecutively.

We estimated the level of excitement of each hemisphere during arithmetical operation work and maze work. Arithmetical operation work was mainly carried out by the dominant hemisphere and maze work by the minor one. In arithmetical operation work, the level of both hemispheres before work was nearly equal to that after work. This result shows that the dominant hemisphere controlled the minor one. In maze work, some parts of the minor hemisphere were in the loaded state after work; however, the dominant hemisphere was stable. Therefore, there was a difference in the level of excitement of the two hemispheres.

Measurement on Brain Arousal Rate

By S. INABA

Inaba Institute of Human Engineering, 2-801 Mimomi-cho, Narashino, Chiba 275, Japan

In lieu of a conventional flicker tester, an excito-meter for measurement of brain activity has been developed.

1. Brain excito-meter

- (1) Large figures are lit on a display panel so as to give stimulus regardless of the brightness of the light source.
- (2) Stimulus is not to the first optical region alone, but numerals are also programmed.
- (3) Numerals will be lit sequentially as an aid to memory (temporal lobe) functions.
- (4) Diversity (e.g. missing, duplicate or reverse) is programmed between numerical order for coalition of discriminating conception which helps to detect discontinuity.
- (5) A 20 min time limit is set for participation of will (frontal lobe) to response measurement.
- (6) Regarding recognizing capacity as the sense level, change sequence of numerals (i.e. replace successive order), maintain Hz constant for lighting speed, ask testee the changed number after 20 min lighting. If response is correct, increase Hz and the maximum Hz corresponding to correct response will be defined as the sense level.

- (7) Alternating numbers will be changed at every test by tester without notifying the testee.
- (8) Initially, test details are explained to testee by 2 Hz, lighting after notifying change number, actual test will be carried out after understanding the test details.

2. Measured results of drunkenness

Degree of drunkenness is detected by amount of alcohol in testee's expiration which is gathered into test balloon, if the value exceed 0.25 mg/l, his situation is hazardous for car driving.

Performing accuracy test on various drunkenness testers for the Medical Properties Committee of the Japanese Automobile Research Institute, the author has surveyed several items including the brain excito-meter and the results were in perfect correlation to variations of alcohol content in testee's expiration.

3. Conclusion

The brain excito-meter will be termed a novel, practical and reliable tester to use for sense level detection; according to a recent survey on mental patients, details and degrees of mental disease to scale recovery condition of patient by dosing is also detected.

Information Load and its Norming

By A. HONKASALO

Lappeenranta University of Technology, PL 20, SF-53851, Lappeenranta 85, Finland

and H. KAUTTO

Helsinki University of Technology, Tekniikantie 3 A, SF-02150, Espoo 15, Finland

Wearing out the labour force in the man-machine system may be considered separately on the levels of energetic and information loads, provided it is understood that both these effects are integrated in the organism of the worker. The question, on the one hand, is thus of evaluation and norm setting for the load generated by energy and metabolic work and, on the other, information work. From the standpoint of ergonomics it is of minor significance to know the mechanisms that transform internal load into strain and into diseases of occupational origin. More important is a sufficiently accurate analysis of how these reactions can be eliminated via intervention into the working environment and the work process itself.

The accelerating rate of automation in production processes has made an evaluation of the total internal load generated in the worker by the work tasks an even more urgent undertaking. One reason is the prevailing trend of change in this loading in the course of automation, the mechanism being such that one-sided work motions and postures, as well as mental stress and load—not physical strain—become the most likely causal agents of safety and health risks. A common notion among work psychologists probably is that the knowledge available today is insufficient for setting of norms and limiting values for mental load of occupational origin. This is true in the sense that current scientific knowledge forms a basis for neither norm setting nor evaluation of total mental load. Yet, this does not imply that unambiguous limit values would be impossible to set for some partial loading factor.

Disturbances in Curve Progress Smoothness of Pupillary Reflex Induced by Mental Workload in the Long Period of Time

By T. MAREK and C. NOWOROL

Institut Psychologii UJ, ul Manifestu Lipcowego 13, 31-110 Kraków, Poland

The present investigation is the continuation of research into changes in pupil diameter and pupillary reflex induced by mental workload (Marek *et al.* 1979, 1980, Moray 1979). Pupillary reflex to changes in illumination is unconditioned. The increment of light intensity causes pupillary contraction. When the course of reflex is recorded the empirical curve may be drawn as a function of time, where axes of abscissae and ordinates are the time and the pupil diameters, respectively. The curve may be analysed from various viewpoints.

The aim of this research was to find out whether the smoothness of the pupillary reflex empirical curve is disturbed under the long-term mental workload.

Thirty female telephone operators aged 21–39 were examined. They were tested during the morning shift before starting work (series A) and after 6 hours of work (series B). It has been proved through ergonomical work analysis that the subjects of investigation were influenced mostly by mental load. The electronic system

of pupillography was used (Venables and Martin, 1967). Measurement accuracy was 0.05 mm. The pupil diameter was measured every 0.0625 s. The standard light stimulus (100 lx) was the cause of pupillary reflex. Darkness adaptation was 8 min.

Two empirical curves were drawn for each person and changes in progress curve smoothness were tested. For this aim the experimental error was considered. It is expressed as

$$e = (1 - r^2),$$

where e is the experimental error and r is the curvilinear correlation coefficient. Mean values for series A and B are $e_A = 0.01$ and $e_B = 0.05$. As may be observed progress curve smoothness is disturbed due to mental workload ($p < 0.05$). The discovered disturbance seems to constitute a mental load measure.

REFERENCES

- MAREK, T., NOWOROL, C., and ZARCZYNSKI, Z., 1979, Objective fatigue measurement by pupillography. *Ergonomics*, **6**, 721.
- MAREK, T., NOWOROL, C., and ZARCZYNSKI, Z., 1980, Pupil reflex with light velocity in its initial phase influenced by mental load. XXII International Congress of Psychology—Abstract Guide, p. 591.
- MORAY, N., 1979, *Mental Workload Its Theory and Measurement*. (New York and London: Plenum).
- VENABLES, P. H., and MARTIN, I., 1967, *A Manual of Psychophysiological Methods*. (Amsterdam: North Holland Publishing Company).

A Basic Study of the Prediction Method for Clerical Human Errors Based on Pulse Speed Variability

By E. KOYANO

5-6-5, Asagaya-kita, Suginami-ku, Tokyo 166, Japan

The purpose of this study is to develop a prediction method for learning the physical conditions of clerical human errors which may soon occur. The prediction method employs the co-efficient of deviation value of the pulse speed rate (CDPS) of clerical personnel who work in the office. The pulse speed rate (PS) is a value turning each pulse time interval into numbers of pulsations per minute. Therefore, 60 pulsations per minute gives 59 PS. Also, the co-efficient of deviation value is a value for dividing standard deviation value by mean value, and it shows the variation value of PS. From the results of the author's experiments, using 26 subjects, this study found that there is a difference between simple clerical operations and mental clerical operations by using CDPS, and also it is found that CDPS is more useful than the mean value of PS for indicating clerical human activity by using the analysis of variance method (ANOVA). From the experiments of 60 subjects who used typewriters and calculating machines for a period of 40 min, this study found that 57 subjects (95% of the total) showed the number of errors to indicate that there is an inverse correlation between the value of CDPS and the number of errors that occur. It has also indicated that 45 subjects (75% of the total) show the above-mentioned fact under the less than 5% level of significance. Also CDPS showed that these variations resulted about 15 min before clerical human errors occurred. According to these experimental result, the new prediction method for clerical quality control can be developed using CDPS.

Mental Effects of Risky Behaviour Seen by Means of a Portable Heart Rate Analyser

By H. MUROYA and M. IKEDA

Laboratory of Work Physiology, Railway Labour Science Research Institute,
5-6, Izumicho 2-chome, Kokubunji 185, Japan

A portable heart rate analyser has been worked up to monitor heart rate changes continuously in free moving conditions. It enables continuous recording of the numbers of heart beats in 10–60 s periods or the beat intervals. The data can be kept in an integrated-circuit memory unit and reproduced off-line to give heart rate curves and distributions of heart rate levels. The device was used to examine the mental effects seen during risky behaviour on an elevated platform and during a few unusual circumstances. Decrease in standard deviations of heart rate was shown to accompany increase in its mean level. These changes seemed to be more marked than in the case of mental effects by sedentary strainful conditions, and to have certain specific after-effects. The results are discussed in comparison with our previous data from various industrial mental work.

The Development of Ergonomic Solution Proposals by Analysis of Task

By H. BUBB

Institut für Ergonomie der Technischen Universität München,
Barbarastraße 16, D-8000 München 40, F.R. Germany

Today physical activities are being replaced more and more by mental activities due to mechanization. Ergonomics provides scientific tools for a humanitarian organization of mental loads during the manipulation of machines. The first step in this direction is analysis of the task. It can be shown that mental tasks which are created by the interaction of men and machines possess the following five independent properties:

- (1) The temporal sequence of partial tasks, called *operation*.
- (2) The active, respectively passive, involvement of men in the working process, called *manner of task*.
- (3) The spatial, respectively temporal, restriction of task, called *manner of control*.
- (4) The number of degrees of freedom to be controlled, called *dimensionality*.
- (5) The principle of displaying task and result, called *display*.

It will be shown, by examples, how to find priorities of mental load by such an analysis of task and how to develop technical solution proposals through it, by which better control of machine by men is guaranteed.

The Influence of Visual Workload History on Visual Monitoring Performance

By M. L. MATTHEWS

Department of Psychology, University of Guelph, Guelph, Ontario N1G 2W1, Canada

An increasing number of industrial settings require workers to monitor and react to information from disparate and varied signal sources. Typical examples may be found in air traffic control, manufacturing process control and power generating station control rooms. Such situations often require that operators be responsive to varying levels of visual information over time with the extreme cases being (a) a sudden increase in the number of visual signals following a period in which signals were infrequent. cf (Three Mile Island) and (b) a reduction in visual processing demands following a period of high activity.

History of workload remains an area that has not received systematic laboratory exploration although the effects of discrete load levels, whether in the form of an increase in the number of visual targets (visual load) or an increase in rate of targets is a well-documented area. To date there is only one reported study known to the author which has examined the role of workload history on current performance and this has dealt exclusively with the effects of rate of auditory signals on choice reaction time.

The aim of the present series of studies is to provide basic data on how variations in visual workload history may influence current visual processing performance.

Subjects were exposed to a monitoring situation in which they were required to search for and identify a target string that was presented upon a video monitor in a background of noise strings. The number of strings presented to the subject varied from a low of three to a high of twelve during the course of the experiment. Trials were presented at a rate of one every 10 s. The subject's task was to first search for the target string (presented on 50% of the trials) and to identify its position by pressing an appropriate response key and then make a decision based upon the information within the target string by pressing one of a further set of two keys. The independent variables were visual workload history and time on task and the dependent variables were speed of visual search and speed and accuracy of decisionmaking.

The results (which are too complex to present in detail here) showed that as time on task progressed subjects became more sensitive to disruptions in visual workload and that performance fell below that of appropriate control groups when there was a rapid change of visual load in either an upwards or downwards direction.

The implications of these results are discussed in terms of their application to human monitoring performance in an industrial context.

Lambda responses and Evaluation of Visual Task Load

By A. YAGI

Industrial Products Research Institute, 1-1-4, Yatabemachi-Higashi, Tsukuba, Ibaraki 305, Japan

The visual evoked potential (VEP) varies with information processing load. Eye movements are usually very restricted in the use of VEP. Recently we found that the lambda response (LAR) is a kind of VEP associated with offset of the saccade, e.g. onset of the fixation pause. Eye movements allow detection of LAR.

The use of LAR can be a more natural way of evaluating information processing than the use of VEP. The relationship between the variability of LAR and the visual information processing load was examined.

Eleven subjects were presented with simultaneously random patterns and tone pips. The visual task was to search on the random pattern and detect the visual signals. The auditory task was to listen to tone pips and detect the tone signals. EEGs from Oz and Cz, and EOGs were recorded. Occipital EEG epochs time-locked to offset of saccades were numbered. Odd-numbered epochs were summed fifty times in one array and even-numbered epochs were summed fifty times in another to obtain a pair of LARs. An index of variability was obtained by computing a correlation coefficient between two LARs, time point by time point. A pair of averaged auditory evoked potentials (AEP) to tone pips were obtained from the vertical EEG to compute a correlation coefficient between two AEPs.

The mean correlation coefficient of LAR during the visual task ($r=0.92$) was significantly higher than that in the auditory task ($r=0.80$), ($p<0.01$). On the other hand, the mean correlation coefficient of AEP in the auditory task ($r=0.53$) was significantly higher than that during the visual task ($r=0.24$), ($p<0.05$).

LAR was more stable during the visual task. This result suggests that variability of LAR reflects visual information processing. Variability of LAR can be applicable as an index of visual information processing load in eye movement situations.

Measurement of Pilot Workload During Take-off and Landing by C-1 Jet Carrier

By Y. NAGASAWA, S. ARAMAKI and N. UTSUKI

Aeromedical Laboratory, JASDF, 1-2-10, Sakae-Cho, Tachikawa-Shi, Tokyo, Japan

Pilot workload during take-off and landing at Iruma local airport was measured by means of a secondary task method. The flying manoeuvres were arbitrarily divided into ten segments: take-off, first turn, climb, level, descent, initial approach, brake, down wind, base turn and final approach. Three captain pilots participated in the study as the subject, and one co-pilot played an important role in checking and monitoring their performance. As a secondary task, the visual auditory discriminative task discussed in a previous study was used: a lamp box consisting of red and green lamps was mounted on top of the instrument panel, and a small speaker was installed on the backward wall of the captain's seat. By using a signal oscillator, signals synchronized with red light and tone burst at 1200 Hz and other signals synchronized with green light and tone burst at 800 Hz were randomly presented to the subject at intervals of 1-2 s. The subject was required to detect only the signal synchronized with red light and 1200 Hz tone, instructed previously, and to respond to the signal via microswitches mounted on both sides of the control wheel. The collected data on miss rate and response time of the secondary task, VTR of instrumental display and pilot activity, voice and cockpit noise were analysed. Task-flow analysis on each flying segment was performed in advance. Main results concerning a change of the secondary task during take-off and landing, relationship between the secondary task and the task time stress index estimated by task analysis are discussed.

Measurement of the Effect of Central-acting Drugs on Performance and Reaction Time

By H. KRÜGER

Institut für Arbeitsphysiologie, Technische Universität München, Barbarastrasse 16, D-8000 München 40, F.R. Germany

Central acting drugs like tranquillizers or hypnotics change the level of vigilance. Therefore the effect of these drugs is important in driving and controlling activities. In practice men not only have to drive or to control but simultaneously have to do additional tasks. Driving a car one has to identify traffic signals near the central visual field and to discover dangerous events in the peripheral visual field as well. It is a well-known fact that the diameter of the visual field shrinks with increasing load of the task in the central visual field. Based on this effect a new experimental arrangement was set up to test central-acting drugs. The main task is to control and to minimize the displayed difference between a stochastic altered voltage and a regulated one. Men have to recognize tachistoscopically presented linear arrays of four alphanumerics in central vision and to detect flickering lights on stochastic positions in the peripheral visual field. A visual-mental reaction time to the displayed array and a motoric reaction time to the flicker are measured. The experimental set-up was tested in two experiments. For different amounts of blood alcohol we found a significant correlation to the three parameters: integral of deviation in regulation, visual-mental and motoric reaction times. In a second experiment two hypnotics of the group of benzodiazepines (long and short lasting) were tested against placebo in a double blind manner. The integral of deviation in regulation, visual-mental and motor reaction times showed significant differences between long- and short-lasting hypnotic 7 hours after medication. Whereas performance of the arrays, heart rate and variability of heart beat allowed no significant discrimination between the three conditions.

Time Pressure, Training and Decision Optimality

By D. ZAKAY

Department of Psychology, Tel Aviv University, Tel Aviv 69978, Israel

Two experiments were carried out in order to evaluate the effects of time pressure and of training on the utilization of compensatory and non-compensatory decision process. In the first experiment 20 student nurses made professional decisions in a time-pressure condition and a no time-pressure condition. It was found that in the time-pressure condition the percentage of non-compensatory decisions was significantly higher than in the no time-pressure condition. In the second experiment 60 high school graduates made buying decisions with and without training in the process of compensatory decisionmaking. This was again done with and without time pressure. It was found that training was effective only with no time pressure. Under time pressure the training was not effective at all and the optimality of the decisions was significantly lower than under no time pressure. It was concluded that specific training methods should be designed to help decisionmakers improve their decisions under time pressure.

Alpha Wave and Miss of Signal Detection

By H. KODAMA

Department of Human Factors Engineering, Industrial Products Institute, 1-1-4 Yatabe-machi, Higashi, Tsukuba-gun, Ibaraki 305, Japan

The relationship between the alpha wave of EEG and the miss of signal detection was studied in this experiment. Subjects, four adults, were requested to press the corresponding key as fast as possible when they detected one of three numerical numbers (2, 3, 5) presented on an LED display in random order and intervals. EOGs were recorded in order to monitor the eye movement. The experiment was done in a dimly illuminated and electrically shielded room. The display of numerical numbers was controlled by a computer. The detection miss of signals increased along the time course of the detection task. The peak value of the alpha in the power spectra of EEG showed no clear correlation to the number of misses. Alpha waves which were not contaminated by the eye movement were analysed at the presentation of numerical signals. The averaged root mean square value of alpha waves was larger at the time of stimuli which were missed than at the time of stimuli which were detected. Three of four subjects showed the significant trend with less than 2% in *t*-test. This trend extended considerably before and after the time of stimulus presentation. The result showed that the root mean square value of alpha waves is an effective measure of performance lowering in numerical signals discrimination.

On High-order Dynamic Activity and its Component Activities

By K. SATO

Research Foundation on Traffic Medicine, 1-9-3 Higashi Ikebukuro Toshimaku, Tokyo 170, Japan

EEG is such a high (*M*th) order dynamic bio-phenomenon exhibited by a brain system neighbouring the lead electrode(s) that can be described by an autoregressive (AR-) process of order *M*, which is given as a high-order dynamic extension of the basic law of excitability, that is (Threshold Stimulus) × (Excitability) × (Unit Response) relation in physiology.

The *M*th order dynamic bio-phenomenon is decomposed into, in general, some of the first- (*M* = 1) and second-order (*M* = 2) component ones, each of which is characterized by one and two AR-coefficients, respectively. Each of the former manifests base line sway in the EEG and displays in average a damped exponential time-configuration and a peak at 0 Hz in its power spectrum, while each of the latter describes delta, theta, alpha and beta waves, respectively, displaying on average a damped oscillatory time-configuration with a damping frequency and a peak at a resonance frequency in its power spectrum.

The AR-coefficients *M* in number, which characterize the *M*th order EEG activity, display an *M* variates normal distribution, since EEG sways show a normal stochastic process. The smaller the first coefficient of the second-order component wave in EEG, the higher the frequency of the component wave.

The use of LAR can be a more natural way of evaluating information processing than the use of VEP. The relationship between the variability of LAR and the visual information processing load was examined.

Eleven subjects were presented with simultaneously random patterns and tone pips. The visual task was to search on the random pattern and detect the visual signals. The auditory task was to listen to tone pips and detect the tone signals. EEGs from Oz and Cz, and EOGs were recorded. Occipital EEG epochs time-locked to offset of saccades were numbered. Odd-numbered epochs were summed fifty times in one array and even-numbered epochs were summed fifty times in another to obtain a pair of LARs. An index of variability was obtained by computing a correlation coefficient between two LARs, time point by time point. A pair of averaged auditory evoked potentials (AEP) to tone pips were obtained from the vertical EEG to compute a correlation coefficient between two AEPs.

The mean correlation coefficient of LAR during the visual task ($r=0.92$) was significantly higher than that in the auditory task ($r=0.80$), ($p<0.01$). On the other hand, the mean correlation coefficient of AEP in the auditory task ($r=0.53$) was significantly higher than that during the visual task ($r=0.24$), ($p<0.05$).

LAR was more stable during the visual task. This result suggests that variability of LAR reflects visual information processing. Variability of LAR can be applicable as an index of visual information processing load in eye movement situations.

Measurement of Pilot Workload During Take-off and Landing by C-1 Jet Carrier

By Y. NAGASAWA, S. ARAMAKI and N. UTSUKI

Aeromedical Laboratory, JASDF, 1-2-10, Sakae-Cho, Tachikawa-Shi, Tokyo, Japan

Pilot workload during take-off and landing at Iruma local airport was measured by means of a secondary task method. The flying manoeuvres were arbitrarily divided into ten segments: take-off, first turn, climb, level, descent, initial approach, brake, down wind, base turn and final approach. Three captain pilots participated in the study as the subject, and one co-pilot played an important role in checking and monitoring their performance. As a secondary task, the visual auditory discriminative task discussed in a previous study was used: a lamp box consisting of red and green lamps was mounted on top of the instrument panel, and a small speaker was installed on the backward wall of the captain's seat. By using a signal oscillator, signals synchronized with red light and tone burst at 1200 Hz and other signals synchronized with green light and tone burst at 800 Hz were randomly presented to the subject at intervals of 1-2 s. The subject was required to detect only the signal synchronized with red light and 1200 Hz tone, instructed previously, and to respond to the signal via microswitches mounted on both sides of the control wheel. The collected data on miss rate and response time of the secondary task, VTR of instrumental display and pilot activity, voice and cockpit noise were analysed. Task-flow analysis on each flying segment was performed in advance. Main results concerning a change of the secondary task during take-off and landing, relationship between the secondary task and the task time stress index estimated by task analysis are discussed.

Measurement of the Effect of Central-acting Drugs on Performance and Reaction Time

By H. KRÜGER

Institut für Arbeitsphysiologie, Technische Universität München, Barbarastrasse 16, D-8000 München 40, F.R. Germany

Central acting drugs like tranquillizers or hypnotics change the level of vigilance. Therefore the effect of these drugs is important in driving and controlling activities. In practice men not only have to drive or to control but simultaneously have to do additional tasks. Driving a car one has to identify traffic signals near the central visual field and to discover dangerous events in the peripheral visual field as well. It is a well-known fact that the diameter of the visual field shrinks with increasing load of the task in the central visual field. Based on this effect a new experimental arrangement was set up to test central-acting drugs. The main task is to control and to minimize the displayed difference between a stochastic altered voltage and a regulated one. Men have to recognize tachistoscopically presented linear arrays of four alphanumerics in central vision and to detect flickering lights on stochastic positions in the peripheral visual field. A visual-mental reaction time to the displayed array and a motoric reaction time to the flicker are measured. The experimental set-up was tested in two experiments. For different amounts of blood alcohol we found a significant correlation to the three parameters: integral of deviation in regulation, visual-mental and motoric reaction times. In a second experiment two hypnotics of the group of benzodiazepines (long and short lasting) were tested against placebo in a double blind manner. The integral of deviation in regulation, visual-mental and motor reaction times showed significant differences between long- and short-lasting hypnotic 7 hours after medication. Whereas performance of the arrays, heart rate and variability of heart beat allowed no significant discrimination between the three conditions.

Time Pressure, Training and Decision Optimality

By D. ZAKAY

Department of Psychology, Tel Aviv University, Tel Aviv 69978, Israel

Two experiments were carried out in order to evaluate the effects of time pressure and of training on the utilization of compensatory and non-compensatory decision process. In the first experiment 20 student nurses made professional decisions in a time-pressure condition and a no time-pressure condition. It was found that in the time-pressure condition the percentage of non-compensatory decisions was significantly higher than in the no time-pressure condition. In the second experiment 60 high school graduates made buying decisions with and without training in the process of compensatory decisionmaking. This was again done with and without time pressure. It was found that training was effective only with no time pressure. Under time pressure the training was not effective at all and the optimality of the decisions was significantly lower than under no time pressure. It was concluded that specific training methods should be designed to help decisionmakers improve their decisions under time pressure.

Alpha Wave and Miss of Signal Detection

By H. KODAMA

Department of Human Factors Engineering, Industrial Products Institute, 1-1-4 Yatabe-machi, Higashi, Tsukuba-gun, Ibaraki 305, Japan

The relationship between the alpha wave of EEG and the miss of signal detection was studied in this experiment. Subjects, four adults, were requested to press the corresponding key as fast as possible when they detected one of three numerical numbers (2, 3, 5) presented on an LED display in random order and intervals. EOGs were recorded in order to monitor the eye movement. The experiment was done in a dimly illuminated and electrically shielded room. The display of numerical numbers was controlled by a computer. The detection miss of signals increased along the time course of the detection task. The peak value of the alpha in the power spectra of EEG showed no clear correlation to the number of misses. Alpha waves which were not contaminated by the eye movement were analysed at the presentation of numerical signals. The averaged root mean square value of alpha waves was larger at the time of stimuli which were missed than at the time of stimuli which were detected. Three of four subjects showed the significant trend with less than 2% in *t*-test. This trend extended considerably before and after the time of stimulus presentation. The result showed that the root mean square value of alpha waves is an effective measure of performance lowering in numerical signals discrimination.

On High-order Dynamic Activity and its Component Activities

By K. SATO

Research Foundation on Traffic Medicine, 1-9-3 Higashi Ikebukuro Toshimaku, Tokyo 170, Japan

EEG is such a high (*M*th) order dynamic bio-phenomenon exhibited by a brain system neighbouring the lead electrode(s) that can be described by an autoregressive (AR-) process of order *M*, which is given as a high-order dynamic extension of the basic law of excitability, that is (Threshold Stimulus) × (Excitability) × (Unit Response) relation in physiology.

The *M*th order dynamic bio-phenomenon is decomposed into, in general, some of the first- (*M* = 1) and second-order (*M* = 2) component ones, each of which is characterized by one and two AR-coefficients, respectively. Each of the former manifests base line sway in the EEG and displays in average a damped exponential time-configuration and a peak at 0 Hz in its power spectrum, while each of the latter describes delta, theta, alpha and beta waves, respectively, displaying on average a damped oscillatory time-configuration with a damping frequency and a peak at a resonance frequency in its power spectrum.

The AR-coefficients *M* in number, which characterize the *M*th order EEG activity, display an *M* variates normal distribution, since EEG sways show a normal stochastic process. The smaller the first coefficient of the second-order component wave in EEG, the higher the frequency of the component wave.

Effects of Exogenic Stimulations upon Monotonous Performance

By T. WATANABE

4-15-13, Soshigaya, Setagaya-ku, Tokyo, Japan

and Y. KAWAHARA

1-3-9-403, Higashi Magome, Ota-ku, Tokyo, Japan

The monotonous performance adopted in the present study was to push a key in time with a light. The intervals of operation were 1000, 1500, 2000, 2500 and 3000 ms, which were randomly selected. The exogenic stimulation adopted here was the sound of 1000 cycles given 300 or 1000 ms before the light was shown. The exogenic stimulations were given randomly during the performance. The time needed for the response to the light shown was determined for cases of presence and absence of exogenic disturbance. The performance was conducted in a repetition of ten series (650 times, 30 min) of the system which had a random series arrangement.

At the initial stage of the operation, the time of the response was belated if the exogenic stimulation was given 300 ms before the performance and the variations in the response time were also larger, but as the performance advanced, the exogenic stimulations rather reduced the response time and improved performance efficiency.

A similar inclination was noted when exogenic stimulation was given 1000 ms before the performance, but the variations in the response time fluctuated more and were smaller than those when the stimulation was given 300 ms before the performance.

Time-of-the-day Effect on Human Performance in a Combined Manual and Decision Task

By A. RAOUF and T. K. JOSEPH

Department of Industrial Engineering, University of Windsor, Windsor, Ontario N9B 3P4, Canada

Increased automation in industry is changing the role of industrial workers. They are required to use decision-making abilities in addition to their motor skills. Such tasks have been named 'combined manual and decision tasks' (CMDTs). Since automated processes are usually 'capital intensive', managements are, by and large, keen to maximize the utilization of this kind of equipment. These factors are, to a certain extent, the reasons of increased shift work in industry. The effect of the time-of-the-day on worker's performance has been investigated and well documented. However, one does not find much evidence in the literature of research work done to study the effect of time-of-the-day effect on worker's performing CMDTs.

A test depicting a CMDT was used to investigate the time-of-the-day effect on performance time. The decision element involved an informational load of 2.56 Bits (corresponding to six equiprobable response alternatives). Subject's body temperature and performance time for 30 cycles of the task were used as response variables. A $5 \times 4 \times 4$ completely randomized factorial design was used for this study. Results of this preliminary study showed that performance time was affected by the time-of-the-day effect and a negative correlation was found to exist between performance time and body temperature. The overall mean response variables indicated that minimum performance time occurred in the afternoon corresponding to the mean of the subject's maximum body temperature.

Signal Detection Theory in Ergonomics

By H. C. MICKO

Institute of Psychology, Technische Universität, D-3300 Braunschweig, F.R. Germany

The analysis of detection and detection failure of task relevant signals has gained from the introduction of signal detection theory because effects on sensitivity and decision bias can be separated. It will be demonstrated that, nevertheless, classical detection theory yields misleading results if applied to tasks in which attention is imperfect. Tasks of this kind are much more often the object of research in ergonomics than tasks in which attention is perfect, and frequency attention is even the focus of research endeavours. Therefore an extension of signal detection theory is presented which permits the identification and separate measurement of sensitivity, decision bias and attention effects. Prospects and problems of the application of this theory on topics of theoretical and applied ergonomics are discussed.

A 7. Sleep and Circadian Rhythm

Interindividual Differences in Sleep-Waking Habits of Student and Worker Samples

By L. MECACCI and A. ZANI

Istituto di Psicologia del Consiglio Nazionale delle Ricerche,
Via Dei Monti Tiburtini 509, 00157 Roma, Italy

A morningness-eveningness questionnaire was distributed to both students ($N=300$) and white-collar workers ($N=175$) in order to determine their circadian phase position. 'Morning' and 'evening' type samples (respectively, 39 and 54 students, and 32 and 30 workers) obtained from these larger populations were requested to keep logs of bed and rising time for each day of a 2-week period. On the basis of the results it is suggested that:

- (1) The worker population has a more advanced phase position than the student population on the morningness-eveningness continuum.
- (2) The acquisition of a regular job would induce a phase advance of the sleep-wake habits only in the 'evening' individuals.
- (3) The worker 'morning' and 'evening' types have less phase difference than the student 'morning' and 'evening' types.
- (4) The students have more good opportunities to follow their own circadian rhythms than the workers.

A Biotechnological Study of Relationship between Sleep and Beds— A Polygraphic Study with Sounds

By K. FUKADA and others

The Faculty of Engineering, Hosei University, 3-7-2 Kajinocho, Koganei-shi, Tokyo, Japan

In recent years many polygraphic studies of human sleep have been reported, and studies of sleep are making rapid progress. We have produced a special three-stage bed which enables us to compare the depth of sleep in (1) an ordinary bed, (2) a futon (a Japanese bed) and (3) a non-pressure bed.

We have also studied the influence of sounds on sleep by using various stereophonic sounds near the pillows of the special beds. We have made a study of the effectiveness of various learn-while-sleeping methods. Before our experiments, we made a prior check of the physical characteristics and sleep habits of our subjects by use of a special questionnaire so that we could compare their answers with the results of our later experiments.

In our study of learn-while-sleeping methods, we gave a test a few days later in order to find out how much they had learned in their sleep. Our report will include our biotechnological study of sleep based on the above-mentioned experiments.

Effect of Sleep Deprivation on the CNV and Dual Task Performance

By M. MIYAO, T. OHGA, H. SAKAKIBARA, T. NAKAGAWA, F. KOBAYASHI, S. KANADA,
K. TAKIHI, S. YAMADA, M. TERASHIMA

School of Medicine, Nagoya University, Nagoya, Japan

and T. ENDOH

Institute of Human Functions

The purpose of the present study was to estimate the effect of 36 hours sleep deprivation on the CNV and dual task performance.

It is said that the CNV is relevant to 'Expectancy', 'Arousal level' and 'Attention'.

Five healthy young males performed this experiment. Every 3 hours they were measured for the CNV and dual task performance. They worked a calculation task 25 min before each measurement of the CNV and dual task.

We also measured other physiological factors such as critical flicker fusion frequency (CFF), body temperature, heart rate, blood pressure and so on.

The results showed that the CNV had a circadian variation similar to other physiological factors and subjective symptoms.

Apparent and True Phase-shifts of Circadian Rhythms After a Transmission Flight

By Z. VOKAC

Institute of Work Physiology, Gydas vei 8, Oslo 3, Norway

The behaviour of an endogenous circadian oscillator can only be indirectly estimated from the apparent rhythm of its effector, be it body temperature, electrolyte excretion, etc. Thus, the interpretation of the phase-shift of an overt rhythm as a sign of entrainment of the endogenous oscillator to a new time schedule must take into account a possible direct influence (masking effects) of altered synchronizers on the measured parameters of the rhythm. To demonstrate the difference between apparent and true phase-shifts a chronobiologic serial section analysis, of six rhythms was performed in a subject during 5 days before (Oslo), 15 days after an east-west flight with -7 hour time difference (Minneapolis) and 5 days after the return (Oslo). The rhythms were analysed in the continuously recorded rectal temperature and in the urinary excretion of adrenaline, noradrenaline, aldosterone, K^+ and Na^+ (4-hour collection periods). Sleep was fixed between 22:30 and 06:30 local time. The analysed rhythms reacted to the time change in two distinctly different ways: a marked, immediate delay phase-shift occurred in the rhythms of rectal temperature and urinary excretion of adrenaline, noradrenaline and aldosterone. These rhythms stabilized from the third to fourth day around the +7-hour phase difference level. Contrary to this, the K^+ and Na^+ excretory rhythms were initially seriously disturbed and their phases then shifted gradually by about 1 hour/day towards the +7-hour level which they reached on the tenth day. Similar differences between the two types of reaction were observed during the re-entrainment of the rhythms after the return to Oslo. It is concluded that, due to the physiological adaptability of the organism, the advantageous, immediate and nearly complete delay phase-shifts were a direct result of the demands of the changed sleep/wake schedule on these functions, and that no true phase-shifts occurred so early after the time change in the endogenous circadian regulation of these rhythms. The true, slow endogenous phase-shifts were probably represented by the gradual response of the electrolyte excretions.

A 8. Sensory and Cognition

Evaluation of Tactile Sense for Fitting of Plastic Parts

By K. TAKASHI

Keiryō Kenkyūjo, 1-1-4, Sakura-Mura, Niihari-gun, Ibaragi-Ken

Fitting for plastic parts is studied as an example of measurement by tactile sense. Thus, where such requirement is dependent on the judgement made by human senses, a number of characteristic values must be measured in order to obtain the mechanical characteristic values matching with the quantity of the sense. In this context, the application of the multivariate data analysis method to the analysis of the data of the multicharacteristic value concerning the man-machine system is considered. The degree of fitting judged by sense is quantified by the multidimensional scaling, using the capsule-shaped plastic parts. Also, the dimensions, shapes and the degree of mechanical fitting as the mechanical characteristic values are measured and the relationships of these values with the quantified senses are determined by the factor analysis, then it is clarified that the multivariate data analysis are effective for this purpose.

The main points of the conclusion are as follows: (1) The degree of fitting can be classified into two independent factors, that is, the potency factor and the activity factor depending on the individual's senses. (2) First factor corresponds to the average gap between the inside and outside of the parts to be fitted with each other, while the second factor corresponds to the difference between the inside dimensions and the outside dimensions of the parts to be fitted with each other.

Pain Sensation and Skin Deformation

By M. AKAMATSU

Faculty of Engineering, Keio University, 3-14-1 Hiyoshi, Kohoku-ku, Yokohama 223, Japan

Pain sensation is generally considered to be generated by stimulating pain points. However, the fact that thin needle punctures do not generate pain sensation suggests that the mechanical noxious stimuli do not seem to be touching pain points only.

For the purpose of detecting factors of pain sensation the relation between prick pain and skin deformation of an awake human was discussed in this study. Thin needles, a few microns in diameter at the rounded tip, were used as a mechanical stimulator to avoid the influences of touch, pressure and other cutaneous sensation as much as possible. Indentations, from the surface of the skin to the depth where prick pain sensation was first felt (pain threshold), were measured as parameters of skin deformation.

This stimulator could evoke pain sensation at almost any point on the skin surface, and these indentation amplitudes of pain threshold seemed to have unimodal distribution. This means that it is difficult to eliminate pain points on the skin surface clearly. To alter mechanical properties the skin was stretched and relaxed. Threshold indentation amplitudes were on the average, shallower than normal in stretched skin and deeper in relaxed skin. The responses of various indentation velocities were also examined. Fast indentations generated clearer prick pain sensation but deeper threshold amplitudes, while slow indentations generated shallower amplitudes. These differences of threshold were considered to be mainly caused by response time lag, which is dependent on velocity. Analysis of response time to stepwise indentation showed some dependence on the onset and ceasing of indentation. These results suggest that some mechanical skin properties are factors of pain perception, and their dynamic changes are effective on it.

A Multidimensional Scaling Analysis on Perceptual Structures of Japanese Syllables

By K. MIZUKI

Faculty of Engineering, Keio University, 3-14-1 Hiyoshi, Kohoku-ku, Yokohama 223, Japan

There are two main ways to study perceptual structures of speech sounds. One is based on speech waves using acoustic parameters; formant frequencies, spectral envelopes, zero cross numbers, etc. The other is on articulation using articulate parameters; tongue, jaw, vocal tract cross section, etc. Without auditory properties, however, perceptual structures of phones are not explained completely.

In this study syllable confusion data from auditory impressions were evaluated with a multidimensional scaling analysis, and perceptual structures of phones were discussed in consideration of auditory properties. Identification confusion experiments in the noise masking conditions were carried out among 14 Japanese CV syllables formed by pairing the different consonants with the vowel /a/. With the MDSCAL analysis three-dimensional solutions were obtained in which 14 syllables were divided into a few groups. These were compared with the signals of the syllables which were analysed by bandpass filters and spectral time changes were measured including high frequency regions. Implications of these results for some relation between the dynamic features of spectra and perceptual relationships among the syllables were considered.

Tentative Evaluations of Oscillating Sounds Based on Loudness Measures

By P. M. SHAEFER

Institut für Ergonomie, Barbarastrasse 16, 8000 München 40, F.R. Germany

Assessing noise perceptions as closely as possible is the ideal of every noise rating procedure. So it is shown that loudness measures perform best when estimating immediate responses. A set of specific characteristics is derived from these basic loudness traces for further evaluations of longer periods. A comprehensive set of widely independent factors resulted from a study of worldwide noise rating procedures. Here we outline those measures especially designed to evaluate loudness oscillations; for indications are received that noises of varying loudness levels result in a specific kind of subjective noise perception.

A Discriminability Metric for VDU Characters

By M. SCHNEIDER, K. A. HIRSCH-PASEK and S. NUDELMAN

Sperdy Univac, P.O. Box 500, Blue Bell, Pennsylvania 19424, U.S.A.

To predict the confusion between two characters, a technique was developed by extending Gibson's distinctive characteristics (1969). A Figure of Merit (FOM), derived from Tversky's Contrast Model (1977), was applied to the distinctive characteristics and the dot matrix pattern of each character. The FOM, placed on an arbitrary scale of -20 (highly discriminable) to +20 (identical), was tested directly: two characters were presented on a CRT (0.25 s) followed by a mask (0.25 s) to partially obliterate the iconic image. The subject was asked if the characters were the same or different. Stimuli were presented to 24 subjects in a random order

with optional breaks every 15 presentations and required breaks every 45 presentations. The independent variables were 126 pairs containing a special character and either an uppercase alphabetic, a digit or another special character. These were divided into three equal groups of 42 items each: high (FOM = -20 to -15, mean = -16), medium (FOM = -10 to -6, mean = -9) and low (FOM = -2 to +20, mean = +6) discriminability. A fourth group of 69 items, composed of identical characters (FOM = +20), was used to reduce the high percentage of 'different' responses and included in the analysis. The dependent variables were time and errors.

No learning effect was observed. There was a significant difference in the error rates between the groups, $F(3, 92) = 9.22, p < 0.001$; more errors occurred in pairs with a large FOM. In general, times were shortest for pairs with a low FOM and longest for those with a high FOM. A Pearson r (individual times and the mean FOM for the stimulus group) was 0.43, $p < 0.001$. Further analysis and experiments are in progress to refine the FOM.

REFERENCES

- GIBSON, E. J., 1968, *Principles of Perceptual Learning and Development* (New York: Appleton-Century-Croft).
TVERSKY, A., 1972, Features of Similarity. *Psychological Review*, **84**, 327-352.

Standardization of Geometric Radar Symbolology

By R. J. CARTER

P.O. Box 6057, Fort Bliss, Texas 79916, U.S.A.

When cathode ray tubes (CRT) first started to be used in radar-directed air defence systems, only a few geometric shapes could be generated and these available shapes were assigned meanings, such as enemy, friendly and unknown. As the hardware became more sophisticated, the situation changed. Unfortunately these changes did not take place in an orderly fashion because new meanings were assigned to earlier shapes. This practice has continued over the years, and even now, each contractor who develops a radar system constructs a set of shapes and designates its meaning for display use.

There exists a need for a standard symbolology because symbol confusion takes place when ancestral systems are replaced and personnel must be retrained and reassigned to a new system. The Army Research Institute has initiated a research programme which is aimed at alleviating the need.

The first step in the research was aimed at determining whether any of the symbols which are currently being used or are proposed for usage in future air defence systems are stereotyped with the meanings hostile, friendly and unknown. Other shapes which have been studied in discriminability studies were also investigated. Male service members sorted 60 shapes into four categories, namely, friend, hostile, unknown and other depending upon what each shape connoted. Symbol sets of five (two friends, two hostiles and one unknown) and three (one friend, one hostile and one unknown) members were subsequently assembled based upon the results.

Phases two through four in the research had the objective of identifying symbols and sets of symbols which can be quickly and easily discriminated in a mixed display which approximates a console radar screen at a moderate level of saturation. Military personnel had the task of searching for a particular symbol in a field of many. Reaction times and errors were recorded for each subject in each phase. The symbol sets were tested in a paper-and-pencil mode in phase two. In phase three they were investigated in a static, i.e. stationary symbols, CRT mode. During phase four, which is currently on-going, the sets are being looked at in a dynamic, i.e. moving symbols, CRT mode. Symbols and sets of symbols which exhibit the two attributes sought were identified.

How Many Letters Can We Recognize at a Glance?

By T. FUKUDA

NHK Broadcasting Science Research Laboratories, 10-11, Kinuta 3-chome,
Setagaya-ku, Tokyo 157, Japan

Experiment I

To investigate the nature of interaction effect in peripheral letter recognition, I presented embedded letter strings briefly to subjects and noted their response. The results show that lateral interference acts most strongly when an embedded letter string is presented in a radial manner from a direction of line of sight, and furthermore, the most outward letters, far from fixation, score higher than the most inward letters, close to fixation. This reveals a strong adverse interaction mainly acting from the periphery towards the fovea.

Experiment II

To investigate how many letters we can recognize at a glance, I presented patterns (composed of letters randomly chosen) briefly to subjects and noted their response. I employed three kinds of pattern whose letters were put in a straight order, stringed in random direction or put freely randomized. The results show that recognizable letters are limited within about 2 (for Chinese letters), about 4 (for Japanese alphabet) and about 5 (for Latin alphabet) in each condition, and on close examination of the matter, the limitation characteristics reflect the nature of the lateral interference which was clarified in Experiment I.

From these results, preferable presentation of letter information is discussed.

An Analysis of the Interaction Effects Between Two Successively Exposed Figures

By T. YOSHIDA

NHK Broadcasting Science Research Laboratory, 10-11, Kinuta 1-chome,
Setagaya-ku, Tokyo 157, Japan

The information processing mechanism of the human figure recognition system was analysed by the following psychological method. Two figures were successively exposed to a subject for a brief period. The first one of these two figures had a clear meaning which was easily recognized by any subject. This figure was called the 'original figure'. The second one was the 'distorted figure', which was constructed by adding some noise to the original figure. The original and the distorted figure had the same exposure time.

Original figures were limited to those which had a closed contour drawn in a stroke. In such figures, the Fourier spectrum of a figure can be defined by applying a Fourier-descriptor method. Low-frequency components of the spectrum describe the global features of the figure, and high-frequency components describe the local features. The spectrum of the noise had approximately one component, so a distorted figure was different from the original in one frequency component.

The probability of the occurrence of the correct recognition of the original figure's meaning was measured as a function of the exposure time, the noise frequency and the noise amplitude. From these results, the characteristics of the figure information utilized in the human figure recognition system were discussed in the frequency domain.

Inter-item and Intra-item Symmetries in Same Responses to Pairs of Letters

By S. BAGNARA

Institute of Psychology CNR, Via dei Monti Tiburtini 509, Rome, Italy

D. B. BOLES

University of Calgary, Calgary, Alberta, Canada

F. SIMION

University of Padua, Institute of Psychology, P. za Capitanato 5, Padova, Italy

C. UMLTÀ

Institute of Human Physiology, University of Parma, V. le Gramsci, Parma, Italy

When pairs of letters are presented to an observer in a *same-different* classification task *same* responses are often faster than *different* responses. This finding has led a number of authors to suggest a holistic process for the former and an analytic process for the latter judgements. However, another interpretation can be given to the same finding, that is in terms of 'structural diagnostics'. *Same* letter pairs show a number of distinctive properties such as symmetry about the vertical axis (e.g. TT), or the horizontal axis (e.g. EE), or both axes (e.g. OO) which are not present in the case of *different* letter pairs. Such properties may be conceived as 'diagnostics' of sameness. If symmetry were tested by an observer, and the test were positive, no further analysis of the display would be required to conclude that the two letters are the *same*.

Previous studies did not clarify the role of the inter-item symmetry as compared to that of the intra-item symmetry, that is the symmetry of the whole display versus the symmetry of the single letters in a pair. Furthermore, the relative importance of different types of symmetry (horizontal, vertical, horizontal plus vertical) in producing the faster *same* responses was not clarified. Two experiments aimed at answering these questions were carried out.

In Experiment 1 the subjects were required to give *same-different* responses to vertically or horizontally arranged letter pairs. The stimuli were simultaneously presented either to the right or to the left visual field. *Same* responses proved to be significantly faster than *different*, and symmetrical *same* judgements were significantly faster than asymmetrical ones. In both arrangements there were significant effects of symmetry

along the horizontal and vertical axes. The combined effect of the two types of symmetry was not more beneficial than that of one single symmetry taken in isolation. The only significant difference between the two types of arrangements was due to a stronger effect of horizontal symmetry in the vertical arrangement.

Experiment 2 was similar to Experiment 1 with the exception that the two letters to be compared were presented in succession with an ISI of 1 s. The results replicate those of Experiment 1 but the effects of the different types of symmetry were much reduced, suggesting that the use of 'diagnostic' properties in speeding-up *same* decisions becomes less important when part of the relevant information is stored in short-term memory.

The Influence of Colour Saturation on the Chromatic Error of Accommodation of the Human Eye

By H. KRÜGER

Institut für Arbeitsphysiologie, Technische Universität München, Barbarastrasse 16,
D-8000 München 40, F.R. Germany

Colour is a good dimension for encoding visual information on a visual display unit, if it is not used in a senseless way as a distractor. Besides alphanumerics only the dimension of position equals that of colour in search-time and performance. Colour is particularly advantageous if it is used to encode the same information in different positions. In spite of this advantage there are two physiological corner stones to be considered. These two restrict the use of colour in practice. On the one hand there is the group of people who are colour blind. Here it is useful to have redundant codes. On the other hand there are the chromatic aberrations of eye-optics. The eye is short-sighted for colours of the blue spectral end and far-sighted for the red one. That means colour can decrease or increase the effort of accommodation. Three questions were investigated in a subjective technique with a laser optometer.

- (1) Does the chromatic aberration of the optics equal the amount of accommodation effort.
- (2) How does colour-saturation influence the deviation of accommodation effort from the 'white' value?
- (3) How does the brightness of an uncoloured background change the accommodation effort?

The results are:

- (1) Accommodation effort equals chromatic aberration.
- (2) The deviation of accommodation effort from the uncoloured 'white' decreases more than linearly with increasing saturation if the brightness, i.e. the contrast, is constant.
- (3) The brightness of the background influences the accommodation effort for luminous targets. The deviation of effect vanishes if the brightness is increased to 8 cd/m^2 .

Colour Contrast and Visual Task Performance

By H. L. SNYDER

Department of Industrial Engineering and Operations Research, 130 Whittemore Hall,
Virginia Polytechnic Institute and State University, Blacksburg, Virginia 24061, U.S.A.

Vision scientists have worked diligently to define uniform colour scales which predict discriminability among colours when such differences are near threshold. However, when large colour differences exist, the prediction of these scales has been poor. Prediction is even worse when the contrasting colours vary in luminance, in addition to variation in hue and saturation.

This paper presents the results of a series of studies designed to develop a measure of colour contrast which incorporates differences in hue, saturation and luminance. As applied to a variety of information displays, the results of these studies relate chromatic contrast to equivalent luminance contrast, and then show the relationship between perceived contrast and performance on a simple visual recognition task.

Effects of Television Noise Interference on Character Reading Time

By A. WATANABE and M. SAITO

Institute of Medical Electronics, University of Tokyo, 7-3-1 Hongo, Bunkyo-ku, Tokyo 113, Japan

Character reading time and error rate are important objective measures for evaluating effects of noise interference on human pattern recognition capabilities in watching television pictures. Characteristics of prolongation of reading time are studied in relation with the signal-to-noise ratio and error rate under the interference of random, sinusoidal and impulse noises.

Test patterns are arrays of 25 kinds of alphabetical characters (excluding W) arranged in a random order. Subjects are requested to read them as quickly as possible for 15 s. The prolongation time is calculated by subtracting the basic reading time (measured at sufficiently high S/N) from reading time per character. Experimental results are summarized as follows:

- (1) The prolongation time (log scale) is linear with S/N (dB).
- (2) The slopes of the straight lines are $\log 2/-3 \text{ dB}$ for the random noise and $\log 2/-6 \text{ dB}$ for the sinusoidal and impulse noises.
- (3) The prolongation times at marginal S/N for recognition and at the S/N corresponding to the 1/25 error rate are about 100 ms (note that the limit of duration where Bloch's law is applicable is about 100 ms; the marginal S/N is defined as the S/N where any of the 25 kinds of characters becomes illegible even when subjects take enough time).
- (4) Long-term training reduces the basic reading time but little changes the prolongation time.

Based on those results and a mathematical model derived from Rushton's equation, it is concluded that the characteristics of prolongation time depend on the bleaching and recovering process in pigments in the visual cell. Therefore, the visual cell behaves like an average computer with signal decay. The difference between those two systems lies in that S/N in the visual cell cannot reach the threshold level necessary for recognition, when the S/N of the video signal is smaller than a critical level.

Study of Time-Estimation on a Reactive Simple Action

By I. YOSHIMURA and M. NAKAMURA

Kansai University, 261 Hachijo-cho, Yamatokoriyama-shi, Nara-ken 639-11, Japan

P. Fraise's hypothesis about the correlation between the value of estimated time and the number of perceptible changes is widely supported and many studies about it have been done. In this study of a similar process, we recognized that the psychological estimated value of elapsed time does not only depend on the number of changes but also on the changing velocity of stimulation, and in this paper we indicate the approved conditions of the hypothesis through estimation on a reactive simple action.

As a result of the changing numbers of stimulus and reaction in unit time, the degree of underestimate becomes too large in the level of stimulus which inclines toward retarded reaction rather than correct reaction.

In case where interval stimulus is regular, the efficiency of Fraise's hypothesis is explained. On the other hand, in the case where it is random and its variation is large, the degree of underestimate becomes too large, but the average interval is not the direct object of the estimation form.

Accuracy of Time Perception in Rhythmic Movement

By T. NIHARA and K. KUSANO

Department of Education, University of Miyazaki, 1-1 Funatsuka, Miyazaki, Japan

Accuracy of time perception in rhythmic finger movement of 10 children (7 years) and 10 adults were measured in five different tempo conditions (500, 1000, 1500, 2000 and 2500 ms). After 50 successive practices with the sound tempo stimuli, subjects were required to push the key accurately 50 times at the same time interval without the sound signal. Mean error value to the predetermined time interval was used as the measure of accuracy of time perception. The error score increased with increase of the time interval, and the adults showed a higher ability level (16 ms at tempo 500 ms, 148 ms at 2500 ms) than the children (28 ms at 500 ms, 181 ms at 2500 ms) in any tempo conditions. Another 10 students, who take part in musical activities, had a significantly higher ability (14 ms at 500 ms, 78 ms at 2500 ms) than the other two groups. These students estimated the given time interval correctly, however, the children tended to overestimate it (mean reproduced value was 2332 ms at 2500 ms) and the adults, on the contrary, showed underestimation (2639 ms at 2500 ms).

Driver and Pedestrian Speed Estimation

By M. H. BERGMAN

P.O. Box 205, White Sands, New Mexico 88002, U.S.A.

Experiments were conducted to determine drivers' and pedestrians' sensitivity to speed and speed changes. Subjects were in the front passenger position instead of driving the vehicle.

Absolute judgements were estimates of speed in miles per hour, (mph). For relative judgements, subjects decided whether a second run of the test vehicle was 'faster' or 'slower' than a first run. A 100 ft pedestrian-vehicle separation distance was used.

When passenger and pedestrian data were combined the speed estimates in mph were accurate and consistent. Most estimates were in increments of 5 mph. Slow speeds (10-20 mph) were estimated most accurately with an increasing overestimation at higher speeds so the mean estimate for 49 mph was 55-64. Standard deviations (S.D.) of speed estimates did not increase significantly as speed level increased. The estimates were linear over speeds and a Weber fraction of 0.18 was found to describe the combined data. The correlation of estimated to actual speed was 0.92.

Passengers estimated lower speeds than pedestrians at slow speeds. However, by 34 mph both passengers and pedestrians were overestimating by the same amount. Day or night light conditions did not have an affect on speed estimates.

Women estimated higher speeds in mph than men at all speed levels. Subjects over 53 years old estimated higher average speeds at all levels than subjects under 35.

For relative judgements, speed differences of 5 mph were discriminated consistently at all three speed levels (15, 30 and 45 mph). Differences of 2 mph could also be discriminated, but the results need interpretation. Whether a person was a passenger or a pedestrian did not have an affect on the percentage of correct discriminations. Lighting, sex and age also had no significant effects.

A 9. Manual Tracking Tasks

On the Self-paced Preview Manual Tracking Behaviours

By K. ITO

34-38-405, Koihigashi 2-chome, Nishi-ku, Hiroshima 733, Japan

This paper discusses the tracking behaviours of the human operator in self-paced preview control systems, where the operator can look at a limited length of his course ahead and can arbitrarily adjust the driving velocity according to the variation in the course given as an input function. It has been definitely shown by the self-paced preview tracking experiments that:

- (1) Under the performance criterion of minimizing both the error and the time required, the operator adjusts the mean velocity such that the resultant input bandwidth does not exceed 3 rad/s and the desired preview time is ensured.
- (2) The instantaneous tracking velocity is very correlated to the variations of the input pattern in sight ahead.

The following preview control model is proposed from the above results:

- (1) At first, the preview input function $Y_d(z)$ of space $ze[x, x + x_1]$ is transformed into a function $Y_d(s)$ of time $se[t, t + t_f]$ by utilizing the instantaneous velocity.
- (2) Next, the instantaneous desired input $Y_d^*(t)$ and desired velocity $V_d^*(t)$ are calculated through two kinds of convolution integrals which operate on the future input $Y_d(s)$; $se[t, t + t_f]$.
- (3) $Y_d^*(t)$ and $V_d^*(t)$ are, respectively, followed by the conventional servo-mechanisms.

The preview control model is simulated and compared with the responses of the human operator.

Modelling the Human Operator in a Preview Compensatory Tracking Control System

By K. YOSHIMOTO

Department of Mechanical Engineering, University of Tokyo,
3-1 Hongo 7-chome, Bunkyo-ku, Tokyo 113, Japan

In a man-vehicle system such as a man-automobile system, the human operator can preview the future path which he must track. Such a manual control system is generally called a preview tracking control system. This system may be classified into the preview pursuit tracking control system and the preview compensatory tracking control system. In this compensatory system, the human operator can hardly perceive the radius of curvature of the tracking path as it is as though he were looking down a path on a map. The preview distance is usually limited to a certain length. However, moving together with the vehicle on board, the operator obtains control information from the dynamic relation between the vehicle and the path. It is considered that he is able to predict the motion of the vehicle precisely.

In this paper, the behaviour of the human operator in a preview compensatory tracking control system is measured and a new preview tracking control model is proposed. This model is constructed of three operations, which are: the prediction of future state of the vehicle, the detection of future error from the path and the manipulation of an integral correction of the future error. Reliability of this model is confirmed by experimental analysis and application to a simulation experiment of a man-automobile system.

Skill Improvement in Manual Control of a Double Integral Controlled Element

By A. TADA

National Aerospace Laboratory, 1880 Jindaiji-Machi Chōfu, Tokyo, Japan

A manual control experiment in space is being planned. The purpose of the study is to obtain basic data for designing man-machine systems in space, as well as to investigate human perceptual-motor functions. As a part of the study, the skill improvement process was experimentally examined.

Naive subjects were exposed to 200 runs of a compensatory tracking task, where the controlled element is a double integral and the forcing function is a pseudo-random wave. The performance score measured by the integral of the squared tracking error showed little improvement after 140 exposures. The operator describing function showed the development of the operator lead action. A miscontrol tendency, which sometimes drives the tracking error off the display scale, was observed even in the skilled stage.

From the point of view of preparation for the space experiment, evaluation of the experimental devices was also performed. The requirements for the training programme of the payload specialist were made clear, and the procedure and devices of the flight experiment were basically determined in consideration of the results.

Human Operator's Compensation Mechanism for Time-Delay in a Manual Control System

By M. YOSHIZAWA

Aramaki aza Aoba, Sendai 980, Japan

This paper presents a new interpretation of the human operator's compensation mechanism for time-delay in a compensatory manual control system in terms of finite pole assignment and proposes a state equation model describing the operator's transient response.

In the open-loop characteristics of human operators in some compensatory tracking tasks to a random step input, we can observe a remarkable phenomenon—that each open-loop gain curve peaks at relatively high frequencies. This phenomenon cannot be explained by usual transfer function models and may be caused by an inherent human characteristic to compensate the time-delay in a manual control system.

In this paper, we consider the above phenomenon is related to the fact that peaks appear in the open-loop gain curve of the system to which the finite pole assignment method is applied. This idea has been proved by experimental result: the peak of the open-loop gain curve becomes clearer as an additional, artificial time-delay is increased.

Hence, we propose a state equation model representing the operator's transient response to a step-wise input from the viewpoint of finite pole assignment. This model contains an observer estimating the state of a controlled object and a predictor for the time-delay. The predictor can be directly derived from the finite pole assignment method and has the same structure as that of the predictor proposed by Kleinman.

A Consideration on the Index of Precognitive Control Behaviours of Human Operators

By H. TAKEDA

Department of Mechatronics and Information Science Center, Osaka Electro-Communication University,
18-8, Hatsu-cho, Neyagawa, Osaka 572, Japan

Y. IKEDA and S. HATA

Department of Electronics, University of Osaka Prefecture, 4-804, Mozu-Umemachi, Sakai, 591, Japan

It is well known that the behaviour of human operators in manual tracking tasks is classified into two kinds of fundamental modes. One is the predictive mode for a complex input, such as a noise signal, and the other is the precognitive mode for a simple input, such as a single sine wave. But any reports of quantitative analysis on the relation between an arbitrary input signal and these control modes is difficult to find.

In this report, an index which represents how the human operator's behaviour for an arbitrary input signal is similar to the precognitive mode is proposed, and its availability is experimentally ascertained. The proposed index is called IPCB (Index of PreCognitive control Behavior), which is easily obtained from the frequency transfer functions for single sine wave, random noise and arbitrary input signal, respectively. Through tracking tasks for combination inputs of two and three sine waves, the following results were quantitatively obtained: (1) in the case where all of the component frequencies are less than 0.5 Hz, human operators showed the precognitive mode and (2) in the case where both low and high frequency components are contained in the input, operators showed the predictive mode against low frequency components, and the precognitive mode against high frequency components, and so on.

Dependence of Human Performance on Input Information in Pursuit Manual Control Systems

By O. SUENAGA and M. IHARA
5-1, Johoku 3-chome, Hamamatsu 432, Japan

The purpose of this paper is the analysis of human performance depending on input information, i.e. the change in input, error and the change in error on the learning characteristics of human operators in a pursuit manual tracking control task. The human performance for ten subjects (five subjects of each sex) were measured for the same pseudo-random input signal.

As a result of the measurements, performance scores were approximated to the learning curve taking the form of an exponential function about five subjects (two male and three female subjects) out of ten. In these subjects it was found that, through the learning stage, the change in output has a linear relation to the change in input and error but not the change in error. On the relation among the change in output, the change in input, and error, in general, the performance of male's tracking is more systematic than female's. Furthermore, the performance of females is harmonized with the change in input independent of the history of the input signal in the initial learning stage. The performance of either sex is improved in the final stage, however, the performance of females is still affected by the change in input. On the part in which the frequency is different in the same input signal, the performance of male's tracking responds to the change in input in the low frequency part (0.4 Hz) and to the error in the high part (0.94 Hz). On the other hand, the performance of female's tracking responds to the change in input in spite of the frequencies.

Cognitive Psychology of Manual Control: Expert and Novice Differences in Cognition and Performance

By Y. ANZAI
Department of Psychology, Carnegie-Mellon University, Schenley Park, Pittsburgh, Pennsylvania 15213, U.S.A.

and Y. ISHII and Y. HAYASHI
Department of Administration Engineering, Keio University, 3-14-1 Hiyoshi, Kohoku-ku, Yokohama 223, Japan

In spite of an enormous amount of research on manual control systems from the cybernetical viewpoint, and in spite of the awareness of the existence of an early cognitive stage in motor skill learning, almost no attention has been paid so far to the cognitive process involved in manual control and its learning. This paper is concerned with this neglected aspect: how a human operator *thinks* while controlling a manual control system, and how (s)he *learns* strategies to become an expert.

Our work was guided by the hypothesis that the highest-level process of manual control is characterized by symbolic information-processing. Based on this working hypothesis, we first analysed verbal protocol data collected while novice and expert subjects were working on a simple laboratory task that simulated a ship control system. We found first that novices and experts used quite different cognitive strategies: especially, the latter's strategies were essentially goal-directed. Second, it was pointed out that experts used knowledge acquired from experience. This is exactly an example of what we have recently called *learning by doing* in the field of cognitive psychology. Other kinds of experiments were also conducted to support these results. The main purpose of this paper is to present these cognitive differences of novices and experts in the manual control task.

On the other hand, to make things clearer, we built up computer simulation models, each of which simulated a novice, a semi-experienced and an expert problem solver. The models were written in the production system language OPS5, developed at Carnegie-Mellon University. So we also present in this

paper the general feature of those models, especially how knowledge is represented and used in controlling the system.

The paper concludes that it is not necessarily true that the manual control task should be analysed totally in continuous spaces, such as by feedback control theory, and it is possible that the task is dominated by processing of symbolic information.

Analysis of Precognitive Dynamics in a Two-axis Pursuit Tracking Task

By T. AOKI, K. YAJIMA, K. AOKI, H. TANAKA, S. KINOSHITA, N. YAMANOI and T. FURUKAWA
Institute of Medical Electronics, Faculty of Medicine, University of Tokyo, 7-3-1 Hongo, Bunkyo-ku, Tokyo, Japan

Human precognitive dynamics in a two-axis manual pursuit tracking task was investigated with regard to changing its mode of control. The manual tracking system used in the experiment was composed of (1) a CRT which displayed the target and the operator's pursuit point, (2) a control device and (3) a microcomputer which generated the target motion. The locations of target spot were stored in two ROM and read out at 50 Hz, thus the spot moved along a circle modulated by sinusoidal waves. Two devices were used for input control operation, one was a 2 degree of freedom light pivoted joystick and the other was two rotary potentiometers, each of which correspond to *X* and *Y* axis movements, respectively. Control performances were analysed by using mean square control error normalized by the mean square of the input signal. Input-output gain ratio and phase shift were analysed by discrete Fourier transform of input signal and operator output.

Results were as follows:

- (1) Decrease of control performances with increase of modulation signal frequency remarkably occurred in the case of the rotary potentiometer compared with the joystick.
- (2) Decrease of gain and increase of the phase lag of the control operation in a high frequency domain also remarkably occurred in the case of a potentiometer compared with the joystick.
- (3) Control performance changed when the correspondance of right and left potentiometer to *X* and *Y* axis pursuit tracking was altered.

A Study of Human Operator's Dynamics During Training and Transfer Trials of the Tracking Tasks in the Case of a Second-order Lag System

By T. YAMASHITA and E. MASUYAMA
Department of Psychology, Tokyo Metropolitan University, 1-1-1, Yakumo Meguro, Tokyo 152, Japan

A learning experiment was performed in order to examine the process of the operator's adaptation to natural frequency (ω_n) and to damping factor (ζ) in controlling a second-order lag system. Each of four groups of 12 subjects was trained on one of four compensatory manual tracking tasks differing from each other in terms of natural frequency and damping factor. After nine training trials, the numbers of each group either transferred to a task on which they had not been trained or continued their original task. From these tracking data, error scores and operator's describing functions $Y_p(j\omega)$ were estimated. The latter were approximated by $Y_p(j\omega) = K_p(T_L j\omega + 1) \exp(-j\omega\tau)$ for low natural frequency conditions and $Y_p(j\omega) = K_p \exp(-j\omega\tau) / (T_1 j\omega + 1)$ for high natural frequency conditions. From analyses of these data, the following items were summarized.

- (1) For low natural frequency conditions, an improvement of error scores as a function of training trials was observed and this improvement depended on an increase in values of lead time constant T_L in $Y_p(j\omega)$.
- (2) For high natural frequency conditions, error scores were lower than for low natural frequency conditions, but little improvement of performance and little variation of values of parameters in $Y_p(j\omega)$ were observed.
- (3) In transfer data, a significant interaction between training and transfer natural frequency was observed.
- (4) Damping factor was also concerned with error scores, but had little effect on the amount of transfer during the transfer trials.
- (5) These results suggested that operators developed their strategies which were concerned with lead time constant T_L in $Y_p(j\omega)$, mainly for natural frequency during training trials, and that the acquisition of their strategies required several trials.

Effect of Two-handed Asymmetrical Simultaneous Motions and Task Difficulty on Performance Time and Heart Rate Variability

By A. RAOUF and K. TSUCHIYA

Department of Industrial Engineering, University of Windsor, Windsor, Ontario N9B 3P4, Canada

Most of the industrial tasks involve asymmetrical simultaneous motions. Asymmetrical simultaneous motions may differ from symmetrical simultaneous motions in terms of unequal distance travelled by hands, unequal angles of movement made by both hands, unequal target diameter or a combination of these three factors. In this study asymmetrical simultaneous motions had unequal angle of hand motions when the task difficulty was the same for both hands. The task difficulty (TD) was measured using the following relationship $TD = \log_2 2D/C$ Bits, where D is the distance moved and C is the target diameter. In order to have a better understanding of human performance, in addition to performance time heart rate variability was also measured. Heart rate variability was obtained by using an EKG-Tachograph coupled with a mini-computer through an A/D converter.

In this paper the results of a $3 \times 3 \times 4$ randomized full factorial design experiment will be reported. Factors used in the experiment were (1) the angle of hand movement for the right hand, (2) the angle of hand movement for the left hand and (3) the task difficulty. It is hoped that the findings of this study will be of interest to industrial ergonomists and task designers.

A 10. Anthropometry and Posture

Problems in Determining Anthropometric Standards for Persons

By D. GLOSS

Communication System Division, GTE Products Corp., 77 'A' Street, Needham, Massachusetts 02194, U.S.A.

A number of problems arose in attempting to determine experimentally anthropometric standards for persons. Although there is considerable anthropometric data for men and a small data base for women, there have been no anthropometric studies of persons. These issues and their potential solutions are the subject of this paper.

The problems involve statistical analysis, sex differences, job distribution, reproduction and life expectancy.

A significant statistical problem exists in all published anthropometric research because samples were not randomly selected. In our study the volunteers were college students, which might create systematic biases in the data. Research has shown that people who volunteer for research have different psychological characteristics, and might have different anthropometric characteristics as well. Moreover, there were differences between men and women in the standard deviations for several variables. Often the men's standard deviation was significantly larger than the women's; which might result in more men being outside the limits than women.

Substantial sex differences occur in a number of anthropometric variables, and make the interval between 5 and 95% larger by comparison. These include chest breadth, hip breadth and arm length.

For particular activities should it always be presumed that a task will be equally distributed between the sexes? Would some other distribution of males and females be more appropriate when the work is weighted towards one sex or the other? If this occurs, then a larger proportion of one sex may be excluded.

For instance, there are a million pregnant women in the work force at any one time. How should anthropometric standards take into account rapidly changing body proportions, which might happen to be critical to job performance?

Finally, both men's and women's body sizes change with age, but scant attention has been paid to this in most of the studies reviewed.

A Longitudinal Study on Physical Growth at Adolescence

By Y. FURUMATSU, H. MUTO, S. SATO and E. FURUMATSU
2-1-28 Sugawara Niza, Saitama, Japan

Longitudinal growth study with one boy born in 1958 and three girls born in 1959, 1960, 1962 is reported as a fundamental study for planning clothes.

For 14 years since 1968, once every summer, 48 items of anthropometric measurement were measured using Martin's method and the Agency of Industrial Science and Technology's physique study method.

Photographs of the front, back and side of the body were taken using a Linhof 150mm telephoto lens from 9m distance, after setting the basic lines of neck, arms and waist in a normal standing posture. Menarcheal ages of the three girls were, respectively, 10 years 9 months, 11 years 6 months and 12 years.

The main results of the study are as follows. The values of measurements and the silhouettes on each girl have been studied from 3 years before the individual menarcheal age. In their front photographs, all three girls have smaller waist curves 3 years before their individual menarche and gradually get more curved waists as they become older, in the three girls' side photographs, larger dorsal curves can be seen 3 years before their individual menarche and the tendency of having gradually less dorsal curve can be seen by their individual menarche. There is a resemblance in the changes of silhouettes of the abdominal curves of the three girls.

Sex differences can be seen in comparison between the boy and the three girls on longitudinal changes before and after each age at peak height velocity.

On the Analysis of Erect Posture by the Foot-pressure

By M. SAKAMOTO and H. ITOW

Body Reformatory School, 2-4-22 Ohhashi, Meguro-ku, Tokyo-to, Japan

We judged the condition of erect posture by foot-pressure.

We measured 20 parts of the feet (five toes and five other parts of one foot) by measuring apparatus that used ultra-microtransducers. Subjects were male and female adults (age: max 45, min 20). We measured foot-pressure from 5 to 60s in an erect posture with opened eyes.

We classify erect posture into several types by the distribution of foot-pressure.

Two-dimensional Fourier Analysis of Human Torso Surface

By T. FURUKAWA, N. YAMANOI, H. TANAKA, K. YAJIMA, T. AOKI, K. AOKI, S. KINOSHITA and K. HIRAYANAGI
Institute of Medical Electronics, Faculty of Medicine, University of Tokyo, 7-3-1 Hongo, Bunkyo-ku, Tokyo, Japan

A method is presented to describe the geometrical shape of the human torso. The method comprises following two procedures. At first, the human torso is regarded as being composed of horizontal cross sections and their contour lines are measured by a sliding gauge. Second, Fourier analysis is applied to each contour line and sufficient numbers of its Fourier components are extracted to approximate it. This method has an advantage of representing detailed curvature of the torso surface, which cannot be obtained by usual somatometrical data where the torso is characterized by various types of interval lengths between its special points.

Moreover, multivariate analysis was applied to investigate the relations between these Fourier components and somatometrical data such as height, weight, chest circumference and so on. This relation was used to develop a method to approximate the shape of the torso by estimating its Fourier components from somatometrical data.

From the results of contour line approximation of 11 cross sections in a body with 20 subjects, the following conclusions were obtained.

- (1) Approximation using six Fourier components can sufficiently reconstruct the original contour lines at all levels of torso cross section.
- (2) For the level of the nipples four components are sufficient, and for the level of the abdomen only two components.
- (3) The shape of the torso constructed by Fourier components, which were obtained by multiple regression, showed good agreement with its actual shape.

Measurement of Human Body Form Using Pattern Processing Techniques

By N. ITO

Faculty of Engineering Science, Osaka University, Machikaneyama-cho 1-1, Toyonaka, Osaka 560, Japan

This study presents a new method for measuring human body form for the purpose of applying anthropological analysis and medical diagnosis to garment design, using pattern processing techniques such as pattern matching and clustering. Conventional methods of body form analysis and classification are based

on hand-measured values of body dimensions or visual observation of body silhouettes, while the present method can treat body form as a pattern by employing an electronic computer in extracting and representing the features of body form.

The original data for the procedure of the method are body silhouettes in the two—front and side—standardized poses which are stored on the computer memory. On the contour curves of a body silhouette, feature points are placed at intervals of predetermined vertical distances and then a feature vector is defined, each element of which represents the normalized horizontal co-ordinate of a feature point, the origin being on the gnathion. The feature vectors extracted have been shown to have a better reconstructibility of the original silhouettes. They can be processed by means of pattern processing techniques in order to compare and classify body forms and to analyse body form changes during growth or during pregnancy. Some results of applying the procedure to Japanese women's body form are reported.

Mannequins Especially made for Nineteenth Century Costumes

By C. TAMAGAWA

The Kyoto Costume Institute, Wacoal Building, 29 Kisshoin Nakajima-cho, Minami-ku, Kyoto, Japan

Special types of mannequins were developed to display the nineteenth century costumes for the exhibition entitled 'Evolution of Fashion 1835-1895' held in Kyoto in 1980. This paper presents the process of development of these special mannequins, hoping to make a contribution to the research of ergonomics in connection with the kinetic functions of mannequins. Unlike conventional mannequins, they were scientifically designed to approximate human bodies of the nineteenth century in consideration of their kinetic functions, having the following distinguished features:

- (1) Somatomia, somatic type, posture, behaviour and other functions were designed to comply with human bodies of the nineteenth century with as much precision as possible.
- (2) Emphasis was placed on the traditional manners of the people of the nineteenth century. Such traditional manners and behaviour were made available in these mannequins.
- (3) In order to furnish mannequins with kinetic functions similar to those of human bodies, special attention was paid to the movable range of the joints of the mannequins so that they could comply with the movement of the human bodies. Free adjustment was made available for the movement of hands, arms and legs of the mannequins.

The principle of designing these mannequins was to place most emphasis on the historical differences. The Metropolitan Museum of Art provided their full co-operation and useful suggestions to help create these new mannequins.

In viewing the development of these mannequins, we must refer to the features and historical background of the so-called 'Roman Style' of the nineteenth century, influenced by the prevailing romanticisms of that period. Taking this background into consideration, we present the development of these new mannequins in the following segments:

- (1) The creation of the idea and planning for the development of new mannequins.
- (2) The planning of processing the mannequins.
- (3) The functions and forms of the mannequins.
- (4) The structure and materials of the mannequins.
- (5) Conclusion.

A Study of the Anthropometric Differences of the Lordotic Curvature in Adult Men and Women

By N. E. O'NEILL

Lockheed Missiles and Space Company, 4895 Lafayette Street, Santa Clara, California 95050, U.S.A.

Previous studies have indicated that the amount of lordotic curvature differs between men and women. To examine these differences, a sample of 90 adult men and women between the ages of 18 and 60 was selected from a population of sedentary workers in southern California. The sample was divided so that there were 15 men and women in each of three age groups: 18-21, 22-29 and 40-60. For each subject, four measurements were taken using a device called a 'conformateur'. Small-sample *t*-tests were performed between sexes for each age group. It was concluded that there is no significant difference in the amount of lordosis, but that the location of the beginning of the curvature differs among the sexes.

When the total male-versus-female segments of the population were compared with respect to amount of lordotic curvature, no statistically significant differences emerged. However, when each group was examined for male-female differences, the amount of curvature in the 18-21-year group was significant at the 1% level.

On the basis of the statistical analyses, the study conclusions appear justified. A plausible explanation for this might be in the observation that most women carry a greater amount of fat in the buttocks. This could be an important factor in seat design as sex barriers to vocational choices erode. Thus, a lumbar support which is placed too high or too low may cause discomfort and excessive arching of the lumbar spine leading to cumulative low back trauma.

Kinematic Analysis of Three-dimensional Motion in Loading Operations

By K. IWATA, T. MORIWAKI and T. KAWANO

Production Engineering Department, Faculty of Engineering, Kobe University, Rokko, Nada, Kobe 657, Japan

Methodology is developed to analyse and evaluate three-dimensional human body motions under normal working conditions. Simple loading and unloading of a weight was filmed employing a 16 mm high-speed movie camera, while a life-size mirror was placed in front of the subject so that the motions in both the frontal and the sagittal planes are taken simultaneously. The three-dimensional motion data are taken into a minicomputer via a graphic-tablet. The time series data are processed within the computer to reproduce the three-dimensional motion patterns and to display them on the CRT dynamically for detailed analyses of the motions.

A mathematical model of the human body is established and equations of motion are derived to estimate dynamic forces and torques acting at various parts of the body during motion. The model basically consists of 17 rigid cylinders connected by ball joints, each of the cylinders representing an equivalent body segment, such as head, trunk, arm, etc. The forces and torques acting at the individual body joints are computed by solving the equations of motion based on the motion data, taking into account the forces and torques measured at the interface between the feet and the floor.

Loading and unloading motions are analysed for seven male subjects of different ages. The changes in the force and torques during the motions are analysed and related to the motion patterns. The patterns of the forces and torques at some important joints are compared for cycles of motions among the subjects tested. The effects of ageing and fatigue upon motion patterns and forces are also discussed, based on the experimental and computational results.

A 11. Biomechanics

A Force Sensor Using Carbon Fibre and its Application to a Foot-force Measuring System for Gait Analysis

By K. KATAHIRA

Second Department of Physiology, Fukushima Medical College, 5-75 Sugitsuma-chō, Fukushima 960, Japan

In this study force sensors using carbon fibre and the application to a foot-force measuring system for gait analysis are presented. Carbon fibre is produced by carbonization of chemical fibre. Ohmic resistance of the carbon-fibre felt is decreased by an additional force or compression. When the force is removed, the resistance returns to its previous level. Thus, carbon-fibre felt is suitable for use as a force sensor.

For the purpose of measuring a vertical component of foot force on a desired part of the plantars, force sensors or force-sensitive discs, circles 10 mm in diameter and 3 mm in thickness, were designed and constructed using PAN carbon-fibre felt. Force detected by the sensors is transformed into an electrical signal with bridge circuits. The relation between the force (*X*) on the disc and the output of a bridge circuit (*Y*) is linear on log-log scales ($Y = aX^b$). The force-sensitive discs have good properties of responsibility within 10 ms, repeatability and little hysteresis below 10%.

A foot-force measuring system was designed using six sensors and microcomputer apparatus. The data were computed by a microcomputer in order to obtain a normalized and linearized pressure curve, average maximum force and the time when its peak occurs for five successive walking steps. With the present system it was possible to measure simultaneously and dynamically foot forces in human gait. The carbon-fibre sensors and foot-force measuring system are useful for evaluating gait and also for providing important information in rehabilitation clinics.

on hand-measured values of body dimensions or visual observation of body silhouettes, while the present method can treat body form as a pattern by employing an electronic computer in extracting and representing the features of body form.

The original data for the procedure of the method are body silhouettes in the two—front and side—standardized poses which are stored on the computer memory. On the contour curves of a body silhouette, feature points are placed at intervals of predetermined vertical distances and then a feature vector is defined, each element of which represents the normalized horizontal co-ordinate of a feature point, the origin being on the gnathion. The feature vectors extracted have been shown to have a better reconstructibility of the original silhouettes. They can be processed by means of pattern processing techniques in order to compare and classify body forms and to analyse body form changes during growth or during pregnancy. Some results of applying the procedure to Japanese women's body form are reported.

Mannequins Especially made for Nineteenth Century Costumes

By C. TAMAGAWA

The Kyoto Costume Institute, Wacoal Building, 29 Kisshoin Nakajima-cho, Minami-ku, Kyoto, Japan

Special types of mannequins were developed to display the nineteenth century costumes for the exhibition entitled 'Evolution of Fashion 1835-1895' held in Kyoto in 1980. This paper presents the process of development of these special mannequins, hoping to make a contribution to the research of ergonomics in connection with the kinetic functions of mannequins. Unlike conventional mannequins, they were scientifically designed to approximate human bodies of the nineteenth century in consideration of their kinetic functions, having the following distinguished features:

- (1) Somato metria, somatic type, posture, behaviour and other functions were designed to comply with human bodies of the nineteenth century with as much precision as possible.
- (2) Emphasis was placed on the traditional manners of the people of the nineteenth century. Such traditional manners and behaviour were made available in these mannequins.
- (3) In order to furnish mannequins with kinetic functions similar to those of human bodies, special attention was paid to the movable range of the joints of the mannequins so that they could comply with the movement of the human bodies. Free adjustment was made available for the movement of hands, arms and legs of the mannequins.

The principle of designing these mannequins was to place most emphasis on the historical differences. The Metropolitan Museum of Art provided their full co-operation and useful suggestions to help create these new mannequins.

In viewing the development of these mannequins, we must refer to the features and historical background of the so-called 'Roman Style' of the nineteenth century, influenced by the prevailing romanticisms of that period. Taking this background into consideration, we present the development of these new mannequins in the following segments:

- (1) The creation of the idea and planning for the development of new mannequins.
- (2) The planning of processing the mannequins.
- (3) The functions and forms of the mannequins.
- (4) The structure and materials of the mannequins.
- (5) Conclusion.

A Study of the Anthropometric Differences of the Lordotic Curvature in Adult Men and Women

By N. E. O'NEILL

Lockheed Missiles and Space Company, 4895 Lafayette Street, Santa Clara, California 95050, U.S.A.

Previous studies have indicated that the amount of lordotic curvature differs between men and women. To examine these differences, a sample of 90 adult men and women between the ages of 18 and 60 was selected from a population of sedentary workers in southern California. The sample was divided so that there were 15 men and women in each of three age groups: 18-21, 22-29 and 40-60. For each subject, four measurements were taken using a device called a 'conformateur'. Small-sample *t*-tests were performed between sexes for each age group. It was concluded that there is no significant difference in the amount of lordosis, but that the location of the beginning of the curvature differs among the sexes.

When the total male-versus-female segments of the population were compared with respect to amount of lordotic curvature, no statistically significant differences emerged. However, when each group was examined for male-female differences, the amount of curvature in the 18-21-year group was significant at the 1% level.

On the basis of the statistical analyses, the study conclusions appear justified. A plausible explanation for this might be in the observation that most women carry a greater amount of fat in the buttocks. This could be an important factor in seat design as sex barriers to vocational choices erode. Thus, a lumbar support which is placed too high or too low may cause discomfort and excessive arching of the lumbar spine leading to cumulative low back trauma.

Kinematic Analysis of Three-dimensional Motion in Loading Operations

By K. IWATA, T. MORIWAKI and T. KAWANO

Production Engineering Department, Faculty of Engineering, Kobe University, Rokko, Nada, Kobe 657, Japan

Methodology is developed to analyse and evaluate three-dimensional human body motions under normal working conditions. Simple loading and unloading of a weight was filmed employing a 16 mm high-speed movie camera, while a life-size mirror was placed in front of the subject so that the motions in both the frontal and the sagittal planes are taken simultaneously. The three-dimensional motion data are taken into a minicomputer via a graphic-tablet. The time series data are processed within the computer to reproduce the three-dimensional motion patterns and to display them on the CRT dynamically for detailed analyses of the motions.

A mathematical model of the human body is established and equations of motion are derived to estimate dynamic forces and torques acting at various parts of the body during motion. The model basically consists of 17 rigid cylinders connected by ball joints, each of the cylinders representing an equivalent body segment, such as head, trunk, arm, etc. The forces and torques acting at the individual body joints are computed by solving the equations of motion based on the motion data, taking into account the forces and torques measured at the interface between the feet and the floor.

Loading and unloading motions are analysed for seven male subjects of different ages. The changes in the force and torques during the motions are analysed and related to the motion patterns. The patterns of the forces and torques at some important joints are compared for cycles of motions among the subjects tested. The effects of ageing and fatigue upon motion patterns and forces are also discussed, based on the experimental and computational results.

A 11. Biomechanics

A Force Sensor Using Carbon Fibre and its Application to a Foot-force Measuring System for Gait Analysis

By K. KATAHIRA

Second Department of Physiology, Fukushima Medical College, 5-75 Sugitsuma-chō, Fukushima 960, Japan

In this study force sensors using carbon fibre and the application to a foot-force measuring system for gait analysis are presented. Carbon fibre is produced by carbonization of chemical fibre. Ohmic resistance of the carbon-fibre felt is decreased by an additional force or compression. When the force is removed, the resistance returns to its previous level. Thus, carbon-fibre felt is suitable for use as a force sensor.

For the purpose of measuring a vertical component of foot force on a desired part of the plantars, force sensors or force-sensitive discs, circles 10 mm in diameter and 3 mm in thickness, were designed and constructed using PAN carbon-fibre felt. Force detected by the sensors is transformed into an electrical signal with bridge circuits. The relation between the force (*X*) on the disc and the output of a bridge circuit (*Y*) is linear on log-log scales ($Y = aX^b$). The force-sensitive discs have good properties of responsibility within 10 ms, repeatability and little hysteresis below 10%.

A foot-force measuring system was designed using six sensors and microcomputer apparatus. The data were computed by a microcomputer in order to obtain a normalized and linearized pressure curve, average maximum force and the time when its peak occurs for five successive walking steps. With the present system it was possible to measure simultaneously and dynamically foot forces in human gait. The carbon-fibre sensors and foot-force measuring system are useful for evaluating gait and also for providing important information in rehabilitation clinics.

on hand-measured values of body dimensions or visual observation of body silhouettes, while the present method can treat body form as a pattern by employing an electronic computer in extracting and representing the features of body form.

The original data for the procedure of the method are body silhouettes in the two—front and side—standardized poses which are stored on the computer memory. On the contour curves of a body silhouette, feature points are placed at intervals of predetermined vertical distances and then a feature vector is defined, each element of which represents the normalized horizontal co-ordinate of a feature point, the origin being on the gnathion. The feature vectors extracted have been shown to have a better reconstructibility of the original silhouettes. They can be processed by means of pattern processing techniques in order to compare and classify body forms and to analyse body form changes during growth or during pregnancy. Some results of applying the procedure to Japanese women's body form are reported.

Mannequins Especially made for Nineteenth Century Costumes

By C. TAMAGAWA

The Kyoto Costume Institute, Wacoal Building, 29 Kisshoin Nakajima-cho, Minami-ku, Kyoto, Japan

Special types of mannequins were developed to display the nineteenth century costumes for the exhibition entitled 'Evolution of Fashion 1835-1895' held in Kyoto in 1980. This paper presents the process of development of these special mannequins, hoping to make a contribution to the research of ergonomics in connection with the kinetic functions of mannequins. Unlike conventional mannequins, they were scientifically designed to approximate human bodies of the nineteenth century in consideration of their kinetic functions, having the following distinguished features:

- (1) Somato metria, somatic type, posture, behaviour and other functions were designed to comply with human bodies of the nineteenth century with as much precision as possible.
- (2) Emphasis was placed on the traditional manners of the people of the nineteenth century. Such traditional manners and behaviour were made available in these mannequins.
- (3) In order to furnish mannequins with kinetic functions similar to those of human bodies, special attention was paid to the movable range of the joints of the mannequins so that they could comply with the movement of the human bodies. Free adjustment was made available for the movement of hands, arms and legs of the mannequins.

The principle of designing these mannequins was to place most emphasis on the historical differences. The Metropolitan Museum of Art provided their full co-operation and useful suggestions to help create these new mannequins.

In viewing the development of these mannequins, we must refer to the features and historical background of the so-called 'Roman Style' of the nineteenth century, influenced by the prevailing romanticisms of that period. Taking this background into consideration, we present the development of these new mannequins in the following segments:

- (1) The creation of the idea and planning for the development of new mannequins.
- (2) The planning of processing the mannequins.
- (3) The functions and forms of the mannequins.
- (4) The structure and materials of the mannequins.
- (5) Conclusion.

A Study of the Anthropometric Differences of the Lordotic Curvature in Adult Men and Women

By N. E. O'NEILL

Lockheed Missiles and Space Company, 4895 Lafayette Street, Santa Clara, California 95050, U.S.A.

Previous studies have indicated that the amount of lordotic curvature differs between men and women. To examine these differences, a sample of 90 adult men and women between the ages of 18 and 60 was selected from a population of sedentary workers in southern California. The sample was divided so that there were 15 men and women in each of three age groups: 18-21, 22-29 and 40-60. For each subject, four measurements were taken using a device called a 'conformateur'. Small-sample *t*-tests were performed between sexes for each age group. It was concluded that there is no significant difference in the amount of lordosis, but that the location of the beginning of the curvature differs among the sexes.

When the total male-versus-female segments of the population were compared with respect to amount of lordotic curvature, no statistically significant differences emerged. However, when each group was examined for male-female differences, the amount of curvature in the 18-21-year group was significant at the 1% level.

On the basis of the statistical analyses, the study conclusions appear justified. A plausible explanation for this might be in the observation that most women carry a greater amount of fat in the buttocks. This could be an important factor in seat design as sex barriers to vocational choices erode. Thus, a lumbar support which is placed too high or too low may cause discomfort and excessive arching of the lumbar spine leading to cumulative low back trauma.

Kinematic Analysis of Three-dimensional Motion in Loading Operations

By K. IWATA, T. MORIWAKI and T. KAWANO

Production Engineering Department, Faculty of Engineering, Kobe University, Rokko, Nada, Kobe 657, Japan

Methodology is developed to analyse and evaluate three-dimensional human body motions under normal working conditions. Simple loading and unloading of a weight was filmed employing a 16 mm high-speed movie camera, while a life-size mirror was placed in front of the subject so that the motions in both the frontal and the sagittal planes are taken simultaneously. The three-dimensional motion data are taken into a minicomputer via a graphic-tablet. The time series data are processed within the computer to reproduce the three-dimensional motion patterns and to display them on the CRT dynamically for detailed analyses of the motions.

A mathematical model of the human body is established and equations of motion are derived to estimate dynamic forces and torques acting at various parts of the body during motion. The model basically consists of 17 rigid cylinders connected by ball joints, each of the cylinders representing an equivalent body segment, such as head, trunk, arm, etc. The forces and torques acting at the individual body joints are computed by solving the equations of motion based on the motion data, taking into account the forces and torques measured at the interface between the feet and the floor.

Loading and unloading motions are analysed for seven male subjects of different ages. The changes in the force and torques during the motions are analysed and related to the motion patterns. The patterns of the forces and torques at some important joints are compared for cycles of motions among the subjects tested. The effects of ageing and fatigue upon motion patterns and forces are also discussed, based on the experimental and computational results.

A 11. Biomechanics

A Force Sensor Using Carbon Fibre and its Application to a Foot-force Measuring System for Gait Analysis

By K. KATAHIRA

Second Department of Physiology, Fukushima Medical College, 5-75 Sugitsuma-cho, Fukushima 960, Japan

In this study force sensors using carbon fibre and the application to a foot-force measuring system for gait analysis are presented. Carbon fibre is produced by carbonization of chemical fibre. Ohmic resistance of the carbon-fibre felt is decreased by an additional force or compression. When the force is removed, the resistance returns to its previous level. Thus, carbon-fibre felt is suitable for use as a force sensor.

For the purpose of measuring a vertical component of foot force on a desired part of the plantars, force sensors or force-sensitive discs, circles 10 mm in diameter and 3 mm in thickness, were designed and constructed using PAN carbon-fibre felt. Force detected by the sensors is transformed into an electrical signal with bridge circuits. The relation between the force (X) on the disc and the output of a bridge circuit (Y) is linear on log-log scales ($Y = aX^b$). The force-sensitive discs have good properties of responsibility within 10 ms, repeatability and little hysteresis below 10%.

A foot-force measuring system was designed using six sensors and microcomputer apparatus. The data were computed by a microcomputer in order to obtain a normalized and linearized pressure curve, average maximum force and the time when its peak occurs for five successive walking steps. With the present system it was possible to measure simultaneously and dynamically foot forces in human gait. The carbon-fibre sensors and foot-force measuring system are useful for evaluating gait and also for providing important information in rehabilitation clinics.

Finite State Measurement System of Human Gait

By A. KATO, K. ITO and K. TSUCHIYA

Aichi Institute of Technology, 1247 Yagusa, Toyota 470-03, Japan

In a study of human gait, we applied the finite state theory to a description of foot-floor contact. We selected some zones on a sole and represented the states of foot-floor contact of these zones by a gait matrix. A gait matrix for an animal's walk and a human gait has been defined by McGhee, Tomovic and Ito.

In our study, we selected four zones on a sole and called it the eight bits gait. We made a measurement system for the eight bits gait. This measurement system is constructed with two four-bits foot switches, parallel to serial converter modulator, audio-cassette recorder and microcomputer.

Characteristics of Spectral Analysis of Strides on Treadmill Walking

By Y. MASAHIRO

Department of Physiology, Institute of Constitutional Medicine, Kumamoto University,
Kuhonji 4-24-1, 862 Kumamoto, Japan

Iterative movement will follow the same pattern as the performers are accustomed to the movement. However, it should be taken into consideration that the previous movements will affect the forthcoming iteration to a certain degree. In this study, strides were continuously measured and the data in time series were analysed by autoregressive method to assess the characteristics of walking. A computerized system was employed to determine strides. The system consists of a position sensitive device, foot switches and a spectrum computer. The requirements of the system are: (1) continuous measurement of strides above 1000 steps, (2) on-line collection and storage of data and (3) accuracy of strides within 1 cm. Subjects were adult males and females. They walked on a treadmill with inclinations of 0, 5 and 10%, at different speeds between 60 and 120 m/min with an increment of 10 m/min. A thousand strides at a given speed were measured for each of the three gradients. In level walking some subjects showed the difference between left and right strides. The difference increased with speed and it was most pronounced at the speed of 120 m/min. The mean data revealed that right strides were usually longer than left strides. Relation between right-left asymmetry of walking and lateral predominance will be discussed. The power spectrum of strides was obtained for the frequency range 0.05-0.5 cycle/stride in steps of 0.01 cycle/stride by autocorrelation and its Fourier transformation technique. In any case the dominant frequency of strides was 0.5 cycle/stride which means the two-step frequency, although there were some variations among subjects. The order of the power spectral density for each frequency indicated maximum at 120 m/min and minimum at 70 or 80 m/min as a whole. This suggests that there may be a correlation between the auto-regressive activity of strides and optimal speed. In this same way we investigated the walking pattern when the gradient was changed and compared the characteristics of level walking with that of grade walking.

A Study on Walking Width, Time and Speed in Manually Carrying Loads

By Y. OGURO

Kanagawa University, 2-9-6 Wakabadai, Shiroyama-machi, Tukai-gun, Kanagawa, Japan

This paper deals with walking width, time and speed in manually carrying loads. The walking width, time and speed in seven different manually carried loads were calculated on five healthy male students. From these calculations, the walking widths have been found to be correlated closely with the weight of the load carried. The walking time is also correlated closely with the weight of the load carried. The regressive equations of these correlations are given in this paper.

On the Central Control of Voluntary Arm Movements

By T. KUROKAWA

Faculty of Engineering Science, Osaka University, Machikaneyama-cho 1-1,
Toyonaka, Osaka 560, Japan

Although understanding the control mechanism of human limb movement is important in sports biomechanics and man-machine engineering, we know little about it. The purpose of the present study is to examine the motor commands producing voluntary movements of the human forearm. For this purpose

some experiments were carried out in which subjects performed forearm extensions at various amplitudes and speeds. We then extracted the motor commands to both the agonist and antagonist by calculating the time-course of pulse density change in the EMG recorded. This extraction of the motor commands is based on the assumption that the motor information descending to the skeleto-muscle system is conveyed by the change of pulse density in the motor nerve.

Examining the relation between movement and motor commands, it has been confirmed that forearm movement is controlled in two modes. One is the magnitude mode; the magnitude of the motor commands changes with the amplitude of movement and/or peak acceleration. The other is the time-difference mode; the difference between the onset time of the agonistic command and that of the antagonistic one varies according to the peak acceleration of the movement. In the fastest movement these two modes are exclusive. While peak acceleration is low, only the magnitude mode operates, the onset time difference being constant. In movement with comparatively high acceleration we have only the time-difference mode.

Dynamic Analysis of the Human Upright Posture Control Activity

By K. SATO, C. MORISADA and N. TAJIMA

Research Foundation on Traffic Medicine, 1-9-3 Higashi-Ikebukuro Toshimaku, Tokyo 170, Japan

Though the human upright body on earth is very unstable, constant inclination of the body is always corrected so that dynamic equilibrium ('homeostasis') to minimize the postural sway is maintained. Such invisible sway can be recognized as the response of the 'posture control system' in the body caused by various stimulations including gravity.

As the time series of an appropriately magnified sway of upright posture displayed a normal Gaussian process, at least for the first step, it was described as an autoregressive (AR) process, which was generated as a dynamic high-order extension of 'excitability', defined as the inverse of the threshold stimulus of a living excitable system.

The average frequency and time patterns of high-order dynamic posture control activity are determined in turn by AR-power spectral density and AR-covariance function, both of which are characterized by the AR-coefficients of the AR-process. High-order control activity can be decomposed into one or two first-order and some second-order component activities characterized by one and two AR-coefficients, respectively. The first-order one displayed a damped exponential average time-pattern with a time constant and a peak at 0 Hz in its power spectrum, which exhibited more than 90% power. Each of the second-order activities had $\leq 5\%$ power displaying a damped oscillatory average time pattern with a damping frequency as well as a damping time (time constant of the envelope of the oscillation) and a peak at the respective resonance frequency in its spectrum.

In addition to the power of the component control activity, that of smoothness and regularity was treated as 'bio-information activity amount', which did not necessarily parallel that of power.

Desktop Computer-aided Analysis of Dynamics in Human Standing and Walking

By T. YAMASHITA, T. TANIGUCHI and M. ANDOH

Kyushu Institute of Technology, Tobata, Kitakyushu 804, Japan

The steady advancement of computer technology gives us, at an increasing rate, new possibilities to study human movements in various ways. A portable desktop computer equipped with a graphic CRT is a useful means in a laboratory to collect experimental data and to give results in graphical form if the A/D converter is introduced to take data from measuring instruments. This paper deals with a desktop computer-aided analysis system which has been used for the study of dynamics in human standing and walking for normal and disabled subjects. Two force plates are used in the experiment.

Human standing has been extensively studied. The results, however, have, so far, been generally expressed in statical form: the mean position of the point of application of the supporting force in the foot and the fluctuating amplitude of it are often used to show the stability and steadiness of a standing posture. In our study an autoregressive model was derived from experimental data to analyse the dynamic characteristics of each subject. The correlation between the standing posture and the model derived will be discussed.

As for walking characteristics the transient phases, which have not been well studied, are reported: the starting phase of walking and stopping. The characteristics obtained experimentally are compared not only with the steady characteristics but also with the results simulated by a simple mechanical model. The simulation gives a clear insight into the phenomena observed experimentally because it provides detailed information about each variable.

The computer is effectively used for data processing in both the experiment and the simulation. Similar performance may be obtained by a much cheaper computer in the near future.

The Application of Three-dimensional Measurements to Motion Analysis

By Y. SUZUKI

Labor Accidents Prosthetics and Orthotics Center, 10-5 1-chome Komei,
Minatoku, Nagoya 455, Japan

This report treats the problems of three-dimensional coordinate measurement and application to motion analysis. The devices are Selspot system and Force platform with a computer.

I conceived a simple adjusting method for setting up the camera of the three-dimensional co-ordinate measurement for clinical use (the evaluation of rehabilitation training).

In these experiments, the subjects were five persons for the upper limb motion analysis and seven persons for lower limb motion analysis.

This measurement is the 90° optical-axis cross method, i.e. the optical cameras were set up 90° of cross-position on space.

The adjusting method uses two standard targets (LED) for adjustment by knowing the following values: (a) height level of each camera, (b) horizontal angle of each camera and (c) distance ratio of each camera from the origin of the three-dimensional co-ordinates.

In these experiments, using three-dimensional co-ordinate measurement, I tried to analyse the motion of each joint when drinking water, and analysed the angle range of each joint in the dynamical motion.

In this experiment using three-dimensional co-ordinate measurement and Force platform, I tried to achieve a gait analysis in the starting state of walking, because it is a most unstable state for the human body. In my opinion, it is the most suitable way to analyse gait deviation. I tried to analyse the antero-posterior and medio-lateral motion on body and the reaction force on Force platform.

A 12. Training and Simulator

Use of Modular Simulators in Selection, Training and Workpost Design

By J.-E. ROUHET

ERGOS: Société d'Etudes et Réalisations en Ergonomie, B.P. 42, 77201 Marne-La-Vallee, France

An ergonomics study of a prototype armoured car has as its objectives to (i) determine appropriate hardware modifications, (ii) specify user procedures and (iii) develop selection and training specifications.

A preliminary analysis of the system under operating conditions indicates various domains requiring in-depth experimentation. Practical considerations exclude the possibility of prolonged experimentation with the prototype and so a simulator is envisaged to recreate the many parameters involved—a 'global' simulator. But this is only one of the possible options. Another is to recreate operator sensations by physiological stimulation. Another is to develop 'modular' simulators which recreate only the partial conditions necessary for a given purpose.

The development of modular simulators and their use in selection and training, respectively, is described, evaluated and the implications of less costly alternatives to global simulators discussed.

Development of General Purpose Biofeedback System

By M. OHSUGA

Mitsubishi Electric Corp., Nakano 80, Minamishimizu Amagasaki, Hyogo, Japan

In the clinical use of biofeedback technique, the doctor should make a careful consideration of the patient's symptom, his personality, and so on, when deciding the training methodology.

We have developed a biofeedback system which aids the doctor in deciding his methodology and provides an instrument for real time feedback training and future data analysis.

Hardware configuration

The system is composed of three parts.

- (1) The main part: a 16 bit CPU, dual floppy disks, a keyboard, a printer, a display and an audio module.
- (2) The input part: compact modules attached to the patient. One channel is composed of a transducer, an amplifier and a transmitter.
- (3) The data logger: a receiver, A/D converters and some data processing modules controlled by commands words from the CPU.

Characteristics

(1) The doctors can decide the training method by selecting some variables and parameters in the menu presented on the display without any troublesome programming.

Variables and parameters of the physiological indices, the method of data processings, the feedback modalities and the feedback modes are available.

(2) The doctor can also decide the training sequence including rest, baseline and feedback training periods. The training can be executed automatically according to the decided sequence.

(3) The patient's data in the training sessions are recorded on the floppy disk. After training, the doctor can make further analysis of the data and can get outputs on the display or the printer.

We hope this system will contribute to the establishment of the methodology of biofeedback.

Research and Development of Airborne Integrated Display for NAL QSTOL

By M. OKABE, K. TANAKA, H. KAWAHARA and N. ISU

National Aerospace Laboratory, 1880 Jindaiji-machi, Chofu, Tokyo 182, Japan

Airborne Integrated Display (AID) as a future head down display for NAL QSTOL (Quiet Short Takeoff and Landing aircraft of National Aerospace Laboratory) is now under development. The AID system is designed so that it has full capability for advanced aircraft operations. The AID system is composed of a digital computer, a display processor and a shadow-mask type colour CRT. Design and characteristics associated with results of preliminary studies using a prototype set-up of the AID are presented.

Emphasis of this research is placed upon determining the display functions of the AID. In the AID, the control cues are integrated into one flight director symbol which represents three commands: pitch command shown by its vertical motion, roll command shown by its rotating motion and flight path command shown by the vertical motion of the centre part of the symbol. Other cues and information are arranged in rather peripheral positions where they can instantaneously notify their off-normal condition by fully utilizing colour codes.

Analytical evaluation of the dynamics of this newly designed flight director in the flight director-pilot-aircraft system is also given in this presentation.

A 13. The Handicapped

A Study on Handwork of the Mentally Handicapped

By A. TANAKA and others

Hosei University, Faculty of Engineering, 3-7-2 Kaginocho, Koganei-shi, Tokyo, Japan

We have been studying how to judge the physical functions of the mentally handicapped, especially chronic schizophrenics, in their social life, from a viewpoint of human engineering. We have already reported some of our first studies in this area at the 22nd Conference of the Japanese Society of Human Engineering. We would like to report the results of the latest study we have pursued, for which more experiments were conducted.

We have conducted our experiments on the ability of schizophrenics to do light handwork in making *noshi*, or long, thin strips of dried sea-ear to be attached to gifts. We gave an intelligence test to each of them before our experiments, and we also gave them physical tests such as a grip test, a tapping test, etc., in order to pursue the relationship between their physical or mental handicap and their handwork.

Many biotechnological studies have been reported so far as to how to adapt regular healthy persons and the physically handicapped to light handwork, while few studies have been made about the mentally handicapped in this regard. Work for the mentally handicapped should be simple and productive, and it should be able to be accomplished within a limited period of time. It should also be safe and free from any dangers of accident. Taking all this into consideration, we have undertaken a light handwork project for a group of mentally handicapped. At the same time, we have given the same preliminary tests and experiments to a group of regular healthy persons so that we might be able to compare the results with those of the mentally handicapped group.

Diurnal Variations of Reaction Time Performance in Mentally Retarded Children

By K. KUSANO

Department of Special Education, University of Miyazaki, Miyazaki 880, Japan

Circadian rhythmicity in reaction time performance of mentally-retarded children was investigated. Choice reaction time was measured every hour in a day from 6.00 a.m. to 5.00 p.m. on each of 12 days. Subjects were eight mentally retarded boys (10-14 years; IQs 40-62) and ten non-retarded boys (12 years). The mentally-retarded group showed significantly greater diurnal changes in performance level than those of the non-retarded group. In the mean diurnal performance curve, two peaks appeared, the highest was observed at 3.00 p.m. and the second at 11.00 a.m. The incorrect choice reaction occurred more in the evening than in the morning.

Ergonomics for the Mentally Handicapped—Motion Study

By E. KAPECKA and T. MAREK

ul. Nad Potokiem 6/35, 30-830 Kraków, Poland

Work stations for the mentally handicapped persons are not complicated. Workers realize simple manual movement acts in these. Nevertheless, because of the workers' handicap the ergonomic optimization of these work stations is indispensable. A very important problem is to explore what is typical of the movement structure of mentally handicapped persons.

The aim of this study was to examine whether movement smoothness, anticipation of movement operations in turns and movement direction of the mentally handicapped are disturbed.

Thirty mentally handicapped (IQ = 36-51) and 30 normal persons aged 16-20 were examined. The following methods were used: observation, analysis of movement structure and the following manual dexterity tests: the Roloff Rings Test, the O'Connor Finger Dexterity Test and the Meile Ball Test.

It was discovered that the structure of movements is completely different in both groups tested. In the normal group structure disturbances were not observed. In the mentally handicapped group disturbances of movement smoothness and anticipation were detected ($p < 0.01$). No disturbance of movement direction was observed.

An Evaluation of Correlation Between Amputated Limb and It's Dominancy Using Dummy Prostheses

By T. AOYAMA

Labour Accident Prosthetics and Orthotics Centre,
1-10-5 Komei, Minatoku Nagoya, Japan

In assessing the fresh amputation of a lower limb, it is useful to know whether the amputated limb has been 'dominant' or not.

It is well known that everyone has his dominant side especially in the case of arms and hands and if the dominant hand is lost, the patient has to switch the dominancy to the other one. As there is great difficulty in an arm amputation, it is suspected that some relation exists between the feasibility of prosthetic control and the dominancy of the amputated limb. On the assumption that the dominant leg or foot is the one which supports the body when kicking a football, a patient who loses his non-dominant leg is likely to show better prosthetic control in the early stages of training than the other if the rest of the conditions are exactly the same.

To check this relation of cause and effect, we have made bilateral dummy prostheses for normal subjects which simulate a quadrilateral, ischial weight-bearing type above knee prostheses. Two subjects were estimated from the beginning of wearing, changing the prosthetic side each day, both in static and dynamic conditions. Devices used were a Standing Balance Indicator, Force Platforms and a 16 mm movie camera. In this report fluctuation of zero moment point in an upright position and feasibility of prosthetic walking are analysed in relation to the side of prosthetic limb and dominancy.

The Weight Ratio of a Prosthetic Arm to an Amputated Arm Segment

By N. OHNISHI

The Labour Accident Prosthetics and Orthotics Centre, 1-10-5 Komei,
Minatoku, Nagoya 455, Japan

A man-machine system is composed of an amputee who lost his arm and his artificial arm (prosthesis). In this man-machine system the weight of the prosthesis is one of the most important factors.

A weight ratio is adopted to analyse the relations between the weight of the prosthesis and the amputee's subjective judgements on his own prosthesis using the data obtained from enquiries to 149 upper limb amputees. The weight ratio is defined as the ratio of the weight of the prosthesis to the estimated weight of the arm lost by amputation. This ratio is independent of the level of amputation and so is superior to the weight of the prosthesis itself in comparing prostheses of different levels of amputation.

This paper describes the relations between the weight ratio and the following items: (1) kind of prosthesis, (2) level of amputation, (3) whether an amputee feels his prosthesis heavy or not, (4) whether an amputee is satisfied with his prosthesis or not and (5) bad effects on a human body (fatigue, shoulder discomfort).

The Effect of Foot-sole Pressure Sensory Feedback on the Activity of the Lower Limb Amputee

By S. MORIMOTO, K. TSUCHIYA and Y. SAITO

The Labour Accident Prosthetics and Orthotics Centre, 1-10-5 Komei,
Minatoku, Nagoya 455, Japan

The lower limb amputee has lost all of the functions of (1) weight bearing, (2) skin sensation, (3) afferent sensory nerves and (4) the driving torque of the lost joint. Conventional prosthesis supplies only weight bearing.

From the viewpoint of a man-machine system, (2) and (3) can be provided by information transmission as sensory feedback via tactile display, applying engineering technology, and (4) by externally powered prosthesis. Sensory feedback can, by itself, recover muscular coordination of the stump and improve activity, without using external power.

For these reasons, we have developed a foot-sole pressure sensory feedback system applying fluidic technology that can handle both information and energy for stimulation with a very simple and compact circuit. Each pressure of the heel, small and large ball is detected with a small rubber pouch installed in the prosthetic foot, and is translated to the vibration frequency of gas pressure through a fluidic circuit, for cutaneous tactile display.

With this device, a closed loop control system is constructed between the amputee and the artificial leg. The extent of the improvement of control was tested experimentally by postural sway in standing with and without external disturbance. From the statistical analysis of the ZMP sway data, it was proved that control should be improved with this device.

Development of Sensor Pegboard for Performance Test

By Y. OKADA and K. NORO

University of Occupational and Environmental Health, 1-1 Iseigaoka,
Yahata Nishi-ku, Kitakyushu 807, Japan

An objective estimation of the working ability of the disabled, necessary for their return to social life, is one of the consecutive studies which are being carried out on rehabilitation in the health care system.

As an independent ADL (activities of daily living) is essential to the recovery of an individual life without help, so an independence in the working environment is a requirement for an independent social life. The true object of health care is to make the disabled able to join social activities.

To promote the employment of the disabled, it is essential to estimate accurately their individual ability, judge their individual aptitude and prepare a training programme aimed at the utmost development of their latent possibilities. Ultimately it is important to find suitable jobs for them.

In order to evaluate the working ability of the disabled, a computerized pegboard was made for the purpose of a synthetic evaluation of their ability of motion, perception and judgement, and a training evaluation programme was prepared. It was applied to more than 10 cases of cerebral apoplexy and revealed that there is a difference between the cases with each test, and that an improvement of working efficiency is recognized with each test, etc.

A comparison between the measured values and the standard time, an estimate of each individual's ultimate working efficiency achieved and each person's adaptability to the industrial environment were also examined.

The evaluation method of working ability is, in principle, applicable to various types of disabled persons and also those of advanced age. This method is effective for an objective estimation of the synthetic abilities of the man-machine system, such as artificial hands.

A Trial of Introducing a Game Factor into Rehabilitation Training

By N. OHNISHI, K. TSUCHIYA, F. ITO and S. NAGAI

The Labour Accident Prosthetics and Orthotics Centre, 1-10-5 Komei,
Minatoku, Nagoya 455, Japan

A new balance training method with a game factor has been developed to enhance a patient's motivation towards rehabilitation training applying the block break game popularized as a TV game. The device consists of two force plates, a microcomputer and a CRT display.

A racket of the game moves right or left in a display in proportion to the difference between the vertical floor reaction force detected by each force plate. A patient stands upright placing each foot on each plate separately. He shifts his body right or left to control the racket position so as to reflect a ball, breaks piled blocks and trains hard to compete for a higher score.

The effects of introducing a game factor have been investigated by using a semantic differential table. As a result of principal component analysis, patients' subjective impressions can be summarized with three components, that is, 'dislike', 'variety' and 'non-fullness'. The degree of 'dislike' feeling depends on whether a patient knows about TV games or not and the degree of 'fullness' becomes a high value in the case of patients who have never played TV games.

This training method seems to enable a patient to re-obtain postural control and to give him relaxation and entertainment, too.

Tactile Letter Display for a Reading Aid

By Y. SHIMIZU

Industrial Products Research Institute, 1-4-4 Higashi, Yatabemachi, Tsukugagun, Ibaraki 305, Japan

Up to now, many reading machines developed for the blind use tactile sense. Unfortunately, their performance is poor because of their display mode. They mostly employ a static mode, in which all elements defining a letter are simultaneously turned on and off, or a scanned mode, in which a letter moves across a tactile display.

To raise recognition accuracy, we introduced a drawing mode in which a letter was displayed in handwriting order (1977). Furthermore, to overcome the shortage of long display time on the drawing mode we proposed an apparent motion mode in which a stroke of a letter was presented according to the perception of apparent movement phenomena (1981).

In the present conference, three display modes were examined to assess the effect of the apparent motion mode upon tactile letter recognition; (i) static (poor in spatial resolution), (ii) each stroke element of a letter was displayed simultaneously (good in spatial resolution) and (iii) apparent motion mode (moving sensation).

Results show that spatial resolution is affected by tactile recognition, furthermore the moving sensation is still effective in raising recognition accuracy.

Development of a Transfer System for the Severely Handicapped

By K. ICHIKAWA

Tokyo Metropolitan Prosthetic and Orthotic Research Institute, 3-17-3 Toyama, Shinjuku, Tokyo, Japan

A new transfer system for the severely handicapped has been developed. In this system, lifting and travelling are externally powered with electric motors and an electro-magnetic powered clutch mechanism is used as the lifting power transmission. The transmitting torque through the clutch is proportional to the quantity of current supplied to the electro-magnetic power. Using such a clutch mechanism, the transfer system can lift the load (patient) up and down very smoothly. Moreover, the torque for lifting is automatically balanced against the weight of the load. Therefore, when a helper lifts the patient up and down using this system, he can perform the task under a state of non-gravitation, as it were.

We set up the transfer system at a patient's home, and contrived the operation switches, hanger and slings for him to be able to use them for himself. As a result, he became able to transfer himself from bed to wheelchair and vice versa without help. In addition, he can put on and take off his trousers and underpants alone using this transfer system and some self-help devices.

Workload of Disabled People at a Small Factory

By T. HASEGAWA and K. NORO

University of Occupational and Environmental Health, Yahatanishi-ku, Kitakyushu 807, Japan

To plan employment suitable for disabled people, it is necessary to know their actual work status and workload. This paper reports on a study conducted to determine whether working time and rest distribution for sound people works equally well for disabled people.

A study was carried out for 1 week each in July and October, 1981, to establish the actual workload of disabled people working at a factory where many disabled people are employed.

The author questioned the disabled workers about their work, investigated and rated their subjective symptoms of fatigue and measured their critical flicker fusion frequency and near-point accommodation.

The disabled workers made characteristic fatigue complaints corresponding to the type of disability, and their differences in critical flicker fusion frequency depended more on the type of job than on the type of disability.

The correlations among these items of measurement, type of job and type of disability were examined.

A 14. Older People

Measurement of the Older Worker's Capability

By Y. YOKOMIZO

Department of Industrial Engineering, School of Science and Engineering,
Waseda University, Tokyo, Japan

The following test methods are discussed in this paper: MODAPTS assessment test, workability test and Micro-TOWER test.

It results that the older worker's inferior phenomenon become less in order at arm, forearm, hand and finger as he becomes older, concerning the physical capability and becomes also less at the elaborate work than the rough one.

It also results that the capability which he is able to decide lots of affairs in a moment with mental capabilities and his sight becomes remarkably lower.

As compared the clerical employees with the physical labourers, it is found out that the former is superior to the latter in the capability, however, the capability of physical function is similar to the both when he is more than about 70 years old.

Otherwise, it is examined to compare the young worker with the old worker in the business condition of the insurance agent.

A Study of Procedure of Job Redesign for Older Workers

By M. NAGAMACHI

Hiroshima University, 1-12-42, Aga-kita, Kure, Hiroshima 737, Japan

This paper is concerned with developing a research method of the older worker's ability and with developing job redesign points for them in order to activate their ability in working.

A research method is developed by the rearrangement of time study, in which the measures of older worker's sensitivity, judgement ability, muscle strength and skills are recorded. Those data are analysed in terms of cluster analysis which are able to be divided into several clusters due to their distances in Euclid space.

These clusters are arranged by age and age characteristics, and then we can obtain a job hierarchy according to the worker's age.

A 15. Human Factors—Concept, Method and Prospect

Human Factors in Organizational Design and Management

By H. W. HENDRICK

849 Hahaione Street, Honolulu, Hawaii 96825, U.S.A.

For the past 2 years the United States Human Factors Society Committee on Professional Planning has been studying emerging areas for human factors application during the next two decades. One area which was identified and researched was that of human factors in managerial and organizational systems. One outcome of the committee's efforts in this area was the formation of a new Technical Group within the Human Factors Society on Organizational Design and Management. The proposed paper presents the findings of the Professional Planning Committee by the author, who served as the committee's professional specialist in the management and organizational design area, and who currently chairs the new Technical Group on Organizational Design and Management.

The paper systematically discusses four major forces which are increasingly both the need and demand for the human factors specialist in the design of organizational and managerial systems. These are new technology, work force changes (both demographic and psychosocial), increasing public awareness of human factors and its importance and economic, regulatory and productivity pressures. In addition, the paper highlights the five specific areas of human factors research and application, identified by the new Technical Group, which need attention and development to meet this emerging challenge. Implicit in these identified areas are the various roles that human factors specialists can perform in meeting the needs within the organizational design and management area. The paper points these out and discusses each role in turn.

Ergonomics, Has It Specific Laws?

By P. BURLOUI

Academy for Economic Studies, Bucharest I, 71262-strasse Popa Savu 46, Romania

The monodisciplinary training of specialists has determinedly held back those who wish to elaborate interdisciplinary ergonomical researches. The overwhelming majority of researches presented at international congresses consist of monodisciplinary researches. *Monodisciplinary is, in fact, the negation of ergonomics, one danger of death for ergonomics.*

The dispersion of researchers in monodisciplinary researches, proves the absence of one binder which can oblige them to an interdisciplinary co-operation. *We think that this binder must be theoretical, under the form of any objective laws specific to ergonomics.*

Those laws should contribute to the raising to a higher step of the theoretical-scientific level of the ergonomics.

One objective law expresses the compulsory conditions under which it can repeat the phenomenon in nature and society. If the appearance of ergonomics has stemmed from the necessity to realize interdisciplinary researches, it cannot exist but in the condition of interdisciplinarity. *Interdisciplinarity seems to us, then, the condition of the existence of ergonomics, its fundamental law.*

The 'Circle for the study of ergonomics' in the Academy for Economic Studies at Bucharest militates in favour of the promotion of ergonomical interdisciplinary researches.

Ergonomics, through the achievement of equilibrium between physiological and psychological requirements and the human body, brings its important contribution to the raising of the quality of life, which finally materializes in the prolongation of the mean duration of life.

Ergonomics is against the idea of the reproduction of labour force from one generation to another, because this idea is old and reflects indifference for man, who can be replaced easily by another man after his exhaustion. Ergonomics militates for *the reproduction of the labour force from one day to another*. This reproduction can be considered not only as a main objective of ergonomics, but also as *its second objective law*.

We hope that the two laws stated above will stimulate the thinking of specialists in the direction of consolidation of the theoretical basis of ergonomics.

Ergonomic Aspects of New Technologies

By K. J. ZINK

Universität Kaiserslautern, Postfach 30 49, D-6750 Kaiserslautern

Because of the growing use of electronics and shorter innovation periods in production and administration, technological modifications have a significant meaning for ergonomics. A relevant

engagement with new technologies cannot be limited to a narrow ergonomics formulation of questions, there must be some degree of socio-technological approach as well.

The following aspects must be taken into consideration:

- Ergonomics design parameters, in a narrow sense.* First of all, traditional approaches in designing hardware are required. However, adequate design of software is becoming more important in the sense of system characteristics such as the ability for self-explanation, self-control, acquisition, etc.
- Design parameters of the work organization, especially work itself.* The consequences of new technologies on the content of work or work organization must be examined and (if necessary, in the planning stage of work systems), have to be taken into consideration by preventive design parameters, such as job enlargement, job enrichment, job rotation (in the sense of mixed work places).
- Constancy of technical framework.* Nature and volume of design parameters are essentially influenced by innovation periods for improved technologies.
- Different levels of economic results.* The possibility of practical use of ergonomic concepts (in connection with new technologies) is influenced by economic characteristics. It is important to carry out workplace-related calculations besides worksystem-related calculations in order to recognize problems of interdependence which, for example, result from an automation of partial functions.
- Employment effects on the individual level.* The result of these considerations is (from the point of view of ergonomics) the need for an early recognition of qualifications and the requirements of adequate trainee concepts.

The different aspects are discussed by examples.

Cost-effectiveness of Ergonomics: Elusive Data and an Exchange Heuristic

By R. A. BENEL

Essex Corporation, Alexandria, Virginia 22314, U.S.A.

Ergonomics, specifically human factors engineering (HFE), is a critical part of the design process. Failure to follow ergonomic guidelines for the development of the man-machine interface will result in systems which have lower than optimal performance. When systems are not being operated properly by the available personnel, one possible response by managers is that the level of training for those personnel is inadequate. Therefore, a belief develops that a 'well-designed' system is staffed with unskilled and untrained operators. The generally proposed solution to this problem is enhanced training. This belief is likely to be true in some cases; however, a large number of systems have been found to be seriously deficient in design for operability. One routinely proposed solution during system development is to allow training to overcome any residual deficiencies in design.

The implications of this strategy will be described graphically. The hypothetical relationship between operability and training, and operability and HFE application will be shown. This simplified depiction will show that within broad limits it is possible to exchange HFE costs for training costs. (Of course, a modicum of each is absolutely necessary under nearly all circumstances.) Under various combinations of training and HFE outlays a given level of operability is possible (iso-operability functions). Although these functions may have no differential impact on decisions to field a system because the cost outlay would be constant for the initial operation, the implications for life-cycle costs are considerable. HFE expenditures are maximal during development but, HFE expenditures do not increase cumulatively. However, training costs are both high during development and constantly increasing. Any modernization would cause a sharp increase in training costs for new instructional technologies and would also cause an additional HFE expenditure. The critical factor is that training costs increase cumulatively throughout the life cycle and each case of attrition is an example of training costs lost. Proper application of HFE can be effective cost-avoidance strategy. Supporting evidence will be presented.

Applied Psychology and Ergonomics

By W. SINGLETON

Applied Psychology Department, University of Aston in Birmingham, Birmingham B4 7ET, England

The International Association of Applied Psychology holds its triennial congress in Edinburgh in July, 1982. At this meeting Ergonomics is one of seven major topics, the others are: Clinical/Physiological Psychology, Counselling/Psychometrics, Education Psychology, Applied Social Psychology, Industrial/Organizational Psychology and Environmental Psychology.

In order to maintain a separate identity for Ergonomics clearly distinct from the other topics it was necessary to make certain assumptions. Firstly, that the core of psychological aspects of Ergonomics is 'information processing' based on academic knowledge from experimental psychology and cognitive psychology and a practical or field-based knowledge based on the analysis of informational aspects of real tasks. Secondly, that there are bound to be a number of overlapping fields of interest: training and 'quality of working life' aspects are shared with industrial/organizational psychology, environmental issues and community aspects are shared with environmental psychology, there are other overlaps with physiological psychology, e.g. properties of sensory systems and applied social psychology such as sport/leisure activities. Thirdly, there are some all-pervasive issues common to the whole of applied psychology and ergonomics such as stress assessment, cross-cultural differences and professional/legal issues. Fourthly, applied psychology and ergonomics have the same range of objectives roughly divisible into those concerned with efficient performance (productivity, quality, reliability) and those concerned with health (minimization of accidents, stress diseases and optimization of quality of working life).

Chronopsychological Approach to Human Factors

By P. NAITOH

Naval Research Health Center, Environmental Physiology Department,
P.O. Box 85122, San Diego, California 92318, U.S.A.

Chronopsychology is a science to study time structure of psychological functions, including rhythmic oscillation of their efficiency over a time span, especially over a 24-hour period (circadian). Psychological functions, such as memorization, complex additions, encoding/decoding, motor response speed and vigilance, have been known to show circadian rhythms. However, only recently an importance of determining time structure of human psychological functions has been realized by researchers who investigate occupations requiring shift and night work. The purpose of this paper is to review and summarize for ergonomists some of the findings of the recent works on chronopsychology. Reviews will be based on such works as (1) P. Colquhoun's (1981) 'Rhythms in performance' in *Handbook of Behavioural Neurobiology*, (Plenum); (2) K. E. Klein and H. M. Wegmann's (1980) 'Significance of circadian rhythms in aerospace operations' as AGARDograph No. 247; (3) P. Naitoh's (1982) 'Chronobiologic approach for optimizing human performance' in *Rhythmic Aspects of Behavior* (Lawrence Erlbaum) and others. The summarization will not only serve to emphasize an importance of ergonomic measurements taken during the night and early morning, but also suggest more extensive use of autorhythmometric (i.e. do-it-yourself) measurements to examine men and women at their routine work in factory, office and school. As a pointer for the future, a discussion is presented to show how a chronopsychologist could create through time management of a sleep/wakefulness cycle a sustained performance at any time of the day and night. Emphasis is placed on the fact that some aspects of circadian rhythms could be manipulated for the benefit of society or of an individual.

Combined Use of an Ergonomic Checklist and Complaint Rating as a Means of Identifying Problems

By K. SAKAI and K. KOGI

Institute for Science of Labour, 1544 Sugao, Takatsu-ku, Kawasaki 213, Japan

We have developed a corrective checklist by which a checker selects suitable corrective measures from given items. These lists can be used by both specialists and workers to screen out ergonomic problems. Two checklists were provided, one with 216 items for a driving cab and another with 120 items for physically heavy work. In applying each of these checklists, we combined it with the use of self-rating of complaints by workers in the form of the five-point scale. The results by the checklists and those by the complaint rating were compared. Both methods proved useful in pointing out major problems such as those related to space dimensions, working surface height, materials handling, displays, holding work, chairs or floor, rest breaks, etc. The checklists were favourable in pointing out problems of man-machine interfaces and facilities, especially when used by specialists, whereas the complaint rating could more explicitly point out problems of postural or environmental discomfort and problems of unusual situations and long-hour effects. To know the priority problems of workplaces, the combined use of an ergonomic checklist and complaint rating, which should involve both ergonomists and workers themselves, is recommended.

Pluralistic Treatment in the System Research of Ergonomics

By T. MAREK, R. MICHAŁEK and C. NOWOROL
ul. Komandosów 9/45, 30-334 Kraków, Poland

The aim of this paper is the description of the new methodological treatment in the system research of ergonomics.

Check-lists of various kinds are still the basis of the ergonomic system research on work space. The reliable analysis of work space based on check-lists needs the co-operation of specialists of various disciplines. It needs applicable methods, e.g. workload measures, time and motion study, measurements of environmental conditions of work, etc. The existing treatment in the system research of ergonomics is monistic as a result of the research procedure of using check-lists.

More effective pluralistic treatment in ergonomic system researches seems to be possible only when based on the full subjectivization of check-lists. It decreases the accuracy of the investigation but allows examination of a great number of work spaces in a short period of time and the achievement of statistically significant conclusions. It seems that there are two ways of subjectivization of check-lists.

According to the first method, check-lists are based on questions appertaining to subjective opinions of ergonomic inconveniences. These may be questions such as, e.g. in your opinion, is the intensity of lateral illumination right or not?

The second method bases the check-lists on subjectively-felt psychosomatic symptoms of workload and fatigue because of ergonomic inconveniences. The basic investigation technique is anamnesis.

These subjective check-lists may be treated as objective scientific methods after the designation of their statistical accuracy and reliability.

The Department of Psychology of Jagiellonian University and the Department of Mechanization and Energy of the Agriculture Academy in Kraków have constructed a subjective check-list of the symptoms of workload for operators of agrimotors. This list is based on the latter of the above investigation methods.

Check-lists of these kinds are mainly useful for initial investigations of workload.

The Third Dimension—Computer Modelling for Ergonomics

By E. KINGSLEY

Compeda House, Walkern Road, Stevenage SG1 3QP, England

One of the most common complaints made by ergonomists is that they are not consulted early enough in the design process for their contribution to be really effective. Looking at the reasons for this it becomes apparent that ergonomics evaluation methods are primarily suited to three-dimensional assessments. Thus evaluations based on two-dimensional drawings are rarely as effective as assessments of three-dimensional prototypes and mock-ups.

What the ergonomist requires is a means of carrying out three-dimensional assessments at a stage in the design process when the design ideas only consist of two-dimensional drawings. The most effective, flexible and powerful means of doing this is to build three-dimensional computerized models of the equipment or workplaces and to evaluate these in terms of ergonomics.

SAMMIE (a computer program called System for Aiding Man-Machine Interaction Evaluation) has been developed with just that aim in mind. It provides the ergonomist/designer with the ability to visualize and even walk through realistic approximations to the real workplace and to evaluate the design using SAMMIE's main feature, namely its computerized fully variable man-model.

SAMMIE helps the user assess the man-model's reach capability, visual field, access to the workplace and fit within it. The user can also model the reflections in mirrors, quantify obscured areas and remove 'hidden lines' to create realistic 'clean' views.

SAMMIE has already been used in a wide range of applications including transportation (e.g. bus, aircraft, spacecraft), materials handling (e.g. fork lift truck, straddle carrier), manufacturing applications (e.g. assembly jigs, assembly workstations) and interiors (e.g. office control room, kitchen). This paper discusses the facilities and benefits available in SAMMIE with reference to many of these studies. The scope for future applications and the general implications of CAD methods for ergonomists are also briefly described.

An Application of Decision Data Tables Method in Ergonomic Research

By L. PACHOLSKI and B. MATEJA

Politechnika Poznańska, Instytut Organizacji i Zarządzania, ul. Strzelecka 11, 60-965 Poznań, Poland

Treating factual interdisciplinarity as an ideal solution, we nowadays accept quasi-interdisciplinary models of complex ergonomic activities. Searching optimum solutions within such types of models, the

authors of the article suggest the domination of technological and organizing sciences in contemporary industrial ergonomics.

A kind of paradox in terminology consists in the fact that ergonomics, which is humanistic in the subjective sense, should, in the methodological field, make use of technocentric lines of approach, i.e. those referring to measurable elements and to methods applied in engineering.

On the above assumptions the authors present a conception of decision data tables method as an element of ergonomic methodology. The ergonomic complex evaluation of the system, obtained by means of decision data tables, determines the main direction of research and specialistic activities which are monodisciplinary and performed within detailed activities. Monodisciplinary and system-like activities, in the objective sense, are sequential in the whole range of ergonomic problems.

A Systematic Ergonomics Design Procedure

By J.-H. KIRCHNER

Technische Universität Braunschweig Fachgebiet Arbeitswissenschaft,
Postfach 33 29, D-3300 Braunschweig, F.R. Germany

The systematic ergonomics design procedure (SEDP) is based on an ergonomic analysis of the relations between the product to be designed and its user, in order to derive ergonomic requirements and product elements which can influence them. The SEDP consists of a logical plan, which is coupled to the general design procedure for technical products, and lists/catalogues of design elements with their characteristics as support.

- (1) General ergonomic requirements—as wanted or unwanted effects of the product or system—are derived from the task and the system environment.
- (2) Human functions in/for/with the product or system are specified by function allocation and completed by functions for the user himself in the system (e.g. getting/staying in the system). These human functions are broken up into fundamental functions like perceiving, discriminating, etc., each in its special situation.
- (3) Special ergonomic requirements—requirements in their original sense as wanted or unwanted effects of the technical product and its environment to the user, including support for performing the human functions, and/or to other men outside the system—are derived from the human functions and from the general ergonomic requirements. This list of requirements has to be added with the advancing design process.
- (4) The corresponding product elements which are to be specified in the design process can then be found by lists of relations of their properties and possible ergonomic effects. This implies general and specific ergonomic knowledge which may be prepared in adequate catalogues as design instructions (e.g. for displays, controls, etc.).
- (5) In determining the attributes of the properties of the product elements the reciprocal relations and influences have to be regarded. These problems are solved by weighing the force of the influence or its importance for the whole system.
- (6) The result or alternatives can be evaluated with respect to the defined requirements. A prototype of the manufactured product may be checked and tested to see how well it fulfils the requirements. Therefore measurable indicators can be defined with respect to the requirements.

The procedure will be explained by the ergonomic analysis of a fork lift truck as an example.

A 16. Potpourri A

Quantitative Behaviour of Intraocular Ascorbic Acid upon Hypermetropic Amplitude in Overstraining of Fictitious High Altitude

By M. CARAPANEA

21 Prof.I.Bogdan Street, R-71149 Bucharest 22, Socialist Republic of Romania

It is known that vitamin C constitutes, by its quantitative behaviour, an indicator of corticosuprarenal gland activity. The fact has been experimentally proved, being demonstrated that either the injection of ACTH in rats, or the transplantation of the anterior hypophysis in the anterior chamber of the eye, which leads to the secretion of ACTH after a certain supersolicitation, augments the secretion of corticosteroids, together with the evident reduction of ascorbic acid and cholesterol in the corticosuprarenal gland.

In its turn, high altitude supersolicitation also augments the secretion of corticosteroids together with the reduction of ascorbic acid, a fact demonstrated by myself at the level of the aqueous humour, in experimental investigations in hypermetropic rabbits.

Thus, the dosage of vitamin C from the aqueous humour, in parallel with the measurements of the hypermetropic accommodation have shown that—as against the normal figure of intraocular vitamin C an as against the normal number of diopters—intravenous injection of the substance at soil augmented twofold the intraocular concentration and increased the hypermetropy with +1 d. But after intravenous administration at soil of the substance, the exposition at the fictitious high altitude, markedly reduced the intraocular concentration of vitamin C and maintains the hypermetropy practically unchanged.

It results that only a twofold excess, as against the normal one of vitamin C in the aqueous humour, determines the augmentation of hypermetropic accommodation, which prolongs itself unmodified also during the duration of the reduction of the vitamin C concentration, provoked by the homeostatic augmentation of corticosteroids at high altitude, which imposes the administration of vitamin C to organisms submitted to high altitudes, as a necessity against immediate ascorbic deficiency, for maintaining an augmented tonus of the ciliary muscle.

A Consideration on the Classification of Two-dimensional Displayed Patterns of EEG

By H. TAKEDA

Department of Mechatronics and Information Science Center, Osaka Electro-Communication University,
18-8, Hatsu-cho, Neyagawa, Osaka 572, Japan

Y. TAKASHIMA

Junior College of Engineering, University of Osaka Prefecture, Katsuyama, Ikuno-ku, Osaka 544, Japan

Y. IKEDA and S. HATA

Department of Electronics, University of Osaka Prefecture, 4-804, Mozu-Umemachi, Saki 591, Japan

In an earlier paper, the authors reported on the real time frequency detector, which converts the frequency of EEG to the corresponding voltage by use of a PLL (Phase Locked Loop) circuit, and the micro-computerized two-dimensional display system for EEG amplitude versus its frequency, which classifies a set of specific patterns of displayed data by the use of simple image processing techniques. Namely, the procedure is (1) divide the two-dimensional plane into $m \times n$ segments, (2) count the number of frequency-amplitude pairs in each segment, (3) construct a characteristic pattern by putting together the segments which have more than T (T is a threshold number of counts), (4) make a characteristic vector out of the above pattern, (5) repeat j times from (1)-(4) for j subjects, (6) compute the similarity matrix which is constructed from the characteristic vectors and (7) analyse the similarity matrix by cluster analysis.

In the above process, the choice of the size of each segment and threshold T is not clear. In this report, the size of each segment and value of T are experimentally investigated, to obtain satisfactory results on classification. Consequently, in a case where the total numbers of sampled data on the two-dimensional plane were 1600, the following results were obtained: (1) the size of each segment should be less than $0.5 \text{ Hz} \times 4 \mu\text{V}$ and (2) threshold T should be 5-10.

A Comparison of Exponential and Hyperbolic Functions Describing Learning Curves in the Literatures of Psychology and Industrial Engineering

By S. LIPPERT

Department of Industrial Engineering and Operations Research, University of Massachusetts,
Amherst, Massachusetts, U.S.A.

A branch of the hyperbolic function describing a descending hyperbola in the first quadrant in its general form is

$$Y = AX^{-1} + B$$

for distributed practice learning where A is the time above the asymptote on a hypothetical first trial, X is the trial number or day of production and B is the asymptotic value of the performance measure. The value of AX^{-1} can be expressed as $A(1/1, 1/2, 1/3, \dots, 1/n)$ for the successive trials beginning with a hypothetical first trial, when n equals 1. This description of AX^{-1} is possible after a correction parameter, C , has been set equal to zero to give all individuals a common starting point on the learning curve. It is possible to compute a correction term for exponential fits similar to C .

authors of the article suggest the domination of technological and organizing sciences in contemporary industrial ergonomics.

A kind of paradox in terminology consists in the fact that ergonomics, which is humanistic in the subjective sense, should, in the methodological field, make use of technocentric lines of approach, i.e. those referring to measurable elements and to methods applied in engineering.

On the above assumptions the authors present a conception of decision data tables method as an element of ergonomic methodology. The ergonomic complex evaluation of the system, obtained by means of decision data tables, determines the main direction of research and specialistic activities which are monodisciplinary and performed within detailed activities. Monodisciplinary and system-like activities, in the objective sense, are sequential in the whole range of ergonomic problems.

A Systematic Ergonomics Design Procedure

By J.-H. KIRCHNER

Technische Universität Braunschweig Fachgebiet Arbeitswissenschaft,
Postfach 33 29, D-3300 Braunschweig, F.R. Germany

The systematic ergonomics design procedure (SEDP) is based on an ergonomic analysis of the relations between the product to be designed and its user, in order to derive ergonomic requirements and product elements which can influence them. The SEDP consists of a logical plan, which is coupled to the general design procedure for technical products, and lists/catalogues of design elements with their characteristics as support.

- (1) General ergonomic requirements—as wanted or unwanted effects of the product or system—are derived from the task and the system environment.
- (2) Human functions in/for/with the product or system are specified by function allocation and completed by functions for the user himself in the system (e.g. getting/staying in the system). These human functions are broken up into fundamental functions like perceiving, discriminating, etc., each in its special situation.
- (3) Special ergonomic requirements—requirements in their original sense as wanted or unwanted effects of the technical product and its environment to the user, including support for performing the human functions, and/or to other men outside the system—are derived from the human functions and from the general ergonomic requirements. This list of requirements has to be added with the advancing design process.
- (4) The corresponding product elements which are to be specified in the design process can then be found by lists of relations of their properties and possible ergonomic effects. This implies general and specific ergonomic knowledge which may be prepared in adequate catalogues as design instructions (e.g. for displays, controls, etc.).
- (5) In determining the attributes of the properties of the product elements the reciprocal relations and influences have to be regarded. These problems are solved by weighing the force of the influence or its importance for the whole system.
- (6) The result or alternatives can be evaluated with respect to the defined requirements. A prototype of the manufactured product may be checked and tested to see how well it fulfils the requirements. Therefore measurable indicators can be defined with respect to the requirements.

The procedure will be explained by the ergonomic analysis of a fork lift truck as an example.

A 16. Potpourri A

Quantitative Behaviour of Intraocular Ascorbic Acid upon Hypermetropic Amplitude in Overstraining of Fictitious High Altitude

By M. CARAPANEA

21 Prof.I.Bogdan Street, R-71149 Bucharest 22, Socialist Republic of Romania

It is known that vitamin C constitutes, by its quantitative behaviour, an indicator of corticosuprarenal gland activity. The fact has been experimentally proved, being demonstrated that either the injection of ACTH in rats, or the transplantation of the anterior hypophysis in the anterior chamber of the eye, which leads to the secretion of ACTH after a certain supersolicitation, augments the secretion of corticosteroids, together with the evident reduction of ascorbic acid and cholesterol in the corticosuprarenal gland.

In its turn, high altitude supersolicitation also augments the secretion of corticosteroids together with the reduction of ascorbic acid, a fact demonstrated by myself at the level of the aqueous humour, in experimental investigations in hypermetropic rabbits.

Thus, the dosage of vitamin C from the aqueous humour, in parallel with the measurements of the hypermetropic accommodation have shown that—as against the normal figure of intraocular vitamin C an as against the normal number of diopters—intravenous injection of the substance at soil augmented twofold the intraocular concentration and increased the hypermetropy with +1 d. But after intravenous administration at soil of the substance, the exposition at the fictitious high altitude, markedly reduced the intraocular concentration of vitamin C and maintains the hypermetropy practically unchanged.

It results that only a twofold excess, as against the normal one of vitamin C in the aqueous humour, determines the augmentation of hypermetropic accommodation, which prolongs itself unmodified also during the duration of the reduction of the vitamin C concentration, provoked by the homeostatic augmentation of corticosteroids at high altitude, which imposes the administration of vitamin C to organisms submitted to high altitudes, as a necessity against immediate ascorbic deficiency, for maintaining an augmented tonus of the ciliary muscle.

A Consideration on the Classification of Two-dimensional Displayed Patterns of EEG

By H. TAKEDA

Department of Mechatronics and Information Science Center, Osaka Electro-Communication University,
18-8, Hatsu-cho, Neyagawa, Osaka 572, Japan

Y. TAKASHIMA

Junior College of Engineering, University of Osaka Prefecture, Katsuyama, Ikuno-ku, Osaka 544, Japan

Y. IKEDA and S. HATA

Department of Electronics, University of Osaka Prefecture, 4-804, Mozu-Umemachi, Saki 591, Japan

In an earlier paper, the authors reported on the real time frequency detector, which converts the frequency of EEG to the corresponding voltage by use of a PLL (Phase Locked Loop) circuit, and the micro-computerized two-dimensional display system for EEG amplitude versus its frequency, which classifies a set of specific patterns of displayed data by the use of simple image processing techniques. Namely, the procedure is (1) divide the two-dimensional plane into $m \times n$ segments, (2) count the number of frequency-amplitude pairs in each segment, (3) construct a characteristic pattern by putting together the segments which have more than T (T is a threshold number of counts), (4) make a characteristic vector out of the above pattern, (5) repeat j times from (1)-(4) for j subjects, (6) compute the similarity matrix which is constructed from the characteristic vectors and (7) analyse the similarity matrix by cluster analysis.

In the above process, the choice of the size of each segment and threshold T is not clear. In this report, the size of each segment and value of T are experimentally investigated, to obtain satisfactory results on classification. Consequently, in a case where the total numbers of sampled data on the two-dimensional plane were 1600, the following results were obtained: (1) the size of each segment should be less than $0.5 \text{ Hz} \times 4 \mu\text{V}$ and (2) threshold T should be 5-10.

A Comparison of Exponential and Hyperbolic Functions Describing Learning Curves in the Literatures of Psychology and Industrial Engineering

By S. LIPPERT

Department of Industrial Engineering and Operations Research, University of Massachusetts,
Amherst, Massachusetts, U.S.A.

A branch of the hyperbolic function describing a descending hyperbola in the first quadrant in its general form is

$$Y = AX^{-1} + B$$

for distributed practice learning where A is the time above the asymptote on a hypothetical first trial, X is the trial number or day of production and B is the asymptotic value of the performance measure. The value of AX^{-1} can be expressed as $A(1/1, 1/2, 1/3, \dots, 1/n)$ for the successive trials beginning with a hypothetical first trial, when n equals 1. This description of AX^{-1} is possible after a correction parameter, C , has been set equal to zero to give all individuals a common starting point on the learning curve. It is possible to compute a correction term for exponential fits similar to C .

In terms of closeness of fit, there is little practical difference between exponential fits and hyperbolic fits. The hyperbolic fitting process demands rigor in the definition of trials. It does not incorporate the learning rate into the exponent, but provides it by the differentiation of AX^{-1} . It permits the averaging of the parameters A and B . It permits group scores of greater precision than those obtained from raw scores and leads to the use of representative group equations whose parameters can be used to make an index of difficulty for a given task and for comparisons between tasks.

Dynamics of Physical Fitness and Orthostatic Tolerability During Hypodynamics Exposure

By H. SAIKI, M. NAKAYA, M. SUDOH, M. ABE and K. SHIODA

Space Medicine Laboratory, The Jikei University, School of Medicine, Minato-ku, Tokyo 105, Japan

Studies on orthostatic tolerance during hypodynamics exposure seem to be significant in connection with clinical treatment in gerontology, valetudinarian medicine, space medicine and physical fitness sciences.

In this report, using the scores of male human subjects of various physical fitness levels, fluctuations of their physical fitness levels and physiological and biochemical functions were measured in many parameters. The effects of 6 hours thermal neutral water immersion exposure on the previously mentioned functions and orthostatic tolerability of the subjects were compared, in cases of different kinds and levels of training.

The main results obtained were as follows. Before training, orthostatic tolerability before hypodynamics exposure increased, following the physical fitness levels, and the value after hypodynamics exposure decreased in all cases, but no differences were observed between the physical fitness levels. As a result of training an increase in physical fitness capacity was observed. An increase of orthostatic tolerability before hypodynamics exposure was noticed except in some athletes.

The urinary excretion of noradrenaline of non-athlete subjects before hypodynamics exposure increased following the increase in the level of physical fitness. Values were decreased with increased physical fitness made possible by physical training.

A strong decrease of the urinary excretion rate of noradrenaline after hypodynamics exposure was observed in non-athletes. But in some athletes, the decrease brought about by hypodynamic conditioning reveals a neuro hormonal mechanism detrimental for adaptation to hypodynamics.

Some findings on animal experiments related to the levels of physical fitness acquired through training are also discussed.

Effect of Physical Work on Rate of Dispersal of Bacteria in the Air from Man

By K. TERAYAMA, H. OHNO, F. HIRATA and T. KAWARABAYASHI

Department of Hygiene and Preventive Medicine, Asahikawa Medical College, 5 Go, 4 Sen, Nishikagura, Asahikawa 078-11, Japan.

In an indoor labour environment the bacteria-carrying particles dispersed from the bodies and clothing of workers are generally considered to be the main sources of bacterial contamination in the air. However, we have very few reports about quantitative estimations of dispersal of bacteria into the air from workers in relation to workload. In the present study the influences of physical work on the rate of dispersal of bacteria per person in a model room were demonstrated.

Variations in the number of airborne bacteria from healthy volunteers in a poorly ventilated model laboratory (20.3 m^3), previously sterilized, were investigated under two conditions; at rest and during physical exercise. Four subjects kept quiet for 2 hours and two subjects alternately worked on a bicycle ergometer (Monark, Sweden) with a load of 100 W for 10 min during a period of 2 hours and two subjects alternatively worked on a bicycle ergometer (Monark, Sweden) with a load of 100 W for 10 min during a period of 2 hours in the model laboratory, respectively. Airborne bacteria-carrying particles were sampled using an Anderson sampler, an M/G air sampler and a pin-hole sampler. The number of colony forming units (c.f.u.) obtained during physical exercise (mean: 26.1 c.f.u./ft^3) greatly exceeded that at rest (mean: 15.5 c.f.u./ft^3). The equilibrium concentration of airborne bacteria in a room was given by the equation $Ne = nB/K$; n is the number of persons, B is the rate of dispersal of bacteria per person and K is the die-away rate. The die-away rate K was obtained as 3.0/hour both at rest and during physical exercise by examining the removal of bacteria from the air after the subjects left the room. Therefore, the rates of dispersal of bacteria per person (B) during physical exercise (468/min) showed a marked increase compared with those at rest (139/min).

These results suggested that physical work effects the rate of dispersal of bacteria into the air from the bodies and clothing of workers and airborne bacteria provides a reliable index of sanitary conditions in an indoor labour environment.

An Experimental Study on Human Behaviour Under a Suddenly Hazardous Situation

By W. MASADA

Department of Psychology, Rikkyo University, 16-29 Fujimidai 4 chome, Nerimaku, Tokyo 177, Japan

Problem: Today we are exposed to various kinds of dangers in our lives which we have never thought of; for instance, walking along a street we may encounter an unfortunate accident or dangerous materials like an iron bar falling down to the ground. There are many latent hazards around us.

Purpose:

- (1) Is it possible or impossible for us to step out against a suddenly hazardous situation?
- (2) Are there certain tendencies in the direction of stepping out and behaviour of stepping out or not?

Experimental method: Subjects stood beside the outer wall of the psychological laboratory and they received the following instruction: 'We are going to carry out an experiment about the balance of the posture. As we take a picture of you, take the normal standing posture and keep your posture until you get a sign.' We confirmed the normal standing posture of subjects. We called each subject by name loudly from the small window on the third floor of the building which is 7 m above the heads of subjects. The very moment a subject noticed the call and turned his face upwards, a 30 cm black cubic sterol block was falling directly above the head of the subject. This block weighed 460 g and it fell with a velocity of 1 or 2 s. It was hanging on the end of a cord.

Results:

- (1) Although subjects stepped out promptly from the danger facing them, there were very few subjects who could step out completely from the danger.
- (2) They protected the important part of their bodies, their heads, by bending their arms and bodies.
- (3) Most subjects could not move and became deadlocked by stiffening bodies!

B. HUMAN FACTORS IN INDUSTRY

B 1. Shift Work

Subsidiary Behaviours of Bottle Inspection Workers in a Three Shift System

By K. KISHIDA, M. SAITO and T. HASEGAWA

Takasaki City University of Economics, 277 Yono, Yono City, Saitama Prefecture 338, Japan

This research was carried out to see the relationship among subsidiary behaviour, performance and physiological functions in glass bottle inspection. The investigation was made in a bottle manufacturing plant in Gifu prefecture, Japan, in 1980. Inspection speeds tested were 120, 150, 190 and 200 bottles per minute. In bottle inspection, bottles containing even a slight foreign object or with even a minute defect are rejected. The working system of the plant is as follows: the first shift starts at 7.00 a.m. and ends at 3.00 p.m. the second shift is from 3.00 p.m. to 11.00 p.m. and the third shift is from 11.00 p.m. to 7.00 a.m. Working time of each shift is 8 hours. Mealtime recess is 20 min in each shift. The work cycle for bottle inspection is a combination of 50 min bottle inspection and, subsequently, 10 min recess. The investigation was made for 6 days using the same six male inspectors. Hourly variation of CFF, rejection rate of defective bottles and occurrence rate of subsidiary behaviour were observed in this investigation. Subjective fatigue symptoms were surveyed before and after work in each shift.

There was no correlation between CFF level and rejection rate of defective bottles in the first and the second shift, but in the third shift, there was a significant correlation between the two items. The correlation coefficient was 0.54. Subsidiary behaviour, such as yawning and moving their bodies, increased, especially in the third shift. Subsidiary behaviour is considered to be a compensatory motion, the occurrence of which was related to a low level of the inspector's consciousness during bottle inspection. It is considered that subsidiary behaviour is an escape from monotony and is required as a stimulus which may relieve the feeling of monotony.

A Case Study on Work Burden of Shift Workers

By T. KONDO, T. OKUBO, M. AOKI and Y. HORIE

The College of Industrial Engineering and Management, Nihon University,
1-2-1, Izumi-cho, Narashino, Chiba, Japan

Adoption of a shift system is apparently indispensable to streamline ever-changing modern social activities, especially those engaged in public services, or those engaged in a conveyor system. Laboratorial research, for example, of diurnal variations in fatigue of shift workers engaged in security, is aimed at presenting various reactions or responses in physical, physiological or psychological aspects by providing some fundamental solutions to the problem arising from shift work, especially a night-shift-work system. The survey was conducted on two male workers and the items measured in this research were heart rate, CFF, body weight, body temperature, subjective feeling of fatigue, simple reaction time, subsidiary behaviours, etc.

As a result, it was discovered that there are many disadvantages to the psycho-physiological aspects of the night-shift worker. The effects of such working conditions on their health cannot be ignored.

Changes in the Subjective Fatigue Scale Characteristic to the Post-night-shift Period

By K. KOGI

Institute for Science of Labour, 1544 Sugao, Takatsu-ku, Kawasaki 213, Japan

Fatigue symptoms characteristic to the post-night-shift period were discussed by analysing changes in the subjective fatigue scale (F scale) of the Japanese Industrial Fatigue Research Committee. The F scale consists of 30 items grouped into three components: drowsiness-dullness, difficulty in concentration and physical disintegration. Results from various groups of shift workers working both day and night shifts were studied. The mean frequency was significantly higher after a night shift than after a day shift for all three components. But, by examining the temporal pattern of changes in frequency, some symptoms were found to persist through the day-time following the end of a night shift and recover only after a night's sleep. These symptoms included general tiredness, difficulty in concentration and low back pain. The weight of symptoms of difficulty in concentration continued to be high throughout the post-night-shift period. The exhaustive feeling typical to the period is thus suggested to be based on decrease in activation and in capacity of keeping concentration. We should facilitate early recovery from this fatigue by avoiding successive night shifts.

Shift-work Research at the U.K. Medical Research Council Perceptual and Cognitive Performance Unit

By W. P. COLQUHOUN

Laboratory of Experimental Psychology, University of Sussex, Falmer,
Brighton BN1 9QG, Sussex, England

The programme of research at this unit includes three projects in the area of circadian rhythms related to shift work.

It has been found that these rhythms differ both in their basic phase, and in the rate at which this phase adjusts to an altered sleep-waking routine; thus it is becoming possible to predict not only what kinds of task will be most adversely affected by a switch to night shift, but also how rapidly the level of performance at a particular task will return to its 'day work' value over a series of consecutive night shifts. Such information will be of value for the design of optimal shift-working rotas for different jobs.

Certain characteristics of the normal rhythm in body temperature have been shown to be related to introversion and neuroticism, as have also the extent and duration of the disruption in this rhythm caused by phase-shifting of the sleep-waking cycle; thus the possibility of identifying those people whose bodily systems will be most (or least) affected during a given spell of night work (short-term adjustment) appears to exist.

A first version of this questionnaire, designed to predict the ease (or difficulty) with which people will achieve *long-term* adjustment to a shift-working situation, has already been shown to have concurrent validity for the adjustment of existing night workers; an improved version is now being tested, prior to its administration to groups of beginning shift workers, whose sickness, absenteeism and 'drop-out' rates will then be monitored over a number of years. Proof of the test's predictive validity would lead to the possibility of providing guidance to prospective entrants to shift-working industries.

Psychophysiological Effects of Shift Work in a Small-Medium Sized Factory

By M. KUMASHIRO, K. MIKAMI and K. SAITO

Department of Engineering Production, The University of Birmingham,
P.O. Box 363, Birmingham B15 2TT, England

In this project, the mental stress of machine operators working in a small-medium sized company was investigated. Despite the introduction of modern automated machines and accompanying technology, the company was managed in an old fashioned style. Seven shift workers were monitored while they worked under a complex shift system involving a rapid rotation of single days of 12 hours day work, 12 hours night work and rest followed by a period of four consecutive days of normal 9 hours day work.

Measures were recorded of the function of concentration maintenance (TAF), critical fusion frequency (CFF), body temperature rhythm and multiple choice reaction time. The work rate, posture and frequency of non-work activities were observed. Questionnaires were administered to the workers in order to establish their attitudes towards their job and management as well as to evaluate their subjective feelings of fatigue and state of health.

Results indicated that the circadian rhythm of body temperature remained normal during night work. However, measures of TAF and CFF were significantly reduced during night work compared with pre-work values. Equivalent differences were not significant for the day work periods. Compared with the day work values, workers adopted a sitting posture more frequently during night work and showed an increase in choice reaction time. Overall, the results indicated a significant decrease in psychophysiological function during night work compared with day work. Finally, compared with non-shift workers they were less favourably disposed towards their work and towards management and that they felt an increase in boredom, loneliness, irritation, anxiety and depression.

Critical Flicker Fusion and Grammatical Reasoning in the Evaluation of Shift Schedules

By B. PEACOCK and R. SCHLEGEL

School of Industrial Engineering, The University of Oklahoma,
202 West Boyd, Suite 124, Norman, Oklahoma 73019, U.S.A.

Critical flicker fusion and the Baddeley grammatical reasoning test were used in a comparison of the human responses to 8- and 12-hour shift schedules. Both measures had been shown by previous investigators to be sensitive to within-shift changes in performance, they are both relatively easy to administer and impose only minimal interference with the subjects' duties. In this investigation the tests were applied to 75 policemen at the beginning and end of each shift under each shift schedule. Observations of the 8-hour/12-day schedule were conducted first and those of the experimental 12-hour/8-day schedule were conducted 6 months after its introduction.

They were large individual differences in both tests although they both showed acceptable within-subject consistency. Both measures showed some guessing. This was easy to detect and correct at source by replication in the case of CFF but the grammatical reasoning test does not lend itself to such control. Learning was also apparent in both tests.

CFF was sensitive to within-shift changes and indicated a marginally greater decrement over the 12-hour than the 8-hour shifts. There was also an indication of circadian variation in CFF performance with higher levels being observed in the mornings. Grammatical reasoning on the other hand was relatively insensitive to shift related factors. Although every effort was made to control the subject's attitudes towards the tests CFF appeared to achieve a greater face validity than did grammatical reasoning.

Neither test appeared to be likely to carry much weight in the choice between schedules which is more influenced by subjective and operational factors. However the simplicity and psychophysiological reliability of the tests are such that they merit extended investigation in longitudinal studies of alternative work schedules in order to establish their credibility and utility.

Circadian Rhythms of Body Temperature and Performance under a Weekly Rotating Shift System

By S. MILOŠEVIĆ and M. CABARKAPA

Faculty of Traffic Engineering, Beograd, Vojvode Stepe 305
and Institute of Occupational Health, Beograd, Deligradska 29, Yugoslavia

The circadian rhythms of body temperature, catecholamine excretion, simple and choice reaction time, visual search, immediate memory and logical reasoning were studied in nine operators at a hydro-electric power station. The operators had long experience of shift work, and the weekly rotating three-shift system

had been in operation for 1 year. Measurements were made at the beginning, middle and after each of the morning, afternoon and night shifts. Most of the variables studied showed non-significant variations over the day, with the exception of the otic temperature and immediate memory. Circadian variation in temperature was pronounced and showed a very early peak, while for immediate memory there appeared to be a complete inversion of the normal rhythm. The digit span performance was best in the evening and night, and lowest in the morning. Immediate memory performance showed quicker adjustment to shift work than other performance and physiological variables. It was concluded that these weekly rotating shift workers showed only partial adjustment of their circadian rhythms in physiological and performance functions.

Human Reliability in Process Control with Shift Work

By G. DE TERSSAC and Y. QUEINNEC

LAAS-CNRS et Laboratoire de Psychophysiologie, Université Paul Sabatier, 31069 Toulouse, France

The development of process control has not brought about the disappearance of the human operator (H.O.), who remains an important element in the man-machine system. Nevertheless, the tasks which fall upon him and the nature of his work are deeply modified, in that normal running is automatically controlled. In this case, the efficiency of human intervention depends on the ability to act at the right moment, that is to say to quickly change from a state of passive observation to one of active involvement in the process. In numerous situations, the role of the H.O. consists of anticipating or solving malfunctioning. At any given time therefore the response of the H.O. will depend on: (a) his capacity to move quickly, (b) his idea as to the state of the system, (c) his knowledge of the causes which may have brought about the disturbance in the system and (d) the relationship between the members of a working team.

Analysis of incidents in an automated situation (chemical factory) with shift work, show an important augmentation in the amount of information the H.O. perceives but no change in his working procedure. It is, however, clear that in shift work, and notably at night, the H.O. does not have at his disposition either full knowledge of the situation or the possibility to act quickly. Furthermore, the mental representation of the system which the H.O. built up, changes with the different shift but less with malfunctioning situations.

These data deal with the reliability and the security of the man-machine system.

Energy Expenditure and Energy Intake in Selected Groups of Shiftworkers

By W. M. WIRTHS

University of Bonn, Römerstrasse 164, 5300 Bonn 1, F.R. Germany

Data were available from 2436 survey-days, representing a total of 58 subjects, studied in two periods of 21 days. Subjects were steel-workers with a three-shift-rhythm. With six subjects, we studied the energy requirement in work-time using the Max-Planck-Respirometer. Furthermore we calculated the work elements, which were sometimes from day to day very different during leisure time. With the experimental controlled basal metabolic rate and the specific dynamic action we obtained figures about the total energy expenditure. Energy expenditure was in the average of the six subjects 4100 kcal/day (17.2 MJ), $s \pm 124$ kcal. The range was 3950–4280 kcal/day (16.5–17.9 MJ). The energy intake in average was 4160 kcal/day (17.4 MJ), $s \pm 162$ kcal, measured by a precise weighing method. The average of the energy expenditure in all three shifts is about 6 kcal/min in working energy with a range between 0.3 kcal/min and 18.8 kcal/min. The energy expenditure in the three shifts was comparable. The work capacity and the work performance of the subjects were in a good agreement.

B.2. Productivity and Occupational Health in Various Industries

Eyestrain of Individual Visual Workers

By M. SAITO, K. KISHIDA and T. HASEGAWA

University of Tokyo, Faculty of Medicine, 7-3-1 Hongo, Bunkyo-ku, Tokyo 113, Japan

Monotonization and miniaturization of visual stimuli in our living environment by the rapid introduction of modern technology make us eye-strained and give us tension and fatigue. This study deals with the functional reactions in two levels, central and peripheral, of the visual nervous system during

inspection work. Subjects selected were veteran male workers aged 21–32 with more than 5 years of work experience. The factory operates 24 hours a day manufacturing glass bottles and uses a 3 shift work system. Workers engage 2 days in a shift with an 8-day cycle.

Physiological reaction in the central level of visual pathway (function 1) and ocular accommodation in the peripheral visual organ (function 2) were discussed during visual work and compared by shift. Relationships between function 1 and function 2 were also discussed. Initial increment of function 2 as previously reported in the day time operation was not specifically seen in either the evening or the night shift. In the later session of the 8-hour working period, a larger variation of ocular accommodation was observed in each work shift with the trend diminishing towards the end of the day. Function 1 gradually varies decreasing in each shift, and decreases lower in the night shift than in the day or evening shift. A characteristic relationship between function 1 and function 2 was obtained in the night shift, i.e. accommodation function was activated during work while the activity in the brain was inhibited. This trend was shown more remarkably in normal eyes than in myopic eyes.

Speed Skill in Short-cycle Repetitive Work

By A. KHALEQUE

Department of Psychology, University of Dacca, Dacca-2, Bangladesh

As an index of speed skill in a cigar-making machine operation, the number and duration of machine stoppages of 15 high-performance and 12 low-performance experienced (minimum 2 years experience) workers and those of three new (without any experience) workers were compared.

The task of the workers consists of feeding a machine with tobacco leaves for wrapping and finishing cigars. The work is machine paced and the cycle time of the machine is very short (3 s).

To study the work activity in detail, the number and duration of machine stoppages were registered with a punch tape-recorder with the precision of 0.1 s for each of the 27 experienced workers once during the morning shift (06.00–14.00) and once during the afternoon shift (14.00–22.00), and that of the three new workers were registered only during the morning shift over four successive days.

The results showed that the experienced low-performance workers stopped the machine nearly three times more and twice as long as the experienced high-performance workers (the mean number of stoppages for high and low performers were 415 and 1264, respectively, and their mean durations were 30 and 56 min, respectively). The total time lost over the working day was significantly longer in the morning than in the afternoon shift for both the high- and low-performance workers.

The comparison between the experienced and inexperienced workers showed that the latter group stopped the machine nearly three times more and four times longer than the former group (the mean number of stoppages for the experienced and inexperienced workers were 836 and 2470, respectively, and their mean durations were 46 and 178 min, respectively).

Considering the quite large differences in number and duration of machine stoppages between the different groups of subjects, it may be suggested that as long as the present type of machine is used, the differences in speed skill between the workers should be taken into account in setting the cycle time of the machine.

Finally, this short-cycle repetitive work, in its present form, does not seem to be ergonomically acceptable because it requires a too long learning time (Crossman, 1959), and even after learning only a very small fraction of people are able to reach the speed and precision standard set by the organization.

The Effects of Ergonomic Measures on the Health of the Neck and the Upper Extremities of Assembly-line—A 4 Year Follow-up Study

By T. LUOPAJÄRVI, I. KUORINKA and R. KUKKONEN

Institute of Occupational Health, Department of Physiology, Laajaniityntie 1, SF-01620 Vantaa 62, Finland

Occupational hand diseases had become a serious health problem in a food production plant where women workers performed repetitive packing tasks on assembly-lines. Therefore, in 1976, a project was begun so that such diseases could be decreased and prevented.

The project programme was carried out during 1977–1979 and consisted of an ergonomic survey of the work conditions and work methods, correcting the health hazards observed and teaching the workers good work techniques together with active recuperation during breaks.

The effectiveness of these measures has been evaluated each year, using the statistics of sick leaves and compensation paid by insurance companies. In 1976 there were 51 compensated occupational diseases. Year by year the number of such diseases has decreased; in 1980 no new cases were registered. In 1977, investigators from the institute of Occupational Health examined the neck and the upper extremities of the

152 packers. As the control group 133 shop assistants were also examined. Tension neck was found in 57 packers and 37 shop assistants, arm syndrome in 29 packers and 8 shop assistants and muscle-tendon syndrome of hands in 85 packers and 18 shop assistants.

In 1981 the same examinations were repeated by the same investigators, now 146 of the packers and 113 of the shop assistants were examined.

Examples of the corrective measures and the results of the follow-up health examinations are presented and compared with those of the controls, who have continued their work without alterations.

Analysis of Film Copy Workplaces for Improving Job Design, Environmental and Ergonomic Conditions

By H. STRASSER

Institut für Arbeitsphysiologie, Technische Universität München,
Barbarastrasse 16/I, 8000 München 40, F.R. Germany

In ergonomic field studies objective measures, physiological reactions and subjective ratings of the workers and employers are considered to be valuable methods in order to both assess workload and give indications for improving working conditions.

In a research project workload factors from the environment in an industrial film laboratory were measured and spatial working conditions were noted. Full-shift analysis in group measurement techniques delivered profiles of physiological reactions of the workers and harmonographic work pattern studies were registered in order to calculate reaction types for specific activities. Additionally, by means of a standardized questionnaire subjectively experienced working conditions were identified. On the basis of the complete analysis, deficiencies in the development section of the film copy works were evaluated, and a large amount of proposals initiated in order to improve the work system from an ergonomics aspect, in acoustic and climatic environmental conditions as well as in work-structuring elements.

For instance, noise could be essentially reduced by means of changing from chain-drive to belt-drive aggregates of the development machines and by fixing absorption materials on the walls. Alternating darkroom and day-light working became superfluous for the film development section. Job enrichment for all the film developers resulted from the inclusion of film copy inspection tasks on a monitor. The manual operation and the visual control elements of the development machines were redesigned from an ergonomics aspect and longer time tolerances for performance were included. All these measures took place accompanied by interrogation of the employers and workers, which gave an insight into the subjective experienced proposals and the expected acceptance of the new working conditions. In this way direct co-operation of the workers and employers is obtained in order to ensure that redesigned workplaces are practically proved as well as accepted by the film developers.

Women and Work in a Finnish Manufacturing Plant

By M.-L. HONKASALO

The Finnish Foundation for Alcohol Studies, Kalevankatu 12 00100, Helsinki 10, Finland

The aims of this report are twofold. Firstly, it forms a part of a theoretically oriented investigation on the situation of working-class women; particularly on the reasons why the situation remains unchangeable and even deteriorates, as indicated in terms of education, payment, security of work and health. Secondly, the investigation attempts at an empirical evaluation of a hypothesis generated by the theoretical part. The core issue is the complex factors regulating the situation of working-class woman. Supplementary evidence is provided by description and analysis of the particular working situations of women and the jobs they are doing, and by analysis of the inter-relationships between work and health status.

The data derive from a manufacturing plant of electronics equipment with a labour force of 400, of which 140 are women. The methods used are sociological and sociomedical and both qualitative and quantitative. The qualitative part of the study consists of participant observation and biography interviews of the workers. Questionnaire data have also been collected. The investigator was working for 5 months in the factory, performing the same work as the female workers in the plant. The work of the female workers is highly decomposed, simple, monotonous short-phase work. The health of the workers shows a distinct pattern, differing from the health profile of female workers in the average Finnish labour force.

High-tempo monotonous work together with a long working day due to long work-trips is associated with the following principal effects in their well-being and way of life:

- (1) Work stress reactions typical to monotonous, high-tempo content of work.
- (2) Ergonomic health problems.

- (3) Passive leisure time activities.
- (4) Passive trade-union activities.
- (5) Drinking habits typical of Finnish male workers; more severe use of alcohol than the average female population.

The Aggregation Method of Heterogeneous Material Environment of Work Factors

By L. PACHOLSKI and A. JASIAK

Technical University of Poznań, Poznań, Poland

The paper deals with investigations on the quantitative and qualitative structure of material environment of work in industry. The subject of the investigations was to find out technological systems which consist of man-machine units. Measurements of the intensity of environmental factors have been taken by apparatus on work-stands. Burden has been evaluated by workers and a group of experts independent of each other. The evaluation scale contained five degrees, each of them having verbal interpretation. On the basis of the results of the investigation the following patterns have been set: empirical patterns of environmental factors intensity, and empirical patterns of quality of evaluating subjective burdens. The analysis of empirical patterns determined the intensity of factors of representative values characteristic of systems under investigation together with the respective representative degrees of subjective burden.

Furthermore the following points have been determined during the investigation: ranges of the intensity of the variation of each factor in engineering industry, and optimum values of the intensity of each factor from the point of view of an influence upon man. Boundary values of variation ranges, representative and optimum values, have been reduced to a uniform decibel scale. Each factor has been ascribed a liminal intensity value. Partial indices of burden of each factor have been calculated by means of modified mathematical dependencies taken from the quality theory.

The strength of a relation between the results of apparatus measurements and evaluation of subjective burdens has been examined by means of a non-parametric measure of inter-dependence. A significant dependence between the variables examined has been proved. A representative rate of subjective burden has been assigned to each partial index of burden.

Aggregated indices of burden of material working environment for technological systems under examinations have been calculated on the basis of partial indices. The results of the research permitted the formulation of a universal algorithm of aggregation, applicable to any industry.

A Contribution to Methodology for the Evaluation of a Welder's Workload

By N. DAZORD, E. RICHARD and J.-L. FLORES

74 Rue Pasteur, B.P. 155, 69224 Lyon, Cedex 1, France

In the context of an exhaustive global investigation of working conditions in the welding sector, we made a detailed study of two factors: asthenic debility and eye-strain in welders. These conditions appear specifically in welders, and more particularly in welders working on high pressure assemblies and stainless steel welding.

1. In order to evaluate subjective exhaustion symptoms, we used the following tests:

- (a) A questionnaire developed by the psychology laboratory of the CRSSA in Lyon. This describes three factors: vitality scale: energy/exhaustion; optimism scale: optimism/pessimism; and sociability scale: affability/aggressivity.
- (b) A free translation of the questionnaire published by the Japanese Committee on Research on Industrial Exhaustion (Logi 1970).
- (c) Two anatomo-morphological figures.
- (d) An exhaustion sensation scale.

2. Three tests were used to measure eye strain:

- (a) The punctum proximum of convergence.
- (b) The punctum proximum of accommodation.
- (c) The 100-hue Farnsworth test. This test, in which the subject is asked to classify cards of slightly differing shades, serves to measure any loss of perception of colour contrast.

The report covers 26 subjects, all manual arc welders working on carbon and stainless steel parts for the primary and secondary circuits of a nuclear power station. The subjects were tested daily, before and after work, over a period of a week, from Monday morning to the following Monday morning (time to). The aim was to determine whether there was any evidence of a cumulative effect in the two factors studied, and whether the weekend rest affords complete recovery.

Results of Field Studies Concerning Stress and Strain at Three Different Blast Furnaces

By H. PETERS

Universitaet Wuppertal, Gauss-Strasse 20, 5600 Wuppertal 1, F.R. Germany

Muscular work, a hot environment by radiation and elevated temperatures and a high-noise level (parameters which are often combined and in addition to growing mental loads) still characterize the stress situation at today's blast furnaces, or more generally at work places in steel mills.

Research work aimed at an amelioration of working conditions often suffers from the difficulties of transferring results between investigators and those responsible for job design.

A method of validating the results of shift studies at work places of the above described type was developed by ASER/University of Wuppertal (Germany) to provide a tool, allowing the validation of the influence of the strain parameters and to point out, for example, the process steps which cause high external loads. The results of 8-hour shift studies are prepared as a first step in time-oriented data-sets, describing the work- and environment-dependent stress situation and the individual strain. These data-sets (as base for their former treatment) are ergonomically validated at seven-step scales, developed on the results of field and laboratory studies. In these seven-step scales the fourth step encloses the tolerable limits for 8-hour exposition, which do not yet (according to today's knowledge) result in permanent injury to workers. Step limits are oriented by the reaction to long- to short-time exposition, the step notation extends from 'very easy' to 'unreasonable load'.

The main results of this method of validation for the relevant stress parameters and the time duration-distribution are given and clearly show long-lasting stress and strain periods. These ergonomic results are completed by subjective ratings of work conditions by workers. The method is outlined in shift studies with twelve furnacemen, working at three plants with different technological conditions.

Influence of Mechanically-assisted Blowing on the Fine-myokinesis of the Forearms on Glass-blowers

By G. SCHÄCKE, A. FUCHS, A. VON LAER and P. MAYER

Institut für Arbeitsmedizin der Freien Universität Berlin, Königsberger Str. 36, D-1000 Berlin 45, F.R. Germany

The art of glass-blowing has been known for approximately 2000 years. The technique of glass-blowing by mouth as well as the occupational strain connected with it underwent little change since that time. The continuous turning of the pipe is the main fine-myokinetic stress for the forearms.

We examined 15 glass-blowers during three shifts, each between 5 hours a.m. and 2 hours p.m. Electromyograms (EMG) of the forearms as well as an electrocardiogram (ECG) were transmitted by radiotelemetry and stored. In a second part of the study five of the glass-blowers did mechanico-assisted glass-blowing to reduce the physical load.

We evaluated pulmonary and cardiocirculatory parameters as well as long-term EMG and ECG. The electromyographic results obtained during assisted and non-assisted glass-blowing were compared under the following aspects: working technique, working procedure and working time.

The findings are analysed with regard to ergonomic consequences.

The Effects of Change in Transport Methods on Stress and Strain of Truck Driver's Work

By J. ILMARINEN and C. H. NYGÅRD

Institute of Occupational Health, Department of Physiology, Laajaniityntie 1, SF-01620 Vantaa 62, Finland

The transport of milk products traditionally involves the lifting and carrying of goods. The new method for packing milk cartons was combined with new rolling transport dollies. The aim of this study was to compare the physiological stress and strain between the traditional and the rolling transport method.

Ten delivery men, mean age 35.4 years, were studied in 1980 (old transport method) and in 1981 (new method). On 20 randomly chosen workdays/year, the heart rate (HR) was recorded continuously throughout the entire workday with a portable cassette recorder (Howel Corder). Parallel to the heart rate recordings, the work tasks, poor working postures and the amount of goods handled were observed minute by minute. Oxygen consumption ($\dot{V}O_2$) was measured from the typical work tasks (Morgan Oxylog). For both years, laboratory studies comprised the direct determination of the maximal oxygen consumption ($\dot{V}O_{2\max}$) and the maximal heart rate (HR_{\max}).

The results indicated that the new rolling transport method reduced the amount of goods lifted and carried by about 1300 kg/day/man, i.e. by 57%. The amount of poor working postures of the back decreased by about 45% during loading and 39% during unloading the truck. The relative aerobic strain (RAS) decreased about 5% during loading and unloading the truck. During the remaining lifting and carrying, however, the RAS increased by about 8%. The new rolling transport eliminated peaks of over 140 beats/min in the HR. The heaviest phase of the delivery of milk products was loading the truck (mean HR 119 ± 11 beats/min or mean $\dot{V}O_2$ 1.68 ± 0.23 l/min).

The ergonomic improvements markedly decreased the stress of delivery work but had only a little effect on the physiological strain. The new transport method still involves too much lifting and carrying. The major drawbacks of the new method are the unergonomic platforms for unloading the truck and the runways for rolling the dollies into the stores. Results emphasize the importance of extending ergonomic improvements to both loading and unloading the trucks so that the overall strain of the truck drivers can be decreased.

The Musculoskeletal Status in Airport Transport Workers

By K. UNDEUTSCH

Institute of Work Physiology, University of Dortmund, Ardeystrasse 67, D-4600 Dortmund, F.R. Germany

Transport and loading work at airports is still a not sufficiently solved ergonomic and occupational health problem. A great variety of tasks are carried out in a modern airport. In spite of all the mechanization, loading and unloading of aeroplanes still involves physical work, which often has to be done under a very low ceiling in awkward positions.

A standardized interview for detecting subjective complaints was made of 366 transport workers to study the long-term effects of this occupation on musculoskeletal health. Low back pain during an ordinary working day was the most prevalent (66%) of all musculoskeletal complaints. Forty-one per cent of the interviewed workers had complaints pertaining to the knees. The prevalence of musculoskeletal complaints correlated significantly with age, but also with body length and weight.

The transport workers are all doing the same work and thus being exposed to a constant training stimulus of the muscles. Therefore it was also of interest to study isometric muscle strength and its variation by age. In 70 workers muscle strength of trunk extensors, trunk flexors, muscles involved in bimanual vertical lifting, elbow extensors and elbow flexors were measured. A method with fixed positions and strictly isometric contractions was used. The absolute strength of the muscle groups declined with advancing age at rates from 0.3% per year for the trunk flexors to 1.5% for the biceps, while the corresponding range for the relative muscle strength (N/kg body weight) was from 0.9% to 2.0% per year. These rates express decrement in a population doing the same work.

Our studies demonstrated that younger, shorter and lighter persons with good isometric muscle strength are best suitable for this kind of work. Ergonomic improvements on the one hand and selection of workers on the other may be expected to lower the prevalence of musculoskeletal complaints.

Health Survey on Plasterers (Stucco-workers)

By C. L. EKKERS

Netherlands Institute for Preventive Health Care (TNO), P.O. Box 124, 2300 AC Leiden, The Netherlands

The occupation of plasterer is known to be very straining for the body. Therefore it is not surprising that this occupational group has high figures for sickness absenteeism and permanent unfit for work. There is reason to assume that, especially, the joints of neck and shoulders and back can be damaged by the working postures and the weights that have to be lifted combined with the speed of working and the number of working hours. More exact data, however, are not available. It is not known which specific complaints and affections are typical for the occupation or which activities cause them. This lack of data hampers effective preventive measures. By order of the BG Bouw an investigation is being carried out by the Netherlands Institute for Preventive Health Care (TNO) aimed at a more detailed analysis of the health problems of plasterers. As a first step a standardized instrument has been developed, consisting of:

- (1) A questionnaire concerning the way of occupation is practised in combination with a list of health complaints.
- (2) A protocol for a physical examination related to symptoms of damage of the motoric system.

As a second step a large group of plasterers was examined using this instrument. A reference group, also from the building industry, was examined in the same way to establish the degree of specificity of the health problems found in the group of plasterers.

The results show the specific health risks of the occupation of plasterer. On the basis of this and the results of an ergonomic analysis of the occupation which had been carried out before, it is possible to develop specific preventive measures.

A Back-care Programme in the Building and Construction Industry in The Netherlands

By E. A. P. KONINGSVELD

BG Bouw, P.O. Box 8114, 1005 AC, Amsterdam, The Netherlands

In The Netherlands, 40% of absenteeism in the building and construction industry is caused by back complaints. This is also the most common diagnosis for working incapacity. For this reason the Foundation for Occupational Health in the Building and Construction Industry (BG Bouw) proclaimed 1981 as the year of the back. An ambitious programme was set up, in which the following elements were distinguished: (i) the establishment of force limits for manual handling, (ii) standardization of methods for medical investigation of the back, (iii) inventory of the most back-straining jobs and professions and (iv) health education.

- (i) To establish force limits over 3000 titles were studied. The existing and forthcoming legal limits of some 30 countries were called in. On this basis preliminary force limits were established. Research projects in this field are now considered.
- (ii) As BG Bouw delegates the execution of the occupational health care to 42 independent regional health organizations, the standardization of procedures is very important, e.g. for epidemiological reasons. The aim is to arrive at early detection of body defects.
- (iii) Many opinions exist on which jobs are straining. However, there has never been an objective investigation. A special check-list was composed, and a sample of building sites has been examined using it. Negotiations were started with manufacturers of heavy materials and products, in order to try to decrease the weights. Attention has also been paid to mechanical aids, e.g. for lifting concrete blocks.
- (iv) Health education activities such as the distribution of posters and leaflets, presentations, some television programmes, etc. were carried out. Special attention was given to vocational training: aspects of back problems and prevention are now integrated in many lessons.

Solvent Mixture Influence Dependent on the Working Process in the Wood Industry

By R. LÜDERSDORF, G. SCHÄCKE, B. HEYDENREICH-ADLOFF and A. FUCHS

Institut für Arbeitsmedizin der Freien Universität Berlin, Königsberger Strasse 36, D-1000 Berlin 45, F.R. Germany

One of the main processes in furniture factories is varnishing. This operation can be done in two different ways: manual spray painting and automatic conveyor varnishing.

We studied the influence of different solvent mixtures upon employees involved in this work. For control reasons a non-exposed group of workers was examined as well. The concentration of airborne solvents at workplaces was determined by personal air sampling and head space gas-chromatographic evaluation.

We were looking for effects on organisms by different approaches. Blood count, coagulation and liver enzyme activity were measured from blood samples and urine analysis, including determination of solvent metabolites, were made. The results were evaluated statistically.

The Apparel Workplace: An Ergonomic Case Study

By L. MIDDENDORF

1040 Berkshire, Grosse Pointe Park, Michigan 48230, U.S.A.

The apparel workplace where stitching operations take place has remained relatively unchanged. Stitching operations, whether in contract shops or sewing factories, are today performed as yesterday with minor changes. The workstation remains a sewing machine, a power supply, small hand tools and bins, trucks or racks to deliver or move away sections or completed garments. The typical sewing machine operator is a female.

Some computer applications such as fabric cutting have been successfully introduced but extensive automation in stitching operations awaits solutions to problems in handling soft goods.

An apparel workplace study at an American sports apparel plant was undertaken to inventory potential ergonomic problems and to recommend improvements. The plant workforce of 300 female operators participated in the study. Data was obtained by task analysis, photographic observations, interviews, anthropometric and equipment measurements and questionnaire responses. Data was then analysed and statistical tests applied.

A major finding was that the power sewing machine operator experiences significant personal body discomfort at the end of a working day. Major discomfort was reported in the back and buttocks region and in the head-neck-shoulders-arms region.

Recommendations for equipment and workplace changes were made based on the results of the initial study. Systematic changes in workplace arrangement and equipment were instituted. Six months later a follow-up study was conducted for comparison purposes.

This paper reports the results of the apparel workplace ergonomic study, discusses specific changes made in the workplace and the implications of the findings for the future apparel workplace.

A Tendonitis Control Programme for the Apparel Industry

By M. A. AYOUB

Department of Industrial Engineering, School of Engineering, P.O. Box 5511, North Carolina State University, Raleigh, North Carolina 27650-5511, U.S.A.

Tendonitis, tenosynovitis and carpal tunnel syndrome are some of the new words finding their way into today's workplace. They replace some of the more descriptive titles such as housemaid's knee, policeman's heel, weaver's bottom, telegraphist's wrist, tennis elbow, golfer's shoulder or baseball player's glass arm. Each describes a disorder characteristic of the occupation it typifies. All names indicate some type of injury or disorder of the tendon and related anatomical structure (sheaths, nerves). This paper details a study that was directed towards defining and implementing an ergonomic solution for the tendonitis problem prevalent at several plants of a large apparel manufacturing company.

This paper is presented in six parts. First, the tendonitis problem and its causes are reviewed and assessed. Next, a model that identifies static loading of tendons as the primary cause of tendonitis is proposed. Poor postures and certain aspects (elements) of work methods are implicated as the main contributors to static loading. In contrast, mental stress and performance rates play a secondary role in the development of the disorders. Following model presentation, a review of the Hanes workplace is given. Poor seating, lack of definitive work surface and an inadequate materials handling system are some of the deficiencies reported.

The remaining segments of the report concern the process of defining an acceptable solution to the tendonitis problem. The recommended solution is centred around maintaining proper postures through improvement of existing workplaces. Specifics of the solution are as follows: (1) using an adjustable chair, work surface and bundle support, (2) enhancing visual interface between operator and machine, (3) updating and upgrading the materials handling system and (4) training of supervisors and employees in proper posture maintenance and in developing proper operator-machine interface.

The solution has been implemented for three plants. Statistics concerning the success and effectiveness of the solution approach in controlling the tendonitis problem will be presented and discussed.

Characteristics of Office Works

By A. KOMATSUBARA and Y. YOKOMIZO

Department of Industrial Engineering, School of Science and Engineering, Waseda University, Tokyo, Japan

This paper deals with work characteristic, necessary to estimate workload of non-muscular works which have recently increased, in various industries, instead of muscular works.

As many factors, such as psychological or physiological stress, which influence the performance of non-muscular works are thought to exist, the method of estimating workload of non-muscular works must be completely different from that of muscular works.

A brain-storming was made to point out such factors and the result shows some important factors exist; worker's interest and/or satisfaction, arousal level maintained by the reticular activating system, circadian rhythm and so on. Experiments were performed in order to make clear those factors which depend on the characteristics of the work. Thirteen work samples from office works were chosen. Each work sample was carried out for 10 min by 30 subjects. Heart rate and respiration rate were measured. After each work sample was performed an SD (Semantic Differential) method and questionnaire, proposed by the author, were given.

The questionnaire reflects the human information processing system and the subject can answer which processing stage he uses when he has carried out the work. Every result was processed by principal component analysis and three or four significant components were obtained in each measurement result, and it was discovered that those principal components have very close relations with the information processing stage, obtained by the questionnaire, the subject used.

Thus the author concludes that obtaining the information processing stage which the worker used during the work is sufficient to make clear those characteristics needed to estimate the workload of the non-muscular work and the proposed questionnaire is also very effective in the inquiry.

On Work Study and Workload of the Computer Operator

By M. UMEMURA

Science University of Tokyo, 11-15-301 Masago 1-chome, Chiba-shi Chiba-ken, Japan

This presentation provides quantitative analyses of work study and workload of operation workers (called 'operators') of a computer data processing workshop. The former analysis involves observing where operators are in the computer room, what kind of physical postures are involved when working and the kind of work activity, by making an 8 mm movie film at intervals of 1 m. For the purpose of the above analysis we took data of work unit distribution, workload levels and of noise levels.

The observation methods were carried out as follows:

- (1) Successive five days (Monday to Friday) of a month, and 12 hours (9 a.m. to 9 p.m.) of each day were chosen.
- (2) We chose two factors, which are variables of two dimensional positions X and Y , Z for nine levels of classified unit physical postures and W for five levels of classified work unit.
- (3) X and Y , position variables, are two 10×11 equi-segmented edges of the workshop room.
- (4) The method of making a film for 10s (one frame a second) every minute was adopted.
- (5) For workload level measurements, the following tests were carried out:
 - (i) flicker test and
 - (ii) subjective symptoms test (mentally and physically).
- (6) For the noise level, measurements were taken at nine sites inside the room.

The results are summarized as follows:

- (1) The relationship of work activities with working sites and working postures was successfully obtained.
- (2) Several points of possible improvements to workshop layout are proposed.
- (3) The proposed method of X - Y - Z - W analysis was applied to other cases and obtained good agreements.
- (4) It is found that the relation of work activities with workload is a functional one.

Study on the Evolution in the Field of Information Management and Working Conditions, as a Consequence of the Development of Digital Technology and Use of VDU Operator Stations in Steelworks

By B. FRANCESCO

Italimpianti, Pizza Piccapietra, 16100 Genova, Italia

One of the most interesting aspects resulting from the expansion of digital technology in iron and steel metallurgy is that of regarding the partial or complete replacement of control desks and graphic panels, traditionally used for the plant control, with supervisory and operator-guided apparatus controlled by microprocessors.

Trials so far carried out in the operation of video stations with microprocessors, show a tendency to centralize the area of operative functions, which has met with operators' favour because of the suppression of fixed stations in uncomfortable or excessively isolated places (e.g. stockhouses of O.S. Blast Furnace no. 2 and Taranto Blast Furnace no. 5). The other tendency is the decentralization of processed information, once accessible only to central offices and qualified people different from the present operators in both their role and function in the company's organization. Both these tendencies being convergent, it ensues that video stations involve a considerable increase in the information flow area.

The true novelty lies in the fact that, thanks to microcomputers, up-to-date processed information is available in technological areas, with the resulting possibility of a timely intervention in those areas where

troubles occur. Furthermore, the availability of a processed reference memory puts trend information at the disposal of operating crews and permits taking decisions on the process, which was impossible before because of lack of information. Also fault diagnosis, thanks to in-phase statistical information, undergoes new developments.

For ergonomics, the video stations, besides the conventional man-machine relationship regarding the methods with which the information is supplied, also involve 'mental load' problems which permit defining the operations requested of the operators and their capacity of acquisition, memorization, processing, making decisions and selection of suitable answers.

Our study, carried out in collaboration with the Italsider people, evaluates all these aspects as well as the social and organizational consequences of these technological innovations.

In fact, modifications of information flow and the consequent decisions implies, also, changes in the practice, control and procedures which, on the whole, constitute the power system of a company.

An Ergonomic Evaluation of Foot Complaints Among Waiters

By J. WINKEL

Department of Human Work Sciences, University of Luleå, S-951 87 Luleå, Sweden

Questionnaire studies among waiters in Norway and Sweden have revealed high frequencies of complaints about the feet. Some authors have suggested swelling of the feet as an important stress factor in occupations dominated by a standing posture. Thus swelling of the left foot was measured on working days for 12 apparently healthy waiters (9 females, 3 males) at two restaurants. For eight of the subjects this measurement was also carried out during days off. Clinical studies of the legs and feet and measurements of subjective rating of foot discomfort on working days were carried out for all the workers at the above-mentioned workplace ($N=25$). Their working shoes were evaluated and photographed. The amount of sitting, standing and walking and the frequency of change between walking and standing/sitting were studied for eight and seven waiters, respectively. Swelling of the left foot was measured on working days for 25 apparently healthy workers in other occupations not known to cause leg complaints, to obtain a reference level of 'acceptable' swelling. All measurements of foot swelling were normalized to 8 hours, assuming a linear change of foot volume over the period.

The mean foot swelling during working hours was 1.3% ($s=1.0$) for the waiters and 1.4% ($s=1.0$) for the reference population, without significant difference between the means. During days off the mean foot swelling for the waiters was 0.4% ($s=0.6$), which was significantly less compared to their swelling during work ($p<0.02$) and to the swelling of the reference population ($p<0.02$). Preliminary results of the activity studies indicate that the waiters are on average standing 57%, walking 38% and sitting 5% of the working hours. The low rate of swelling in spite of the long duration of standing might be explained by the frequent interruption of the standing position by walking (mean: 2.25 times/min) thus activating the musculo-venous pump.

The clinical studies indicate a correlation between complaints and abnormalities of the foot, e.g. pes transversoplanus. According to several authors these abnormalities might develop over years by prolonged standing at work. For one subject the complaints were probably caused by the shoes.

Check-out Systems for Self-service Shops—Standardization and Real Working Conditions

By H. STRASSER and W. MÜLLER-LIMMROTH

Institut für Arbeitsphysiologie, Technische Universität München, Barbarastrasse 16/1, 8000 München 40, F.R. Germany

Recently several research reports concerning working conditions of check-out systems of self-service stores were published. All human factors engineering analysis commonly mentioned spatial workspace data only scarcely meeting anthropometric standards. For instance, deficiencies in important interior as well as exterior ergonomic measures of almost all check-out box systems were shown and sometimes differences exceeding tolerance levels were found between working heights for the left and right arms. Additionally, complaint profiles from subjective rating data indicated unfavourable working conditions.

To improve check-out systems in Germany a special work-place guideline was drafted. In this paper ergonomic standards and guidelines are shown to be helpful in practical implementation of improvements on the condition that they are used carefully and not in a mechanical manner. Many other factors which influence work in an ameliorating or impairing way, as well as ergonomic compromises, must be regarded, too. Ergonomic demands are evaluated and additional indications given in order to guarantee humanization of working life in this field. Care has to be taken that improvements from an ergonomics point of view do not

remain cosmetic and fashionable repairs or bungled work in an unsatisfactory work place. Human factors engineering has to extend from the microstructure of ergonomic check-out systems to the macrosystem of the whole work area in a self-service shop. As far as possible a form of job rotation, from cash registering tasks to general working in the store, should be implemented.

Special problems resulting from technical innovations, e.g. the introduction of scanner registration systems, which can seldom be included in guidelines and regulations are dealt with.

Ergonomic Workstation Design for Supermarket Scanning Systems

By P. L. MARTIN

International Business Machines Corporation, P.O. Box 12195, Research Triangle Park, North Carolina 27709, U.S.A.

In recent years, we have seen a growing concern for the quality of working life and ergonomists have been called upon to evaluate the work environments of unskilled workers which have previously gone unnoticed. The job of a supermarket cashier is one of those little-noticed occupations. To the casual observer, the job of a cashier may appear to be a monotonous but unstressful occupation. However, of the few studies that have been conducted, all have reported that the job of the cashier in a self-service store is one laden with the risk of mental stress and chronic physical symptoms. The modernization and increasing sophistication of checkout equipment is changing the task of the cashier. Whether or not those changes improve the quality of working life for the operator will depend, in part, on the consideration of the ergonomic aspects of the task, particularly the layout of the workstation and the choice of work methods.

This paper discusses the design of a workstation for a supermarket checkout specifically designed for a seated operator using a fixed, in the counter scanner. Designing such a workstation involves a series of tradeoff decisions. Cost and space constraints, operator reach limitations, work methods and productivity, the shopper and security aspects, as well as access for servicing and physical planning for the equipment are all important points to consider. This paper discusses the critical decisions involved in the design of a workstation which houses the distributed IBM 3650 Programmable Store System equipment with the 3687 Supermarket Scanner attached. Although designed specifically with the 3687 Scanner in mind, the critical design decisions are applicable to most in the counter scanning systems. A prototype checkstand was built and tested and the results of the test are also discussed.

Measurement of the Ticket-selling Worksite According to Comfort Experiments

By M. LAUNIS

Institute of Occupational Health, Department of Physiology, Laajaniityntie 1, SF-01620 Vantaa 62, Finland

A study was carried out in the state railways of Finland in conjunction with the instalment of computers to facilitate the selling of tickets. The vertical dimensions of the worksite, such parameters as the sitting height, the level of handwriting, the depth at which the keyboard is inset and the level of the keyboard were experimentally studied in an electrically manoeuvrable simulator. Individual tolerance limits were required so that the dimensions of the fixed worksite could be defined. The maximum, minimum and optimum judgements of 30 women employees were recorded for the mentioned parameters using a modification of the method of fitting trials (Jones, 1969). In order that the results could be referred to other populations of users some anthropometrical reference measures were also recorded.

The results of the experiments showed methodological regularity. The differences between the average maximum and average minimum values were 6.21 cm for the sitting height, 5.13 cm for the level of handwriting and 4.47 cm for the level of the keyboard. The repeated experiments brought about no significant changes in the averages of the maximum, minimum and optimum values, only a slight tendency towards concentration between the ascending and descending experiments. The averages of the optimum values in the fitting trials were equal to those in the free adjustments done by the subjects themselves. The numerical results were directly applicable to the design of the worksite.

Stress and Strain in Cleaners' Work

By V. LOUHEVAARA, J. ILMARINEN, C.-H. NYGÅRD and I. PESONEN

Institute of Occupational Health, Laajaniityntie 1, SF-01620 Vantaa 62, Finland

Health problems thought to be caused by the physiological features of cleaner's work are common, especially among older women cleaners. The purpose of this study was the preliminary determination of physiological stress and strain in cleaners' work.

The study group comprised nine healthy women, mean age 48 years. Three were school cleaners, three were office cleaners and three were hospital cleaners. After a medical check-up the women were given a submaximal bicycle ergometer test. The individual heart rate/oxygen consumption regression equations were used to predict the maximal oxygen consumption ($\dot{V}O_2$ max) and oxygen consumption during cleaning work. The mean $\dot{V}O_2$ max was 32.1 ml min⁻¹ kg⁻¹. The following measurements were carried out on a randomly chosen workday:

- (1) Job description with the AET method.
- (2) Continuous heart rate recording (Howel Corder) throughout the whole workshift, with a parallel observation of work tasks.
- (3) A work sampling study, using the OWAS method, to determine the number of poor working postures.

The profile analysis of the cleaners' work emphasized the versatility of the tasks and the physiological work demands. The mean heart rate was 101 beats min⁻¹, the estimated oxygen consumption was 0.91 min⁻¹, and the relative aerobic strain (RAS) was 43%. The highest mean heart rate of 113 beats min⁻¹ was measured during vacuum cleaning. The highest heart rate was 136 beats min⁻¹, and the duration of heart rate over 130 beats min⁻¹ was 26 min (below 1% of the work hours). The cleaners spent 56% of their work hours with the back bent forward or twisted. Strenuous combinations of different poor work positions of the back, legs and arms were observed for 9% of the work hours. No systematic differences between school, office and hospital cleaning were found.

The cleaning work studied was found to be heavy physical work, with some peak loads for women over 40 years. Poor working postures were especially common. When efforts are made to improve or plan the work methods and tools of cleaning, attention should be paid to reducing static work and poor working postures.

A Study of a Space Allotment Procedure for a Dental Treatment Area Using Measurement of Human Posture

By T. SHIBAHARA and M. CHASHI

Nihon University, School of Dentistry, Department of Dental Materials, 1-8-13 Surugadai Kanda, Chiyodaku, Tokyo 101, Japan

In allocating space for a dental treatment area, the space to be occupied by functional objects such as dental chairs and cabinets is generally about 50% of the area of a unit treatment area on a plane figure. Therefore, if the disposition of these functional objects had been decided preferentially as a space allotment procedure, the space necessary for working and moving of the operator, assistant and patient, which is an essential aim of a treatment area, may happen not to be rationally secured. Such irrational examples are often seen at general dental clinics in Japan.

In order to remove such defects of 'space allotment', it is thought that the application of a 'measurement of human posture', based on the technical skill of human engineering, is very effective.

The reason is that by the method of 'measurement of human posture' we can measure the space necessary for the most natural (1) posture, (2) movement and (3) transferring of humans who may act inside the treatment area, in three dimensions numerically and then in the basis of the numerics we can make the space allotment for the treatment area. By this method, we take the procedure that first the space for the humans who may act inside the treatment area is regulated and second the necessary functional objects are placed so as not to be inconsistent with the said space. Consequently it is expected that such defect of 'space allotment' as seen in many clinics at present can be resolved. The relative procedure is presented in detail.

Localized Fatigue Complaints Related to Output and Body Posture of Dentists

By K. MAEDA

Department of Environmental Health, Kurume University School of Medicine, 67 Asahi-machi Kurume-shi 830, Japan

Because dentists have to treat teeth in the narrow mouths of patients using fine upper limb exertions, their work postures are unnatural. In the present study, relations between localized fatigue complaints and output/posture were analysed among 410 male dentists. The results obtained are:

- (1) Prevalence of neck, shoulder and lower back pain was related to output.
- (2) Prevalence of pain and tiredness in the arms was also related to output.
- (3) Posture of head, upper arms and torso was compared between the two types of work posture, i.e. standing and sitting. The results suggest that localized fatigue complaints relate to work posture.

Physiological Load on the Back of Postmen During Letter Distribution in Urban Districts

By K. JØRGENSEN, H. CHRISTENSEN and E. DALTORN

University of Copenhagen, Universitetsparken 13, DK 2100 Copenhagen, Denmark

In this investigation the load on the back of postmen is measured during mail delivery. This is part of a project where an attempt is made to relate the objective back stress in the work situation to complaints and diseases in the lower back in different occupations.

The load on the back was measured indirectly by EMG in ten experienced male postmen of average age 40 years (32–48 years). The electrical activity from the lumbar part of *M. Erector spinae*, both left and right, was obtained in three different 30-min periods by surface EMG during a normal working day. The preamplified EMG (Medenic) was transmitted telemetrically to a main amplifier (Medenic) and registered on a tape recorder (Brüel and Kjaer), situated in an accompanying car. Before starting the working day both MVC and due EMG-force-relation of the back muscles were measured. After the working day the EMG corresponding to 30 and 60% MVC was measured. After rectification and smoothing all EMGs were converted to force (% MVC)-time (s) curves based on the individually obtained EMG force relations.

Special attention was paid to the back strength mobilization during the letter delivery into the letter box with the trunk in a, more or less, bent forward and twisted position. The force-time curves from the back muscles were characterized by the peak amplitude (% MVC) and amplitude distribution. Fatigue reactions from the back muscles were investigated from changes in both EMG force calibrations, centre frequencies of the EMGs (fast Fourier analysis) and by the self-reported degree of perceived exertion (RPE a.m. Borg) in the back.

The strength of the back in the subjects (MVC) was $805 \text{ N} \pm 45 \text{ N}$ (sem.) corresponding to 75% of standard values. 150–200 mail deliveries were performed during a normal working day into letter boxes placed 30–35 cm, 70–75 cm or 110–115 cm above the floor. The average delivery times were 6 s, 4 s and 4 s and the peak muscular force produced by the left side back muscles were 40, 24 and 11% MVC, respectively. The average strength mobilization during each mail delivery was 23, 16 and 5% MVC at the three different heights. The activity in the left back muscles was 1.2–1.3 times higher than in the right back muscles during the deliveries (i.e. asymmetrical load on the back). The mail delivery operation constitutes ~10–15% of the total work day (other operations were: sorting the mail in the post office in the morning, cycling, walking and stair climbing in the postal district, with the postural activity in the back muscles only slightly increased compared to the 'easy standing' position). Fatigue reactions from the back were present after the working day, evaluated from changes in both the EMG response to 30 and 60% MVC, and in the RPE measures during the working day. No significant changes could be demonstrated in FFT analyses and centre frequency of the EMG. The results will be discussed in relation to back complaints and medical findings in a larger group of postmen. Further, the results will be compared to those from similar investigations in other vocational groups.

A Study on the Changes of Physiological Functions on Motorcycle Riding

By T. MATSUMOTO

Department of Public Health, Nagoya City University Medical School, Kawasumi Mizuho-cho, Mizuho-ku, Nagoya 467, Japan

In a previous study, the author summarized, after various considerations of mailmen's motorcycling time, the vibration level of handle-bars, as well as the results of a survey of complaints and objective examinations undertaken by the author, that mailmen's vibration hazards induced by motorcycle riding were widespread in Japan.

This time, in order to get basic information for setting suitable conditions to prevent the vibration hazard, the author made a study on the physiological changes of motorcycling men riding at the various speeds. The measured items were skin temperature, vibratory sense threshold, flicker value and pulse rate of the subjects on and after motorcycle riding at speeds of 20, 30, 40 and 50 km/h. The temperature was within 25–30, 10–15 and 0–5°C.

Subjective Symptoms and Psychophysiological Effects of Motorcycle Riding

By A. HISASHIGE, H. OHARA, Y. KUME, M. YAMAMOTO, T. OGAWA and H. AOYAMA
Kochi Medical School, Okoh-cho, Nankoku, Kochi 781-51, Japan

Recently, the postal service has been automated and mechanized in Japan, and motorcycles have been rapidly introduced for delivering and collecting mail. It has been reported that the incidence of suspected vibrational disease has been increased by motorcycle riding.

In a previous study, the author measured vibration levels generated from motorcycles used in mailmen, and demonstrated that the levels were over the guidelines proposed by the ISO. In this study, the author discusses the effects of motorcycle riding on subjective symptoms and psychophysiological functions, using epidemiological and experimental methods. The results were as follows.

- (1) Subjective symptoms of numbness, pain and fatigue during work were surveyed on 68 mailmen riding motorcycles for 6 days. Subjects were divided into two groups by duration of exposure to vibration, and the prevalence rate of symptoms were compared between the two groups. The prevalence rate of symptoms increased as the time since work started increased. This tendency was especially strong in the group which was highly exposed to vibration.
- (2) Experimental studies on the effects of motorcycle riding on psychophysiological functions were performed on eight persons. Peripheral circulation, peripheral nervous function and central nervous function were tested every 40 min during 120 min riding and every 20 min at rest for 60 min after riding. These functions decreased as riding time increased and did not recover in the 60 min rest.
- (3) A field survey was carried out on three persons during their ordinary daily work and the functions mentioned above were tested. Results were the same as in the experiments.

These results suggested that motorcycle riding had an effect on disorders of peripheral circulatory and nervous functions and fatigue among mailmen.

Fatigue and Health Problems of Workers in a Home for Mentally and Physically Handicapped Persons

By Y. ONO

Department of Hygiene, Nagoya University School of Medicine, 65 Tsurumai-cho, Showa-ku, Nagoya 466, Japan

Health problems, namely, lumbago and cervicobrachial disorders occurring in nurse teachers in institutions for physically and mentally handicapped children have been noticed in Japan. In a home, night-duty work was partially added to day-duty work without a break, since April 1980. Thereafter, many symptoms of general fatigue, lumbago and neck and shoulder pain gradually increased among nurse teachers. Therefore, a survey was carried out.

The subjects were 48 workers (30 nurse teachers, 9 office workers and 9 cooks) with an average age of 31.7, 35.7 and 38.4 years, respectively. In a questionnaire, many workers had complaints of the neck, shoulder, hand, arm and back. After orthopaedic and neurological examinations, about 67% of nurse teachers and cooks were classified into 'the many findings group' requiring some medical or preventive care. On the other hand, the rate of office workers was only 22%. Nurse teachers who have to discharge night duty after day duty without a break more than three times per month were classified into 'the many findings group' with a significantly higher percentage than the teachers doing less than twice per month.

Afterwards, a survey was made on fatigue during work for 4 days. Complaints of fatigue, especially items concerning difficulty in mental concentration were markedly increased during night duty, and CFF and calculating accuracy were decreased at the beginning of dawn. Also in day duty, the relative flicker values in the evening compared with those in the morning were significantly less in teachers discharging the third continuous day duty than those in the teachers discharging the first day duty after a day off.

According to the analysis of working conditions, too long night duties, insufficient rest periods and high mental stress were considered to be factors contributing to the fatigue.

Introduction of Ergonomics in the Development of Educational Systems

By S. KOZUKI

When we think about the educational system, we find that it consists of many factors, and its researches cover a large number of domains, such as industrial technology (hardware), informational technology (software), psychology, theory of communication media, physiology, ergonomics, educational philosophy, etc.

At present we must conduct researches in ergonomics because it is charged with the greatest mission in the educational system. Especially as information based on physiological psychology is the most important basic item in designing educational systems.

In Japan Dr. Oshima and others have given wide information on the fatigue of adults, but researches concerning children still remain an underdeveloped domain. Experiments have been made. The degree of fatigue-load by measuring flicker value (CFF) and heart rate in children's life cycle has been described.

Moreover, information has been obtained on the daily variation of subjective symptoms of fatigue in before and after school hours. As a result, it is recognized that CFF precedes heart rate in the basic wave by about 3 or 4 hours.

It has been made clear that the measured value of the sense of fatigue is higher before school (in the morning) than after school (in the evening). We think that this phenomenon is caused by slippage of the phase of the sleeping rhythm in children's life cycle. We must make good use of this information, so that children may grow up mentally and physically sound, and we must make developments towards the optimum educational system.

B.3. Field Studies of Safety and Occupational Health

Influences of Thermal Environment on Safety Behaviour

By J. D. RAMSEY, C. L. BURFORD, M. Y. BESHIR and R. C. JENSEN
Texas Technical University, P.O. Box 4130, Lubbock, Texas 79409, U.S.A.

General agreement exists and considerable research effort has been expended in the validation of relationships between hot environmental conditions and fatigue or physical work stress. There is also good evidence suggesting an optimal range of environmental conditions above which and below which performance on sedentary or mental tasks is less than optimum. However, the effects of thermal environments on safety behaviour, which is a correlate of accidents, have not been thoroughly investigated, due in part to the difficulty in evaluating safety behaviour. This report describes a study using safety sampling procedures to determine safety behaviour, and using environmental measurements to define the thermal environment in order to establish the relationships between these two variables.

The study was conducted in two industrial firms, a metal products manufacturing plant and a foundry. A wide variety of industrial work tasks and work stations were observed. The data was collected over a 14-month period starting from the 1 July through the end of August of the following year. Measurements were taken twice daily for a total of over 17 000 observations. A typical data collection visit consisted of measuring the thermal environment in a work area, then randomly observing the specific workers in the area against a taxonomy of unsafe behaviours developed specifically for this purpose. Thermal measurements were taken by a Reuter-Stokes heat stress monitor. The WBGT was selected as the index for analysis of the results.

The statistical analysis indicated that temperature had a significantly detrimental effect ($p < 0.01$) on safety behaviour. The relationship between unsafe behaviour and the ambient temperature was found to form a U-shaped curve with the minimum unsafe behaviour rate occurring around the zone of thermal neutrality (approximately 19–25°C, WBGT). Other factors such as metabolic workload and period of the day were also found to have significant effect ($p < 0.01$) on safety behaviour.

One Method for Evaluating Safety Performance in Working Places

By S. HANAYASU
Research Institute of Industrial Safety, Ministry of Labour, 5-35-1, Shiba, Minato-ku, Tokyo 108, Japan

In many industrial areas, the accident frequency rate is often used as a measurement for evaluating their occupational safety performance for a long time. The accident frequency rate is generally defined as the number of occurrences of accidents for a certain unit of man-power or employee-hour exposures. This paper deals with the time intervals between occupational accidents, instead of the number of accidents, in the hope of establishing its usefulness as a measurement of safety performance in a working place having a certain accident risk, as well as establishing a methodology of evaluation of the safety performance analysing the period of time of occupational accidents. This research is divided mainly into two parts.

First, in order to discover whether there is any significant tendency for changing accident situations in succeeding intervals of time, statistical significance test for accident frequency rate using time to accidents was studied.

Second, for the purpose of evaluating the probability of the range of accident frequency rate in which accident rate calculated from the accident data varies, interval estimation of the accident frequency rate was performed.

From the study above, it is concluded that the time intervals between occupational accidents can be used as a useful measurement of safety performance. Especially, it can be used as an earlier indication of changes of an accident situation. Also interval estimation of accident rate using time intervals provides useful information.

Ergonomics of Safety

By V. DE KEYSER
84 rue du Tabellion, 1050 Bruxelles, Belgique

Research work over the past 20 years in the field of accidents at work in ECSC countries has highlighted the mechanisms of production of accidents at work. Arising from the simplistic alternative of the human-technical factor, it has presented the accident as an indicator of an inadequacy, not to say a contradiction, between the objects of the production system, expressed in terms of production quantity, quality, costs and delivery times, and the means installed to attain them: men, machines, technology, work organization and physical, psychological and social environment. From this tension ensues a set of chain reactions of risk factors, interwoven in a complex way, which contribute to produce the accident. This is but one of the pathological manifestations which can occur: others are technical incidents, breakdowns, lack of operator regulations which pass as 'human errors'; accordingly it would appear arbitrary to attribute the accident or incident to just one of these factors, without taking into account the process which causes them, and the interaction linking them.

At present research work is on the analysis of the risks linked to specific sectors—nuclear power plants, building and public works, etc—so as to seek not only an assessment of them, but, consequently, also, on the conception of the diagnosis, tools to arrive at this result.

These tools must satisfy several requirements:

- (1) To determine the *process* of the accident or incident.
- (2) *Open the field of prevention to multiple factors*, including ergonomic and organizational ones.
- (3) *Allow the establishment of data banks* on accidents and incidents.

One of these methods is discussed, with its benefits and limits, together with the prospects which it opens up for the study of human reliability in the framework of continuous processes. Its possible use in the nuclear sector is emphasized.

Life Stress and Occupational Injuries

By D. GLOSS
Communication Systems Division, GTE Products Corp., 77 'A' Street, Needham, Massachusetts 02194, U.S.A.

Life stress has been implicated in a number of diseases, including heart diseases and cancer. However, it has never been associated with occupational accidents. From a purely practical point of view, life stresses might be seen as directly causing a chain reaction which leads to an occupational accident which then results in a worker's compensation claim.

In a study of occupational accidents, the patients were asked to respond to a life stress scale. They were asked to check all items which applied to them in the year preceding the accident and in the year after the accident.

The results were compared with a control group of workers who had not sustained an occupational injury in the previous year. The patients did not significantly differ from the control group. Therefore, occupational accidents do not appear to have resulted from life stress. Life stress was correlated with two measures of physical impairment. The Pearson product moment correlation was not significant. There was a significantly substantial and statistical increase in life stress after the accidents which indicated that the accident induces life stress and not vice versa.

A Report About the Changes of Working Environment Conditions in Sweden

By C. NILSSON
The Swedish Trade Union Confederation, S-105 53 Stockholm, Sweden

To some extent the project was a repeat of an investigation from 1970. It was, therefore, possible to make comparisons between the research results of 1970 and 1980. The results are based on about 9000 members and safety delegates answers to inquiry questions. One of the main results is that ergonomic problems are still now, as in 1970, among the most widespread risks in the work environment. Comparison between the investigations of 1970 and 1980 also shows that members are more critical about work-environment conditions now than in 1970. This is probably because their knowledge about the working environment is better today than in 1970. But also, of course, real changes in conditions, for example technological changes, have contributed to the results. The most widespread ergonomic problem is heavy lifts and repeated movements. For many workers ergonomic problems seem to be combined with stress and monotony.

The Functioning of the Occupational Health Service in Scandinavia—on the Basis of Empirical Research in Norway and Sweden and Experience from a Field Research Project in Denmark

By O. RIEPER

The Institute of Organization and Industrial Sociology, The Copenhagen School of Economics and Social Service, 60 Howitzvej, DK-2000 Copenhagen F, Denmark

A. SAABY JOHANSEN

Department for Industrial Psychology, Technological Institute, Gregersensvej, DK-2630 Taastrup, Denmark

The past history of the occupational health service, the organization of the primary health care system, the industrial relations systems as well as the legalization of the occupational health system is different in Scandinavian countries. On the basis of these differences operating in a common cultural and political background the differences and similarities of the functions of the occupational health services (OHS) are compared.

The variation in composition of qualifications of the professional staff and the different professional ideologies are among the most decisive factors in limiting which tasks of the OHS are conducted. The tasks themselves differ particularly on the prevention–healing dimension, on the technological–medical dimension, on the organizational–technical dimension and on the collectively learning–individual informing dimension.

What kind of tasks are operative, however, depends not only on the characteristics of the OHS–professional group, as mentioned above, but also on how the workers and management of the enterprise meet the OHS. Their demand for OHS will depend on a range of factors such as strength and knowledge of the workers, the technological and economic premisses of the employer, and the character of the joint regulation system at the workplace. Data from the Danish field research project that support this proposition will soon be available.

The law and agreements, as well as the industrial relations system, do, however, set the overall national framework within which the OHS have to function. In Denmark the OHS is governed by the work–environment law, and the OHS is administratively isolated from the public health system. In Sweden the OHS is regulated by agreements between the national trade union and the employers' association as well as by the co-determination law. The administrative agents are the counties, which manage the public health system. In Norway the regulation of OHS is more divided among public agencies, but in general the OHS is close to the industrial system compared with Sweden, but is not legally prescribed as in Denmark. In Denmark the technical and ergonomical qualifications of the OHS are much greater than in the other two countries.

These national differences are related to the functioning and effects of the OHS in the three countries, showing how the operation of occupational health services is related to and depends on institutional and structural characteristics of these societies.

An Investigation on the Actual Conditions Pertaining to the Introduction of Ergonomics into Japanese Industries

By N. SHINHACHI

Department of Public Health, School of Medicine, Nihon University, 30-1, Ohayaguchikami-machi, Itabashi-ku, Tokyo 173, Japan

It is very important for the health care of industrial workers to apply ergonomics into the workshop. In order to make clear the actual conditions pertaining to the introduction of ergonomics into Japanese industries, questionnaires were distributed by direct mail, in the middle of October 1981, to 440 Japanese industries, which are members of the Japanese Association of Industrial Health. Replies were obtained from 188 industries.

The rate of response was 42.7%. Furthermore, the same questionnaires were sent to about 1000 minor industries which are situated in Itabashi-ward in Tokyo. The questionnaires consisted of ten large questions, namely, classification by the industry, number of workers, percentage of women workers, average age of workers, mean length of the service of workers, the year of establishment of the industry, whether ergonomics are introduced into the industry or not, kinds of ergonomics, manager in charge of the introduction and the effects of ergonomics on the workers. The items concerning ergonomics which were introduced into the workshop varied immensely, for example, design of man–machine system, method of work, working clothes, operation of machine, work shift, working hours, working stroke, on the job training, recreation and others. Some interesting findings could be obtained from this study.

The Tasks of an Industrial Physician

By J. I. KAMØY

Løvetannvn. 4, 2200 Kongsvinger, Norway

The Norwegian Association of Industrial Physicians has worked out instructions for the tasks of an industrial physician. The tasks are primarily of a prophylactic nature, in particular primary and secondary prophylaxis.

The industrial physician is to participate in all planning of conditions mentioned in the Act relating to worker protection and working environment, §§ 8, 11, 12 and 14, i.e. the physical framing of the working place as regards safety, health and welfare, production, packing, use and storage of materials hazardous to health, adjustment of the working place and current environment supervision.

Further, the physician is to participate in education and advise in health questions, undertake specific and selective health examination and other inquiries of a medical and biological necessity, and finally to carry the administrative responsibility for the rehabilitation of employees.

General health controls should be kept to a minimum and treatment of employees be limited. It is the establishment, not its employees, which is the industrial physician's patient.

Details on the above-mentioned paragraphs of the Act relating to working protection and working environment and the instructions will be presented more closely.

B4. Work Load and Performance of Car Drivers

The On-line Use of Driving Performance Measures to Detect Abnormal Driving Behaviour

By D. A. ATTWOOD and Y. A. NOY

Road Safety Unit, Transport Canada, Toronto, Ontario, Canada

This paper describes the research programme underway at the Road Safety Unit which is attempting to develop an on-line, vehicle-based technique for detecting abnormal driving behaviour.

The paper begins by reviewing the effects of common stressors on driving performance, particularly those occurring as the result of alcohol intoxication. Early efforts to develop ignition interlocks designed to inhibit drunk drivers are critically examined.

Current efforts are aimed at developing an on-line driver performance monitor. The results of general driving research are described which suggest that certain performance variables and analysis techniques could be used to develop a multivariate performance criterion to continually evaluate driver performance. An on-board, computer-based instrumentation system was developed on the basis of this review and a series of experiments that were conducted using this instrumentation system is reviewed. These experiments attempted to study driving performance under the effects of different stressors and to evaluate the real-time application of multivariate criteria.

Analysis on the Driving Operations of Drivers

By S. UENO, K. HANEISHI and M. NISHIKAWA

Osaka Institute of Technology, 5-16-1 Omiya, Asahi-ku, Osaka, Japan

This study analyses questionnaires on the driving operations of drivers confronted with various traffic situations. The questionnaire was conducted on 1200 drivers in the Kinki district, of which 400 were owner drivers, 400 were professional drivers (taxi and bus) and 400 were undergraduates. The items of investigation were braking, handling, accelerating and safety driving attitude, etc.

In the 8th Congress of IEA, the results of simple and cross analysis on the driving operations of drivers in various traffic situations are discussed.

Experimental Study on the Cognitive Process of Streetscape

By Y. KUBOTA

Faculty of Engineering, Saitama University, 255 Shimo-ohkubo, Urawa, Saitama 338, Japan

In order to elucidate the cognitive process underlying the visual experience of street environment from the viewpoint of an automobile driver, five types of experiment were conducted. Each experiment, except Experiment V, was based upon the momentary exposure of streetscape as external stimulus presented in the form of still colour slides projected on a screen. Several kinds of streetscape were selected typologically so as to reflect the variation of types in reference to existent townscapes in Japan.

In Experiment I, recollection of elements composing streetscape was expressed in a free verbal report. In Experiment II, the subjects were requested to sketch out elements borne in mind. Experiment III could be called an identification test, requiring the subjects to find the presented scene out of options. In experiment IV, the task was to search out the correct content of a signboard superimposed into the scene. Experiment V was a so-called semantic differential. Major observations and considerations are summarized as follows: streetscape is a sequentially assembled experience through the temporal focus of attention, that is, hierarchical gestalt composed of accumulated visual perception of figures. Elements perceived can be divided into two extremes; one is such that articulation of the gestalt into further figures terminates in a very early stage, and the other in a very late stage. Although focus of attention tends to vary with the condition around the figure and ground, fundamental components of street space are perceived in a very early stage. But paraphernalia on the streetside are not. The relationship between the overall verbal evaluation of a scene and its components was clarified quantitatively. Aesthetically good streetscape has an optimum saturation level of gestalt articulation, but the contrary does not apply.

Rural Road Delineation at Night

By T. J. TRIGGS

Department of Psychology, Monash University, Clayton, Victoria 3168, Australia

It is now commonly recognized that some form of visual augmentation over those cues that occur naturally is necessary to define the roadway ahead, particularly under night conditions. However, much of the current practice that has developed appears to be based on accumulated experience rather than systematic study.

The rural road situation most deserves attention as it is this environment that appears to be over-represented in both the frequency and severity of single vehicle accidents. These can be attributed at least in part to lack of pathway information.

Drivers tend to obtain visual information by taking visual samples over time. A field experiment is reported to evaluate driver visual sampling requirements under different rural road delineation conditions.

The use of a visual interruption apparatus forces drivers to perform to a limit by only allowing them to view the driving scene intermittently. The rate and pattern of these visual glimpses gives a measure of the sampling requirements for the various driving environments considered.

The results indicate that driver visual sampling was significantly affected by the delineation treatment independently of any specific informal delineation cues. The effect of delineation was shown to be most marked when the potential sight distance along the road was relatively large, but has less influences when close to crests and curves.

Effects of Fatigue and Drugs on Driving Performance

By K. YAJIMA, K. AOKI, T. AOKI, N. YAMANOI, H. TANAKA, S. KINOSHITA and T. FURUKAWA

Institute of Medical Electronics, Faculty of Medicine, University of Tokyo,
7-3-1 Hongo, Bunkyo-ku, Tokyo 113, Japan

As a criterion to evaluate the effects of fatigue and drugs (alcohol and antihistamine substance), a multiple regression formula was proposed. The data observed were (1) critical flicker fusion frequency, (2) systolic blood pressure, (3) diastolic blood pressure, (4) select reaction number and (5) tapping number.

The effect of fatigue of long-term driving was observed in a highway test course. Other experiments on alcohol drinking and antihistamine substance were done using an automobile drive simulator.

In the alcohol drinking group, the relation between RAL (respiratory alcohol level) and the physico-psychological data (including driving performance indices) was analysed by multiple regression analysis. The equation obtained is as follows:

$$\text{RAL} = -0.0195 \times \text{CFF} - 0.0012 \times \text{Syst.B.P.} + 0.0006 \times \text{Diast.B.P.} - 0.0293 \\ \times \text{Sel.R.Num.} - 0.0013 \times \text{Tap.Num.} + 1.74$$

Multiple correlation coefficient was 0.765.

In former experiments, it had been found that the effect of fatigue physico-psychological pattern is very close to that of alcohol drinking. Assuming the multiple regression for RAL is able to be applied to the other conditions, the data obtained from a 15-hour long-term driver suggested driving performance reduced to the level of alcoholic intoxication, i.e. estimated RAL of a 15-hour driver was almost 2.5 mg/l.

Autoregressive Analysis of Highway Driving Performance by a Simulator

By S. KINOSHITA, K. YAJIMA, K. AOKI, H. TANAKA, T. AOKI, N. YAMANOI and T. FURUKAWA

Institute of Medical Electronics, Faculty of Medicine, University of Tokyo, 7-3-1 Hongo, Bunkyo-ku,
Tokyo, Japan

Human performance in automobile driving was investigated, from the viewpoint of man-machine interaction, by using autoregressive time series analysis.

To observe driving performance, an automobile driving simulator was devised. The simulator was composed of (1) a driving operation unit in which the steering wheel, accelerator pedal and other operation parts were easily accessible and (2) a video projected screen which displayed the frontal view of the driver which moved coincidentally with the driving operation. The following mechanical and physiopsychological data were recorded in the course of a 15 min driving experiment: (1) the deviation of the simulator automobile location, (2) the angle of the steering wheel, (3) EMG of the upper brancium, (4) ECG, (5) EOG, (6) GSR and (7) respirogram. The dynamical correlations among these data were analysed by applying the multiple autoregression model. Driving performances were separately evaluated into cases of (1) well-skilled, (2) unskilled and (3) alcohol drinking drivers.

Main results were as follows:

- (1) Five to ten orders of autoregression models are sufficient to describe the dynamics of all measured data.
- (2) In the case of an alcohol drinking driver, the spectrum of the steering wheel showed a high frequency resonance peak, which accounts for the periodic instability of driving operation.
- (3) The spectrum of the respirogram showed a good correlation with driving operation stability.

Evaluation of Vehicle Steering Control Characteristics by Skin Resistance Level and Heart Rate

By T. SAWADA

Shibaura Institute of Technology, 307 Fukasaku, Omiya-shi, Saitama 330, Japan

This study, with vehicle phase-lag which is the important response parameter of steering response characteristics as the object, conducted the evaluation of driver's mental burden by skin resistance level (SRL) and heart rate (HR). It also examined the interrelation with control performance, control contents and subjective rating on which research has so far been made.

Two kinds of experiments were made; steering simulator test using analog computer and steering control test with the driving test stand carrying an actual vehicle. In the former experiment, follow-up control was conducted using oscilloscope by steering system of proportion, an integral and an integral of the second order. Then the relationship between these steering systems and responses of SRL and HR was studied. The bigger the phase-lag involved in the steering system, the more changes could be seen in the responses of SRL and HR. As SRL response changes according to individual consciousness level, it is essential to take various things into consideration when fixing the condition of the experiments.

In the latter experiment, follow-up control was made with a driving test stand carrying a variable steering response vehicle which could change the phases of steering control characteristics. Phase-lags of steering system were set at four different kinds. The desired values used two sorts of random frequency and steps.

The analyses revealed that the smaller the phase-lags of the vehicle, which was the important response parameter of steering control response, the less changes were seen in SRL and HR, and the smaller was the mental burden on drivers. It also showed that there are certain correlations among the control performance represented by ITAE or settling time, the control contents in which steer angle or lateral acceleration were represented by power spectral density, crossover model, which is examined based on transfer function of drivers and vehicles, subjective rating and SRL or HR.

Evaluation of the Arousal Level of Automobile Drivers Based on Their EEG, etc.

By T. YANAGISHIMA

Central Engineering Laboratories Nissan Motor Co. Ltd. 1-Natsushima-cho, Yokosuka, Japan

In our study, we have tried to determine the arousal level quantitatively and investigate the relationship between the arousal level of human beings and the ability to maintain control. From our study, we have determined the stage of the arousal level beyond which is dangerous.

We selected three physiological elements; EEG (electro-encephlogram) α wave component, blinking and facial expression as the characteristics most truly representative of the arousal level. Quantitative determinations were made by ranking the characteristics of these elements according to the changes in the arousal level. The total sum of the ranking marks of all of the elements was used as an index to the arousal level. This index was divided into nine stages.

Then the arousal level and the corresponding ability to maintain control were investigated by using a tracking tester and a drive simulator.

Tracking is a test in which a follow up point moves in a circle on a Braun tube and the subject attempts to follow it by operating a steering wheel and an accelerator. We prepared three different circulating cycles for the target.

Fatigue of Bullet-train Drivers Operating on Multi-tunnelled Sections

By A. WATANABE, K. KOGI, N. ONISHI, H. SHINDO and K. SAKAI

Institute for Science of Labour, 1544 Sugao, Takatsu-ku, Kawasaki 213, Japan

Effects on drivers of driving a high speed electric railcar train with a maximum speed of 210 kmh were studied. The driving time was about 260 min passing through 145 tunnels. Manual operation concentrated on departure and arrival, while operations during high-speed running were infrequent with only 0.67 times/min. This resulted in increased mental strain when arriving at stations, with a sharp rise in systolic blood pressure. Ear discomfort frequently disturbed the drivers as intra-cab air pressure fell steeply when passing through a tunnel. Nevertheless, the generally monotonic driving situation through tunnels caused lowered heart-rate levels in the second and later hours. This was in agreement with low flicker fusion levels, increased subsidiary motions and delayed response to secondarily given auditory signals. Drowsiness occasionally occurred with increased blinking rates and with specific electroencephalographic changes. Fatigue feelings were noted especially for drowsy-dull and mental components. As sleeping hours during an overnight stay at the destination were shortened by about 2 hours, driving back on the following day unfavourably influenced the driver's conditions. These results pointed to the need of airtight cabs, measures against monotony and improved work schedules for bullet-train drivers.

B5. Traffic Systems and Vehicle Design

Holding Performance of Automobile Seats

By M. SANO

Shibaura Institute of Technology, 307 Fukasaku, Omiya-shi, Saitama 330, Japan

The present study evaluates automobile seat holding performance from the viewpoint of stable holding of body position, by measuring body displacement under lateral force, using seven sample seats.

Generally, human bodies are relatively displaced to seats in two cases, i.e. where external force is applied to seats and inertia force is applied to the human bodies on the seats, and where man moves intentionally. In the present study, the scope is limited only to the body displacement under external force.

Experiments were made with the upper torsos of subjects pulled laterally in the same way as the action of inertia force, and with the seats inclined laterally to apply lateral acceleration to the bodies.

Preliminary experiments were made photographically measuring the relative displacement of lower neck, right and left shoulders and abdomen, and studying the displacement in relation to the applied lateral acceleration, and as a result, the lower neck was found to be the position suited for measurement in actual experiments.

Experiments were made with the subjects in three levels of muscle tension intensity; relaxation, normal and tension.

The experiments showed that with some seats, the change of muscle tension level had a great influence on lateral force, body displacement correlation, while with other seats the change of muscle tension level had only a small influence.

On the other hand, four seats with particularly large estimated difference of holding performance were selected, and with these seats, mounted on cars driven on courses containing many curves, feeling tests were conducted. In the tests, paired comparison method was used for the evaluation of feeling, and eight researchers and designers of automobile seats were selected as test subjects.

Comparison of the results of the feeling tests and those of the displacement experiments showed that certain combinations of muscle tension levels, lateral force and human body displacement conformed to the results of the feeling test.

A Study of 'Driving Position' in Passenger Vehicles

By T. SUGIMOTO

Nissan Motor Co. Ltd., 560-2 Okatsukoku, Atsugi, Kanagawa, Japan

'Driving position' (D.P.) means driving posture decided by the specification of a seat and main controls for driving, which are, for instance, height and depth of a seat, diameter of a steering wheel, locations of pedals or mission control and so on.

This paper described how to establish the appropriate D.P. of a passenger vehicle accommodating many people, in view of operating property and muscle fatigue.

We studied as follows:

- (1) Each subject adjusted and selected the locations of main controls in the seating rig installed with an adjustable device for control, and decided his own favourite D.P.
- (2) While each subject operated the controls, his motions were observed and analysed by cine-camera, and also his muscle actions of his arms or legs were recorded by EMG (electromyogram).

As the results of these studies, we have found how to establish the appropriate D.P. of each driver according to his physical constitution, utilizing the sensory evaluation method and EMG.

Design of a Vehicle for Mail Delivery. An Ergonomic Study

By M. BJÖRKSTÉN, D. CAPLE, S. CARLSÖÖ, P. FRIEDRICH and J. E. HANSSON

Work Physiology Unit, National Board of Occupational Safety and Health, S-171 84 Solna, Sweden

In 1978-80 a comprehensive study of the physical workload of Swedish postmen was carried out at the Work Physiology Unit of the National Board of Occupational Safety and Health. The study was initiated by the Swedish Postal Department (S.P.D.) and the trade union of the postmen.

One part of the study, presented here, was devoted to working conditions from an ergonomic point of view. Since 1968, the S.P.D. has used a vehicle for mail delivery in urban housing areas. The care used is an Opel Kadett Caravan modified by the Company according to the requirements of the S.P.D.

Field studies of the mail delivery by car showed that the car could be improved from an ergonomic point of view.

Therefore stepping heights, the door and window of the driver as well as the placement of the steering wheel and the letter tray in the cabin were studied in the laboratory, using a rig constructed for the purpose. These problem areas were studied, employing video tape-recording and time studies of and subjective assessments by 21-24 postal drivers.

Based on the studies and on earlier investigations recommendations were made regarding stepping height from the ground to the cabin, dimensions of the cabin, door and windows, design and location of the driver's seat, visual field available to the driver, mail storage in the cabin and location of regulators and steering wheel.

These recommendations should also be applicable to other distribution vehicles used in similar functions.

Improvement for Visibility of Drivers of Large Trucks to Prevent Unsafe Turning to the Left

By S. HORINO

Department of Industrial Engineering, Faculty of Technology, Kanagawa University, 3-27-1, Rokkakubashi, Kanagawa-ku, Yokohama-shi 221, Japan

There is growing concern about serious accidents caused by large trucks when turning left at a crossing. More than 100 fatal cases have been reported annually. Poor visibility from the driving seat was examined by means of a fish-eye lens and eye movement recorder. Visibility from a cab-over truck seat proved to be poorer than from a bonnet-type truck seat with respect to the area directly at the truck sides and the back. This contrasted with better visibility in the case of a ladder-mounted fire engine or a German-made sight-seeing bus. A person standing quite close to the front-left or left side of the vehicle could hardly be recognized by the driver due to the cab structure of a high eye position, 2.5 m above the ground, and a broad width. Three mirrors mounted on the left corner of the truck did not reduce this blind area sufficiently. Most truck drivers who replied to our questionnaire were unaware of this broad blind area. Eye movements of the driver to the left side were found to be inevitably limited in terms of frequency and duration of fixation, because he had to pay attention to the on-going traffic. An experimentally designed low-cab truck realized wider direct visibility from the driver's position and reduced the blind area. A Fresnel lens attached to the left window of the cab also reduced the blind area. It is essential to secure direct visibility towards pedestrians and bicycle riders along the left and front side of a large vehicle.

Ergonomic Aspects of Operator Cabs on Earth Moving Machines

By M. P. VAN DER GRINTEN and C. K. PASMOLIJ

Netherlands Institute for Preventive Health Care (TNO), P.O. Box 124, 2300 AC Leiden, The Netherlands

Work methods, layout of workplaces and tools used in the building and road construction industry in general do not meet recent standards of ergonomics. The Dutch Government (following German and Swedish developments) in 1982 extended the legislation on the quality of work and working conditions; in the near future more attention will be given to ergonomics in the building industry, as well.

Studies on ergonomic aspects of operator cabs on machines used in this industry are carried out in co-operation with the Dutch Foundation for Occupational Health in the Building Industry (BG Bouw).

Tower cranes and mobile cranes were subjects of previous studies, while different categories of earth moving machines (EMMs) were the subjects in the study reported here. The categories involved were: wheel-loaders, hydraulic excavators, backhoeloaders, bulldozers, graders and draglines. The objective of these studies is to formulate guidelines for ergonomically-designed cabins on different kinds of machines. Main criteria are: the increase in safety and comfort of the operator, the decrease of unnecessary fatigue and the safeguarding of occupational health.

Three methods were used. New machines were investigated by means of an ergonomic checklist. Operators were interviewed by using a semistructured questionnaire. Additionally noise and vibration measures at the operator position during work as well as some workplace dimensions were determined. In general the results show a lot of shortcomings from the ergonomic point of view; however, earth moving machines rate on average better than mobile and tower cranes.

Some specific results are discussed. High levels of noise in most of the cabins and high levels of whole body vibration in cabins of wheel-loaders can cause health problems. Special attention is given to aspects of visibility, workplace layout and control design.

Visibility is a very important factor for these machines; some reported driving and slewing accidents were due to lack of good visibility. Seat position in relation to the position of hand or foot controls as well as dimensions of cabin can hamper operational activities, especially in wheel-loaders and excavators of very low capacity with small overall dimensions.

Some remarks on pedals and handles are made, e.g. lack of standardization in allocation of functions and high control forces, causing unnecessary muscular fatigue. Finally, attention is given to the anthropometric data of young Dutch people.

On the basis of the results, existing standards and recent developments in standardization, recommendations for ergonomically well-designed cabins were made, of which some examples are presented.

Evaluation of a Set of Graphic Symbols

By H. J. ZWAGA

University of Utrecht, Psychological Laboratory, Varkenmarkt 2, 3511 BZ Utrecht, The Netherlands

A matching procedure to evaluate the efficiency of a coherent set of graphic symbols for public information in railway stations is proposed. In this matching procedure a referent is specified to a respondent, and he is asked to select the appropriate symbol from the complete set of symbols shown to him.

Data were collected in such a way that the effects of age and travel experience could be evaluated separately. A total of 29 symbols was evaluated using 11 600 railway passengers as respondents.

The results show that only half the number of symbols meet a criterion of 67% correct responses. Both increasing age and a low level of travel experience have a deteriorating effect on understanding the symbols. In addition to the percentage correct responses, analysis of the confusions between symbols allows more detailed assessment of the causes of a low efficiency of a symbol or a group of symbols. It is demonstrated that, based mainly on the measured confusions between symbols, proposals for the redesign of symbols can be formulated.

The Use of Routing Information in a Public Environment

By H. J. ZWAGA

University of Utrecht, Psychological Laboratory, Varkenmarkt 2, 3511 BZ Utrecht, The Netherlands

The purpose of this field study was to determine the effectiveness of some basic rules for the design and positioning of routing information in railway stations.

The need for more definitive evidence of the usefulness of these rules was considered desirable when an extension was planned for one of the main railway stations in The Netherlands. Analysis of the future situation in the station indicated that signposting the route to one pair of platforms would conflict with both architectural and traffic flow features of the route.

The study, to evaluate current user behaviour, was conducted in three phases. In phase 1 the frequency of use by travellers of the original signposted route to the platforms was determined, and also of an alternative, unsignposted, route to the same platforms. This alternative route would be the re-signposted route once the extension of the station was completed. After collecting the data for phase 1, the signposting in the station was changed so as to comply with that signposting proposed for the situation after completion of the extension.

In phase 2, conducted some time after the implementation of the proposed new signposting, the frequency of use of the two routes to the pair of platforms was again determined.

In phase 3, some months after phase 2, the frequency of use of the two routes was again determined. Comparison of the results of phases 1 and 2 showed that the new (proposed) signposting only affected the choice of route of the inexperienced travellers. It proved more difficult to follow the new route than the old route, since twice as many travellers made detours in the new route than in the old route. Comparison of the results of phases 2 and 3 indicated that the change in signposting resulted in a gradual change in the choice of route of the experienced travellers.

It is concluded that the use of some basic rules to decide on the content and positioning of routing information is effective even under adverse environmental conditions.

Standardization of Public Information Symbols

By H. J. ZWAGA

University of Utrecht, Varkenmarkt 2, 3511 BZ Utrecht, The Netherlands

In this paper the development of the ISO testing programme for public information symbols is described. Two decisions taken by Technical Committee 145 of the International Organization for Standardization characterize all the work in relation to the standard.

- (a) The standard will be restricted to a verbal description of the image content for a symbol; no symbol as such is going to be standardized.
- (b) The selection of the standard image content for a symbol on proper evaluation of any proposals to guarantee that the user population will comprehend the symbols.

The development and evaluation procedure implemented after some 6 years of evaluation consists of two parts. The first describes how to use three test procedures to arrive at an image description for a symbol. The second part of the procedure involves the graphic design of symbols to conform to the actual design to the standardized image content.

Is Selective Traffic Code Enforcement Practical? A survey of Canadian Traffic Police

By G. F. RABIDEAU and MAN-LAI YOU
University of Waterloo, Ontario, Canada

and G. SMITH
Transport Canada

Prior investigations have quantitatively demonstrated that certain driving infractions of traffic (safety codes, or laws are 'riskier' than others, also that frequencies of given traffic violations tend to be inversely related to perceived and actual hazard incurred. Some methodological development also has been done to assess the practicality of 'selective traffic enforcement' programmes by traffic police. The general approach would be to increase the rates of citation, or arrest for given violations, while (possibly) decreasing such rates for other violations. The ultimate objective, of course, would be to exert a beneficial effect on traffic safety, e.g. minimize the total accident cost burden attributable to moving traffic violations.

However, the ultimate success of the above kind of strategy could depend on the perceived and/or actual ease of obtaining convictions for the selected violations as well as the perceived degree of hazard of any given violation in the eyes of the traffic constables involved. Hence, the Canadian Department of Transport designed and conducted a questionnaire survey of opinions and attitudes to traffic police in various provinces and cities. Replies from a total of 105 respondents compose the responses discussed in this paper. The survey form consists of nine major items, the majority of which elicit open-ended opinion responses. Five of the items request ratings, e.g. of degree of detrimental influence of reasons listed by any respondent as determinants of number and type of charges laid. The most important results and inferences are covered in the paper.

With respect to the reasons which respondents gave as influences on the number of charges laid, four dominant dimensions emerged from the response data base. Phrased as questions, they are: how serious is the infraction? Can the violator be safely apprehended? How difficult is it to get a conviction? And is the penalty worth the time involved? As deterrents to charging, all of the above 'reasons' were rated among the top half in terms of rated degree of deterrent influence.

Violations which respondents rated as having relatively low probabilities of obtaining convictions are predominantly those for which (according to analysis of 'reasons' given by the constables) judicial requirements re. evidence or judicial biases towards dismissal of charges were deemed most influential. To some degree the opposite appears true, i.e. those violations rated as having relatively high conviction probabilities (e.g. speeding as measured by radar) yielded reasons indicating that evidence requirements did not impose conviction deterrent.

Rank correlation of violations' ratings with respect to likelihood of conviction vs. likelihood of laying a charge for a given violation yielded a significant relationship. Hence, it would appear that the judicial system is a major determinant of what violations are most/least often charged.

Respondents' perceived estimates of relative economic costs of accidents attributable to each of 10 listed violations (0 = 'none of the money', 10 = 'all of the money') reveals that *careless driving* and *speeding* were considered the riskiest, with *following too closely* and *running a red light* of above median risk.

This paper also examines the practicability of selective traffic enforcement in terms of ergonomic prerequisites for its eventual successful implementation by traffic enforcement personnel. It would now seem that it comprises a 'system' problem having, as components, (1) organizations, e.g. police, judicial, driving public, (2) legislation, (3) environment and (4) equipment, etc., and their interactions on the attitudes and decision processes of both police and motorists.

B6. Human Error

A Study of Human-error Caused by Drug Naming

By F. TSUCHIYA
Hospital Pharmacy Faculty of Medicine, University of Tokyo, 3-1, Hongo 7-chome, Bunkyo-ku,
Tokyo 113, Japan

In this paper, the path from the doctor's decision for drug therapy until the drug is given to a patient is regarded as an information transmission system. The causes of human-error which corresponds to a noise in the communication path and bring about incorrect message transmission are analysed and considered.

That is:

- (1) An analysis of human-error factors in this information transmission system.

- (2) Some examples of confusion in the prescribing process: they are divided in two, one related to unsystematized drug naming and the other to mistranslation between Japanese and English, i.e. the same pronunciation in Japanese but different spellings in English.
- (3) Proposal of a systematized drug naming method necessary for the real safety of a drug.

Signal Vigilance Errors by Railway Drivers

By S. HAGA
Railway Labour Science Research Institute, 2-5-6 Izumi-cho, Kokubunji-shi, Tokyo 185, Japan

Emerging mechanism of signal vigilance errors by railway drivers is analysed through case studies and experiments, and some effective preventive measures are presented.

Every year on the Japanese National Railways, approximately six accidents are reported which are caused by human errors on the occasion of train departure. While signalmen, station masters, train conductors, etc., are also responsible for this kind of accident, the errors of the drivers who directly operate the trains are explicitly the most important to investigate.

In the case of electric trains, the motorman ought to confirm the clear signal and begin the starting operation after receiving the sign of departure presented by a small light in the motorman's cab. But it is suspected that the motorman might possibly start the train without confirming the departure signal is clear, especially when he is psychologically in haste or attending to other things. The signal is almost always cleared before the sign of departure is presented to the motorman; signs and signals are considerably redundant. Consequently it is hypothesized that the redundancy facilitates the tendency to respond automatically.

In the first experiment the information from signs and signals is completely redundant during the first half of the 200 trials, and the error responses provoked by false signs in the latter half of the experimental session are analysed. Error rates under controlled various redundancies are examined in the second experiment. The results demonstrate that automatic information processing caused by repetition of the task and by redundancy of information reduces the vigilance ability of the operator and leads to errors and accidents.

In the successive experiments the subject's eye movement is recorded under the dual task method to seek the most effective preventive measures.

Personal Error of Visual Judgement in Precision Measurement

By K. TANAKA
Keiryō Kenyūjo, 1-1-4, Sakura-mura, Niihari-gun, Ibaragi-ken, Japan

Many measurements, particularly calibrations of measuring instruments, are made by observers or operators in spite of the general tendency of automatization. In these measurements the data have an error due to human factors, and this error is frequently not negligible. The main cause of human error is personal error. The eye and hand are an interface in the man-machine system of measuring instrument and observer, and visual judgement strongly influences the result of measurement. In this paper personal error is caused by visual judgement in the measurement.

The measurement of the diagonal length of an indentation in the Vickers hardness test using the usual eye-piece of a microscope is a typical case which has a large amount of personal error. A series of experiments is made to explain the mechanism of appearance of personal error in this measurement. These experimental results make it clear that personal error is caused by individual differences of visual acuity, which consists of two abilities, one is minimum visual threshold and the other is minimum resolving threshold. After the above study a new improved micrometer eye-piece is used which succeeds in decreasing personal error. This new method frees visual judgement from the resolving power.

Visual interpolation between two scale lines is the most common visual judgement in measurement. Personal error occurs in this case too, and it becomes clear from the experimental results that the error comes from individual differences of optical illusion.

In the microscopic measurement, the image of the objective lens has shade in the edge of it by optical disturbance, and this shade causes personal error. The experimental results show that this error comes from the difference of inner standards in the judgement of the observer.

Reliability of the Human Operator in Man-Machine Systems

By M. IGUCHI

Department of Mechanical Engineering, University of Tokyo, 7-3-1 Hongo Bunkyo-ku, Tokyo 113, Japan

It is well known that many causes of failure in man-machine systems originate in the human operator. As the first step to evaluating man-machine system reliability at a design stage, the operator's reliability in simple logical judgement work was measured experimentally and analysed.

For fundamental logical works, six logical gates of AND, OR, NAND, NOR, EXOR and EXNOR were selected. After one of the six gates and two inputs to the gate are displayed in a CRT display, the operator has to push one of the answer buttons 0 or 1 as soon as possible.

The results showed that the mean judgement time, the deviation of it and the error rate are smallest in AND and OR gates. The logical judgement of AND and OR seemed well trained in daily activity. NAND and NOR showed the longest mean judgement time and deviation of it, and the largest error rate. EXOR and EXNOR are intermediate.

About 90% of the errors are found by the operator soon after a miss operation of the answer button, and can be corrected by a correct button if devised.

For each of the six logical gates computer models to calculate the judgement time and the error rate as a function of allowable working time were made, two logical judgement works which were composed of six and twelve gates were simulated by a computer, and the results were compared with the experiments.

Psychophysiological Criteria in the Analysis of Hypovigilance in Control Rooms

By J. C. ROUHET

ERGOS: Société d'Etudes et Réalisations en Ergonomie, B.P. 42, 77201 Marne-La-Vallee, France

Vigilance in surveillance tasks varies with many factors including characteristics of the individual, the environment in which he works, the job he does and particularly the data with which he deals.

The term hypovigilance is used to describe the case in which operator performance is characterized by an elevation in reaction time and in frequency of omissions. This situation appears to arise not only with 'information overload' but also in other circumstances in which the data does not require action, is insufficient to keep the operator alert and so on.

Many vigilance studies concern outmoded data presentation devices, in systems of limited automatization and their relevance to today needs to be examined. The usefulness of psychophysiological measures of long duration, needs, equally, to be considered.

The present study examines the characteristics of data presentation and man-machine dialogue which influence performance. Their repercussions on the level of vigilance of the operator are determined by measuring performance (detection rate and reaction time) and psychophysiological parameters in the 24-hour cycle.

The research covers two phases: the experimental phase in the laboratory and exploitation in real control rooms. It also evaluates the value of psychophysiological criteria in the analysis of vigilance levels and specifies guidelines for data presentation and man-machine dialogue in control rooms in order to avoid hypovigilance.

A Case Study on a Plant Factory from the Human Factors Point of View

By K. HASHIMOTO, M. AOKI and Y. HORIE

1-2-1, Izumi-cho, Narashino, Chiba, Japan

Some reports have been published on the TMI-2 accident by authoritative organizations and institutes, but, unfortunately, lots of uncertainties and differences can be seen in those reports. As for the direct cause of the accident, there still exist some quite different and sharply divided opinions, one depending mainly on misjudgement and wrong operation performed by system operators and another on inappropriate design of the fundamental system. However, it seems undoubtedly true that human error has some vital and important role in the TMI-2 accident, and, therefore, correct and appropriate analysis based on human factors research is to be introduced in order to evaluate it objectively. A case study of the accident at the factory mentioned above is carried out through application of the proposed analysing methods for human error accident by the Japanese Ergonomics Research Society to try to find out the correct, reliable and latent reasons for the accident.

Analytical Procedures on Causes of Human Errors in Plant Accidents

By K. HASHIMOTO, M. MORIOKA and M. AOKI

Department of Hygiene, Nihon University School of Medicine, 30 Ohyaguchi-Kamimachi, Itabashi-ku, Tokyo 173, Japan

According to a survey report on the causality of accidents in the Japanese petro-chemical industrial zone, the ratio of accidents attributed to errors by operators amounted to 30-40% of the total cases even in the most modern automated plants. We should note that there is still a tendency to blame inattention or inexperience of those operators, resulting in the larger emphasis on safety education alone. True safety cannot be achieved, however, without eliminating physically and materially unsafe factors and improving production systems. It is, important, therefore, to develop a method of relating human errors to such countermeasures. Analytical procedures dealing with causes of operators' errors are proposed on the basis of a scheme of information processing in the brain. The procedures examine information processing activities in the following three aspects. First, where and how the operator error occurred must be identified, considering the whole process of information handling from reception and recognition of the required information, to selection and verification with respect to previous memories, to decision making and output control. Second, the cerebral activity level at the moment of error and its category should be described. Third, the multiple factors in the environment and in the production system are to be analysed as potential causes leading to the accident in question. A flow chart developed by Hashimoto is used in showing the outbreak of the accident, changing situations in the environment, the time scale and human behaviour at all possible moments. These procedures have proved useful in detecting the most probable causes of human errors and pointing to preventive countermeasures.

Hazard Analysis in Japanese Chemical Industrial Complexes Especially on Human Errors

By Y. HAYASHI

Faculty of Engineering, Keio University, 3-14-1 Hiyoshi, Kohoku-ku, Yokohama 223, Japan

Accidents in the Japanese chemical industrial complexes at the Tchiba, Mizushima, Sakai-Senpoku, Yokkaichi, Kashima and Tokushima-Ohtake areas are examined from the past to the present. Comparisons with the number of accidents caused by hard errors and soft errors were made; where the hard errors are defined as the faults of the machines and facilities, and the soft errors as human errors and the faults of the systems. The results may be summarized as follows: the ratio of the number of accidents caused by the hard errors to the soft errors is about two to three in all areas.

Correlations between the factors in hard errors and in soft errors are investigated by the method of multivariable analysis, and interesting results are obtained.

Using the data obtained from a questionnaire on the latent accidents from about 200 workers engaged in chemical industries, comparisons with the causes of the latent accidents and the accidents exposed by human errors were made, the results agree approximately with the causes of the accidents exposed.

Fuzzy Fault Tree Analysis for Accident Caused by Human Errors

By K. NOMA, H. TANAKA and K. ASAI

Department of Industrial Engineering, University of Osaka Prefecture, Sakai, Osaka 591, Japan

The Fault Tree is useful for analysis of the cause of an accident. This paper proposes the Fuzzy Fault Tree Analysis in which vagueness of human factors is handled by using the idea of fuzzy truth value proposed by L. A. Zadeh (1975). In treating man-machine systems by using the fault tree, human factors might be included in basic events. Ambiguity exists in human factors in nature. For instance, in reading the value of a meter, it is possible to take 10 or 11 mm for 10.5 mm. This is vagueness of recognition. In saying that a machine is overheated, the verbal expression 'overheat' is very fuzzy. Someone means over 80°C but someone else means over 100°C. This is ambiguity of linguistic expression. Therefore it is impossible to define human factors without taking this ambiguity into account. This ambiguity can be well-treated by using the idea of fuzzy truth values. Treating fuzzy truth values leads to a fuzzy linguistic logic in which the ambiguity of verbal expression is expressed as a fuzzy set on interval [0, 1]. In a Fuzzy Fault Tree, the ambiguity of basic events propagates to the ambiguity of upper events. This propagation can be expressed by mapping from basic events into upper events. The fuzzy truth value of upper events can be calculated from the fuzzy truth value of basic events by using an extension principle. The calculation procedure is shown by an example of a manufacturing system. This application of fuzzy truth values to the Fuzzy Fault Tree is effective in evaluating how the fuzziness of basic events influences upper events, and in evaluating the fitness of verbal expression for the events caused by human factors.

Reliability of the Human Operator in Man-Machine Systems

By M. IGUCHI

Department of Mechanical Engineering, University of Tokyo, 7-3-1 Hongo Bunkyo-ku, Tokyo 113, Japan

It is well known that many causes of failure in man-machine systems originate in the human operator. As the first step to evaluating man-machine system reliability at a design stage, the operator's reliability in simple logical judgement work was measured experimentally and analysed.

For fundamental logical works, six logical gates of AND, OR, NAND, NOR, EXOR and EXNOR were selected. After one of the six gates and two inputs to the gate are displayed in a CRT display, the operator has to push one of the answer buttons 0 or 1 as soon as possible.

The results showed that the mean judgement time, the deviation of it and the error rate are smallest in AND and OR gates. The logical judgement of AND and OR seemed well trained in daily activity. NAND and NOR showed the longest mean judgement time and deviation of it, and the largest error rate. EXOR and EXNOR are intermediate.

About 90% of the errors are found by the operator soon after a miss operation of the answer button, and can be corrected by a correct button if devised.

For each of the six logical gates computer models to calculate the judgement time and the error rate as a function of allowable working time were made, two logical judgement works which were composed of six and twelve gates were simulated by a computer, and the results were compared with the experiments.

Psychophysiological Criteria in the Analysis of Hypovigilance in Control Rooms

By J. C. ROUHET

ERGOS: Société d'Etudes et Réalisations en Ergonomie, B.P. 42, 77201 Marne-La-Vallee, France

Vigilance in surveillance tasks varies with many factors including characteristics of the individual, the environment in which he works, the job he does and particularly the data with which he deals.

The term hypovigilance is used to describe the case in which operator performance is characterized by an elevation in reaction time and in frequency of omissions. This situation appears to arise not only with 'information overload' but also in other circumstances in which the data does not require action, is insufficient to keep the operator alert and so on.

Many vigilance studies concern outmoded data presentation devices, in systems of limited automatization and their relevance to today needs to be examined. The usefulness of psychophysiological measures of long duration, needs, equally, to be considered.

The present study examines the characteristics of data presentation and man-machine dialogue which influence performance. Their repercussions on the level of vigilance of the operator are determined by measuring performance (detection rate and reaction time) and psychophysiological parameters in the 24-hour cycle.

The research covers two phases: the experimental phase in the laboratory and exploitation in real control rooms. It also evaluates the value of psychophysiological criteria in the analysis of vigilance levels and specifies guidelines for data presentation and man-machine dialogue in control rooms in order to avoid hypovigilance.

A Case Study on a Plant Factory from the Human Factors Point of View

By K. HASHIMOTO, M. AOKI and Y. HORIE

1-2-1, Izumi-cho, Narashino, Chiba, Japan

Some reports have been published on the TMI-2 accident by authoritative organizations and institutes, but, unfortunately, lots of uncertainties and differences can be seen in those reports. As for the direct cause of the accident, there still exist some quite different and sharply divided opinions, one depending mainly on misjudgement and wrong operation performed by system operators and another on inappropriate design of the fundamental system. However, it seems undoubtedly true that human error has some vital and important role in the TMI-2 accident, and, therefore, correct and appropriate analysis based on human factors research is to be introduced in order to evaluate it objectively. A case study of the accident at the factory mentioned above is carried out through application of the proposed analysing methods for human error accident by the Japanese Ergonomics Research Society to try to find out the correct, reliable and latent reasons for the accident.

Analytical Procedures on Causes of Human Errors in Plant Accidents

By K. HASHIMOTO, M. MORIOKA and M. AOKI

Department of Hygiene, Nihon University School of Medicine, 30 Ohyaguchi-Kamimachi, Itabashi-ku, Tokyo 173, Japan

According to a survey report on the causality of accidents in the Japanese petro-chemical industrial zone, the ratio of accidents attributed to errors by operators amounted to 30-40% of the total cases even in the most modern automated plants. We should note that there is still a tendency to blame inattention or inexperience of those operators, resulting in the larger emphasis on safety education alone. True safety cannot be achieved, however, without eliminating physically and materially unsafe factors and improving production systems. It is, important, therefore, to develop a method of relating human errors to such countermeasures. Analytical procedures dealing with causes of operators' errors are proposed on the basis of a scheme of information processing in the brain. The procedures examine information processing activities in the following three aspects. First, where and how the operator error occurred must be identified, considering the whole process of information handling from reception and recognition of the required information, to selection and verification with respect to previous memories, to decision making and output control. Second, the cerebral activity level at the moment of error and its category should be described. Third, the multiple factors in the environment and in the production system are to be analysed as potential causes leading to the accident in question. A flow chart developed by Hashimoto is used in showing the outbreak of the accident, changing situations in the environment, the time scale and human behaviour at all possible moments. These procedures have proved useful in detecting the most probable causes of human errors and pointing to preventive countermeasures.

Hazard Analysis in Japanese Chemical Industrial Complexes Especially on Human Errors

By Y. HAYASHI

Faculty of Engineering, Keio University, 3-14-1 Hiyoshi, Kohoku-ku, Yokohama 223, Japan

Accidents in the Japanese chemical industrial complexes at the Tchiba, Mizushima, Sakai-Senpoku, Yokkaichi, Kashima and Tokushima-Ohtake areas are examined from the past to the present. Comparisons with the number of accidents caused by hard errors and soft errors were made; where the hard errors are defined as the faults of the machines and facilities, and the soft errors as human errors and the faults of the systems. The results may be summarized as follows: the ratio of the number of accidents caused by the hard errors to the soft errors is about two to three in all areas.

Correlations between the factors in hard errors and in soft errors are investigated by the method of multivariable analysis, and interesting results are obtained.

Using the data obtained from a questionnaire on the latent accidents from about 200 workers engaged in chemical industries, comparisons with the causes of the latent accidents and the accidents exposed by human errors were made, the results agree approximately with the causes of the accidents exposed.

Fuzzy Fault Tree Analysis for Accident Caused by Human Errors

By K. NOMA, H. TANAKA and K. ASAI

Department of Industrial Engineering, University of Osaka Prefecture, Sakai, Osaka 591, Japan

The Fault Tree is useful for analysis of the cause of an accident. This paper proposes the Fuzzy Fault Tree Analysis in which vagueness of human factors is handled by using the idea of fuzzy truth value proposed by L. A. Zadeh (1975). In treating man-machine systems by using the fault tree, human factors might be included in basic events. Ambiguity exists in human factors in nature. For instance, in reading the value of a meter, it is possible to take 10 or 11 mm for 10.5 mm. This is vagueness of recognition. In saying that a machine is overheated, the verbal expression 'overheat' is very fuzzy. Someone means over 80°C but someone else means over 100°C. This is ambiguity of linguistic expression. Therefore it is impossible to define human factors without taking this ambiguity into account. This ambiguity can be well-treated by using the idea of fuzzy truth values. Treating fuzzy truth values leads to a fuzzy linguistic logic in which the ambiguity of verbal expression is expressed as a fuzzy set on interval [0, 1]. In a Fuzzy Fault Tree, the ambiguity of basic events propagates to the ambiguity of upper events. This propagation can be expressed by mapping from basic events into upper events. The fuzzy truth value of upper events can be calculated from the fuzzy truth value of basic events by using an extension principle. The calculation procedure is shown by an example of a manufacturing system. This application of fuzzy truth values to the Fuzzy Fault Tree is effective in evaluating how the fuzziness of basic events influences upper events, and in evaluating the fitness of verbal expression for the events caused by human factors.

B7. Eye Movement and Inspection

Maximum Velocity in Smooth Pursuit Eye Movement

By K. HORII, K. TANAKA and Y. TOMODA

Department of Industrial Engineering, Faculty of Engineering, Kansai University, Suita, Osaka 564, Japan

It is commonly supposed that smooth pursuit movement occurs only when the visual target is seen to move and is characterized by its slow velocity being less than $30^\circ/s$.

Watanabe, however, suggested that the maximum velocity of the smooth pursuit movement was attained at about $100^\circ/s$. Bermark reported that the maximum velocity went up to $90^\circ/s$ in pursuing ramp waves. Although these results are very interesting, their evidence is not clear yet.

Hence, we investigated the maximum velocity of smooth pursuit eye movement in pursuing a triangle wave.

We experimented on the maximum velocity with two methods. One was the method of tracking the apparently moving target, and the other was the method of tracking the real target.

As obtained by the experimental results, the maximum velocity $V_{H\max}$ in the horizontal direction is denoted by the formula $V_{H\max} = K\theta + b$, in which K is a proportional number and θ is the width of display expressed in units of visual angle, and the maximum velocity $V_{V\max} = K'\theta^{1/2}$, in which K' is a proportional number. Therefore, it was experimentally confirmed that the maximum velocity had a value of $90^\circ/s$ in the horizontal direction. These two linear relationships are the essential properties of eye movement in pursuing a visual target.

It was found that smooth pursuit movement in an oblique direction was considered to be the composition of the movements in both horizontal and vertical directions. The experimental results in oblique directions are in good agreement with the analytical values computed from the formulae described above, except in the neighbourhood of the horizontal direction.

It seems that the three notable results mentioned above play an important role in developing the mathematical model of the eye tracking system.

Frequency Responses of the Pursuit Eye Movement System

By K. MATSUOKA

Kyushu-kogyo-daigaku, Tobata, Kitakyushu, Japan

Many studies have been made on the frequency responses of the human eye tracking system. One of the interesting features of those results is that the gain and the phase vary conspicuously according to the properties of target motion. That is, predictable target motion (e.g. a periodic sine wave) yields a higher gain and a smaller phase lag than unpredictable motion (e.g. gaussian random motion).

The problem discussed in this paper is which of the saccadic and the smooth system is concerned with the above difference between tracking of the predictable target and that of the unpredictable target. For this question, it has been said that the predictability of the signal permits both the pursuit and saccadic systems to reduce the phase lag attributable to the inherent reaction time.

This paper, however, presents some experiments showing that the above view is not true with respect to the smooth pursuit system. Our results are:

- (1) Smooth eye movements for the predictable target have a larger phase lag than those for the unpredictable target.
- (2) The gain and phase lead of the smooth pursuit, both of which vary with experimental situations, are negatively correlated. That is, as the gain decreases, the phase lead increases (the phase lag decreases).

The most interesting aspect of these results is that they fairly conform to the concept of efference copy or internal positive feedback. The idea of efference copy and its voluntariness successfully explains the above frequency characteristics of the pursuit system.

Modelling of Visual Scanning Sequence to Multiple Targets

By M. MAKIKAWA and H. TAMURA

Faculty of Engineering Sciences, Osaka University, Toyonaka-shi 560, Japan

Perception of a figure is usually accompanied by the fixation movement and many studies have been devoted to clarifying how and where the fixation points are selected on the figure. According to these studies some models are proposed to simulate the spatial distributions of fixation points, but these models cannot

simulate the temporal sequence of fixation point selections. This fixation sequence must also be examined in order to clarify how the fixation movement is controlled in perception.

In this connection it is well known that the fixation movement to a figure often shows a regular pattern. This regularity can be seen as a highly informative image, like a human face or paintings and also simple ones consisting of a few targets. As a first step in studying the scanning sequence to multiple targets we have previously studied the first fixation movement after presentation and some comparatively simple target selection rules have been found.

In this paper we proposed a computer model which includes these rules and aims at predicting the subject's scanning sequence to multiple targets, and then compared this model response with the actual subject's response.

The result is that this model, consisting of some rules derived from the investigation of the first fixation movement, shows good coincidence with the subject's response. And from this result human visual scanning process to multiple targets, which seems apparently complex, is described as a chain of these comparatively simple target selection rules.

A Study of the Constitution of Visual Judgment Process on the Composite Images

By T. KURABAYASHI

Japan Institute Synthetic Technology, 5-10-17 Makuhari-Hongoh, Chiba, 281, Japan

The process whereby man fixates on composite images and judges the quality of the composite images is clarified in terms of the trace and number of fixations in order to establish conditions required to produce images of high rating.

The subject was shown image evaluating factors and was instructed to judge the quality of images according to these factors. The subject wore an eye camera to record the trace and number of his fixations.

The data obtained were analysed from the following standpoints: (1) How do the image evaluating factors relate to the images on which the subject fixates? (2) What effect do different image arrangements produce on the trace of the subject's fixations? (3) What is the basic difference between a non-expert and an expert? (4) On what type of image does the subject fixate most intently?

According to the results of the above analysis, the requirements for producing images of high rating are clarified.

Individual Differences Observed from the Relationship Between Percent Correct Counts and Eye Movements

By H. TOGAMI

University of Occupational and Environmental Health,
1-1 Iseigaoka, Yahata Nishi-ku, Kitakyushu 807, Japan

An analysis was made of the behaviour of man in counting objects. To clarify the visual process in this case, the eye movements of each subject were measured with an eye mark recorder and, at the same time, the time required for the subject to count all the objects was measured with a video motion analyser.

The subject was shown a screen on which two to ten dots were configured, and was instructed to count the dots within a limited time. The percent correct count was calculated from the counting results. The individual difference of the subject was analysed from the relationship between the number of saccades measured with the eye mark recorder and the required counting time measured with the video motion analyser.

It was found that the eye movements, particularly saccades, vary from subject to subject and that these individual differences affect the percent correct counts of the subjects.

Signal Detection in the Noisy Background Figure Through a Limited Area of the Visual Field

By S. SAITO

Department of Physiology, Fukushima Medical College, Sugizuma-cho 5-75,
Fukushima-shi, Fukushima, Japan

The experiment was designed based on the observation that one is not always able to recognize a hidden pattern when the visual field is restricted within the central vision alone, in spite of scanning the whole figure. Visual information processing in this case may clearly reflect a spatio-temporal characteristic of a human higher order visual system.

Construction of stimulus figure and data processing was performed by a microcomputer system. The exposed figure was subject to a random dot pattern with uniform dot density distribution in all parts except for an arbitrary part with a different dot density to the rest. The figure could be represented quantitatively by the ratio of dot densities between the two parts, which was defined as the contrast of the figure. A subject could observe the figure on a CRT by sampling any part of a limited area through handling a joy-stick and video mixing system. The task was to find a different part from the rest and to point to it with a light pen. The restricted size of the visual field was from 0.8° (1.7% of the whole) to 50° (100%) in a subtended visual angle. Eye movements were recorded by electro-oculography.

Experimental results were as follows. The higher the contrast of the figure, the shorter the time to correctly find the different part of the figure. The time correlated to the restricted size of the effective visual field. The minimum contrast of the figure which a subject could discriminate was not concerned with visible window size. Both frequency of saccades and averaged single saccadic size had a high correlation with window size. Resultant total-saccadic travel in the task was constant without relation to window size.

The Distribution of Visual Inspection Times

By T. T. GALLWEY

National Institute for Higher Education, Limerick, Ireland

Researchers (e.g. Spitz and Drury) have shown that visual inspection is a two-stage process—a visual search stage and a decisionmaking stage. Bloomfield among others has demonstrated that visual search times are exponentially distributed (with parameter λ). Other evidence suggests that decision time is normally distributed (with parameters μ and σ). Hence visual inspection time should be describable by a distribution having three parameters equivalent to λ , μ and σ . Where visual search is easy and decisionmaking is difficult μ and σ should have the dominant influence. As the relative magnitude of the visual search time increases the dominant influence will shift progressively in favour of λ to give a different shape of distribution.

This hypothesis is examined in a simulated visual inspection task with easy and difficult to find defects. A between-subjects design is used where one group receives an easy decisionmaking part and the other group a more difficult decisionmaking part. Stimuli are 80 positive (black on white) 35 mm slides where 40 contain no fault, 20 contain an acceptable fault and 20 contain a rejectable fault. Five tests of skill are administered initially, followed by 2 hours of training and a task session of 1 hour. Subjects receive an initial payment of \$20.00 plus 25¢ for every fault correctly classified as acceptable or reject, and lose 25¢ for every fault incorrectly classified. Search times and decision times are measured separately along with search errors, quality judgement errors and decision errors. The logarithmic transformation is used on the search times and the arcsin \sqrt{x} transformation on the error scores. An analysis of covariance is used with the initial test scores as covariates.

Conveyor-paced Visual Inspector Efficiency Over Short and Extended Work Periods

By M. H. ELWANY

Production Engineering Department, Faculty of Engineering, Alexandria University, Alexandria, Egypt

One of the most common types of inspection tasks usually encountered in industrial situations is conveyor-paced visual inspection. Since there are different parameters that may affect the inspection efficiency, the prime objectives of this study were to investigate:

- (1) The relation between inspection efficiency and the linear conveyor speed (V), the percentage defects (D) and the viewing time for each unit (T).
- (2) The decay in inspection efficiency over extended periods.

To carry out this study, an original belt conveyor suitable for inspection tasks was designed and developed. The developed conveyor is capable of presenting subjects with a line of the product being inspected, one at a time. Also, it has the facility of changing the belt speed (V) and product interspacing.

The product selected to serve as the object of the inspection task was 32 mm diameter and 1.8 mm thick washers. Washers which were defined as conforming products were steel washers with one notch at their circumference. The non-conforming washers were made of brass with two identical notches on their circumferences. All washers were plated with a thin layer of nickel in order to indistinguish one from the other. Washers were made from ferrous and non-ferrous materials to facilitate checking the performance of the subject by using a magnet.

A randomized block factorial experiment was conducted to investigate the effect of V , D and T on the inspection efficiency. In this study the inspection efficiency, which served as the dependent response variable, has been defined as the ratio between the number of non-conforming products correctly rejected to the total number of non-conforming products.

The experiment has been carried out on 10 male inspectors. The results of this experiment showed that the inspection efficiency increased by the increase of either the defects percentage (D) or viewing time (T), and that the increasing belt speed (V) was accompanied by a decrement in the inspection efficiency. Also, it showed that the only interaction which proved to be of statistical significant effect was the interaction between the viewing time (T) and the defects percentage (D).

Using the same 10 inspectors over an extended period of time to find: (1) how long the inspector would maintain the efficiency he started with; (2) the percentage decay in efficiency under extended work periods. The experiment time extended for 2 hours. The results showed a decrease of 5% in inspection efficiency after 40 min, and then the decay rate was almost constant of 3/4% per 10 min.

The Method of Evaluating the Aptitude of the Visual Line Inspectors of the Steel Product

By T. KURABAYASHI

Japan Institute Synthetic Technology, 5-10-17 Makuhari-Hongoh, Chiba, 281, Japan

The working performance of steel inspectors at a steelworks is analysed and the method of evaluating the aptitude of the inspectors is clarified.

Visual inspection conducted at the steelworks is divided into on-line inspection and off-line inspection. Inspectors engaged in the inspection of plates (off-line), slabs (on-line and off-line) and wide-flange beams (on-line) were selected as subjects, and their actual inspection performance was rated by miss rate.

Based on this data, an aptitude test was developed to rate the inspectors. The aptitude test assumes actual inspection activities and is designed to rate the inspectors by the following capabilities: (1) Discriminating capability. (2) Comparing capability. (3) Attending capability. (4) Detecting capability.

The stationing of inspectors according to their aptitude is studied by clarifying the correlation between performance predicted by the aptitude test and actual performance.

A Study on the Distribution of Sensory Evaluation and Angular Transformation

By T. TAKAHASHI

BUNKA Women's College, 7-20-7-302 Shinjuku-ku, Tokyo 160, Japan

Sensory Inspection is inspection which examines products and passes or rejects them by the use of human sensory organs such as the eye, ear, nose, tongue and fingers. The qualities of products are not the same one to one but distributed, so that if sensory inspection is carried out on them, the results of the inspection are distributed as Binomial Distribution. Such a binomial distribution model is based on the premise that sensory evaluation is not distributed.

Most sensory evaluations, in general, have dispersion, so that an advanced model which has the condition that sensory evaluations are distributed is needed. In my paper such a model is described as follows:

- C_1 : The qualities of products are distributed as Normal Distribution.
- C_2 : Sensory evaluations are distributed as Normal Distribution.
- C_3 : The result of sensory inspection is 'pass' or 'reject'.

My paper shows that such a model changes into Beta-binomial Distribution and useful information about the distribution of sensory evaluations can be obtained by the use of Angular Transformation (inverse sine transformation) and other considerations.

It is useful to apply this study to the fields in which sensory information is considered.

The Influence of Job Knowledge in Product Quality Judgements on a Continuous Process Production Line

By J. RICHARDSON and X. CUNY

Laboratoire de Physiologie du Mouvement, Bat 470, 91405 Orsay, France

Previous studies have shown that product quality judgements are not always consistent between the professional functions involved in a production process. Individual inspector's judgements are also known not to be stable and are influenced by the changing conditions in a factory environment.

A long term study of a continuous process producing insulation panels showed how necessary it is to have reliable quality control information to run the production line. Task analyses and interviews of the different personnel had shown that, in addition to their basic task of sorting the final product, the line inspectors are an important source of information for the supervisors on the state of the production process. However, it was apparent from the interviews that the product faults are not perceived in the same way by the different operators in the production team and that the concept of overall quality differed between quality controllers and production workers.

An experiment was carried out in the factory to determine whether the indices used to identify product faults varied between professional groups. Twenty eight subjects inspected a prepared batch of panels containing good and faulty items. Subjects were instructed to accept or reject items on one inspection and to identify faults on a second inspection of the same batch. The results indicate that fault identification and description are related to the nature of the operator's knowledge of the process operation. The extent of the operators job knowledge is conditioned by his initial training and the task demands of the job he is assigned to.

Automation, Productivity and Stress in Inspection

By C. G. DRURY

State University of New York at Buffalo, Bell Hall, Amherst, New York 14260, U.S.A.

Recent advances in microcomputers and optics have made automated inspection a viable alternative to human inspection in some applications. Current data suggests that automated systems are appropriate in variables inspection, that is where a physical measurement is required. In visual inspection for discrete defects, automated systems are less useful. Direct comparison of human and machine shows that where the task is entirely search, automation works well, but where complex decisionmaking is required the human has distinct advantages.

For the optimum allocation of functions between human and machine, data on the effectiveness of humans in both search and decisionmaking is needed. Response of humans to paced inspection is shown in two experiments, one in which mainly search was required and one in which decisionmaking was required. The conclusions are that for search probability of locating a fault deteriorates with pacing but efficiency (faults per unit search time) increases. The price the inspector pays is increased stress in paced inspection. For a complex decisionmaking task, pacing did not affect the probability of reaching a correct quality decision. Inspector stress varied in a complex way with pacing conditions rather than increasing with faster pacing as in search.

Implications in terms of automation, productivity and worker stress are that search should be the first targets for automation, with the complex decisionmaking allocated to a skilled human inspector.

Methodologies for Visual Inspection Research and Development of an Inspection Robot

By K. NORO

University of Occupational and Environmental Health, 1-1 Iseigaoka, Yahata Nishi-ku, Kitakyushu 807, Japan

Human inspection is being challenged by increasingly stringent quality demands and by the advent of automated inspection devices. There are two types of inspection conducted by man. One is inspection which cannot be essentially performed other than by man. A typical example is tasting. The other is inspection which is concerned with the physical characteristics of objects. This type of inspection may be conducted by either man or machine. In this case, mechanization is feasible. The trade-off between man and machine is determined by:

- (1) Technical feasibility and investment limit.
- (2) Human physiological surplus.
- (3) Required inspection accuracy.

The research methods to improve visual inspection and to develop an inspection robot are reviewed and the future direction of research proposed.

B8. Tool and Equipment Design

Link Analysis of ECG Manipulation and Application for Design of ECG Equipment

By N. YAMANOI, K. YAJIMA, T. AOKI, K. AOKI, S. KINOSHITA, H. TANAKA and T. FURUKAWA
Institute of Medical Electronics, Faculty of Medicine, University of Tokyo,
7-3-1 Hongo, Bunkyo-ku, Tokyo 113, Japan

Applying motion analysis to device operation, we evaluated the panel design of ECG equipment, which is the most popular electronic device in clinical medicine. Sequential and corresponding link analyses were used for the motion analysis, which was applied to ECG operation observed by VTR monitoring systems.

Results were as follows:

- (1) Sequential link analysis, flow graph, showed that ECG equipment in the past and on sale now was lacking in consideration of human factors, especially in the arrangement of mechanical parts on the panel.
- (2) Corresponding link analysis and link ratio showed that the operator's right hand was used much more frequently than the left.
- (3) The shape and the mechanical characteristics of those parts were still rough and not yet refined.
- (4) There was no standardization of marks and symbols on the panel.

Considering these results, three improved panel designs were proposed and mock-ups equipped. They were actually handled and evaluated by link analysis as improvements were achieved not only in simplicity of outlook but also in manoeuvrability and handling balance of both hands. It became clear that link analysis was an easy and powerful tool for such kinds of human factors research.

Head Dimension Measurement for Telephone Handset Design

By H. MATSUI

Nippon Telegraph and Telephone Public Corporation, 1-2356 Take,
Yokosuka-shi Kanagawa-ken 238-03, Japan

The telephone handset shape and its dimensions have an important influence on both send and receive levels. The earpiece should be put to the talker's ear without any acoustical leak, and the mouthpiece must be capable of getting near to the centre of the mouth without touching the face. Therefore, it is necessary to make the relative position between the ear and the mouth clear.

The head dimensions of 650 Japanese people (376 male and 274 female) were measured. For this purpose, a device was developed which could measure both the ear-mouth distance and the distance between the cheek and the plane including earcap surface in one measurement. Ages of subjects were from 6 to 49. The results obtained are as follows:

- (1) The distance between the ear centre and the mouth centre was 137 mm (mean values for adults), which was nearly equal to the value measured in 1938 and in 1959.
- (2) The manner of holding the handset to the ear becomes looser and the distance between the mouth centre and the mouthpiece centre increases with time.
- (3) The desirable dimension for the handgrip was clarified by measuring the relative position between the cheek and the earcap plane.
- (4) The older people became, the looser becomes the manner of holding the handset to the ear.
- (5) For children, the distance between their mouth and the mouthpiece was nearer than that for adults. This somewhat strange result is due to the fact that children hold their handset more tightly than adults.

Ergonomic changes of our automatic welding machine, our track-pin press machine and our fellics assembling machine in our repair-shop

By A. E. HAUGAN

Pay & Brinck A/S, Engineering Division, Dyno Industrier, Box 65, Risløkka, Oslo 5, Norway

This is an abstract of our work with machines in the engineering industry. It deals with our construction machinery: track-type tractors, hydraulic excavators, skidders, pipelayers, wheel tractor-scraper, off-highway trucks, compactors, wheel-loaders, etc., and the machinery we use to repair them.

In our repair-shop the *automatic welding machine* is used to weld damaged fellies on, for example, off-highway trucks and wheel-loaders, the *fellies assembling machine* is used to repair the fellies and the *track-pin press* is used to repair the belts on, for example, hydraulic excavators.

Serious damages to our specially skilled workers, getting neck, shoulder and arm pain and the enormous sick absence and its economic consequences were the main reasons for the project. The machinery in the repair-shop should be adjusted to the human body. We found no other similar machines on the market, neither in Germany, the U.S.A. nor from the East had anything ergonomically better to offer. For this reason propositions were made concerning the three above-mentioned machines in our repair-shop based totally on the human body and its measurement.

Slides of all three machines will follow my speech, taken before the changes had been done, during the changes, with technical drawings on overheads, and showing the final results. The consequences it had for our workers and on sick absence were remarkable.

Application of the Plane Switch Using a Pressure-conductive Rubber Sheet to a Control Manipulator

By Y. IKEDA and S. HATA

Faculty of Engineering, University of Osaka Prefecture, Mozu-Umemachi, Sakai, Osaka 591, Japan

H. TAKEDA

Department of Mechatronics, Osaka Electro-Communication University, 18-8, Hatsu-cho, Neyagawa, Osaka 572, Japan

The authors have offered a plane switch which consists of two sheets with parallel striped electrodes printed on and a pressure-conductive rubber sheet. The striped electrodes of one sheet and those of the other sheet are at right angle and sandwich the pressure-conductive rubber sheet. It allows an electric current between one of the lateral electrodes and one of the longitudinal electrodes, according to the position at which it was pressed. The positional signal (x, y) can easily be decoded, or, for the other use, the direction-velocity pair $[x/y, \sqrt{(x^2 + y^2)}]$ can also be modified from the positional signal. The purpose of the present investigation is to characterize the plane switch for practical application. This paper presents results and discussions of some experiments on the two variable manual control system:

- (1) From the evaluation of control error, there exists an adequate value of gain between control and display variate.
- (2) It is clear from the experiment with random step forcing input that the plane switch can be used instead of a joystick.
- (3) When the forcing input consists of sums of sinusoidal waves, the human operator tends to intently pursue high frequency component.

Though the plane switch is not practical to control high-speed vehicles, it is suitable to control low-speed vehicles. We are planning to apply it to the controller of a motorchair and estimate its control performance. Compared with a joystick, the plane switch has good points; for example, control action is taken by pushing it with a slight force. Therefore, it may be possible to apply it to the control manipulator of some machinery for the handicapped. The plane switch with the binary format output is easily connected to microcomputers, which will further develop its application to such fields.

An Evaluation of the NAC Eye Mark Recorder

By E. D. MEGAW and J. RICHARDSON

University of Birmingham, P.O. Box 363, Birmingham B15 2TT, England

Recent developments in technology have allowed eye movements to be recorded while observers perform a variety of tasks. One of the most popular methods of recording is based on the corneal reflection technique. This technique is incorporated into the NAC Eye Mark Recorder. The NAC recorder has the advantage of enabling eye movements to be recorded in environments outside the laboratory. However, this apparatus does have a number of disadvantages and the aim of this paper is, therefore, to evaluate the equipment in the context of the published literature. Emphasis is given to the problems of calibration of position accuracy and of establishing reliable estimates of fixation times.

Selecting a Colour Monitor for an Interactive Graphics System Used to Design Integrated Circuits

By A. D. LECOCQ

Texas Instruments Incorporated, P.O. Box 225474, Dallas, Texas 75265, U.S.A.

This paper discusses the human factors effort required to select a colour monitor for an interactive graphics system used to design integrated circuits. Considerable attention was given to this selection process since the display is a critical point of information transfer as the operator proceeds through the complex process of designing an integrated circuit. This system will eventually replace many black and white systems currently used for integrated circuit design.

The effort occurred in several steps. The first step was the determination of operator needs, which was followed by a determination of the display requirements and the corresponding monitor specifications relating to a degree of display quality that would be responsive to these operator needs. These display requirements and monitor specifications then served as selection criteria. Evaluations were performed on numerous 13 in (33.02 cm) and 19 in (48.26 cm) high-resolution monitors that were on the market. Various display quality factors relative to producing the specific type of graphics for integrated circuits were analysed, resulting in the decision to proceed with 19 in monitors. The selection process continued with the analysis of 19 in high-resolution monitors with the result that two monitors were selected and compared side by side. The monitor recommended as a result of the final human factors evaluation was incorporated into the overall interactive graphics terminal design.

Computer Technique Usage in Design and an Ergonomic Attestation Function of Controlling Devices Distribution

By L. PACHOLSKI and S. SZCZEBELSKI

Politechnika Poznańska, Instytut Organizacji i Zarządzania, ul. Strzelecka 11, 60-965 Poznań, Poland

Working out elementary questions in the ergonomics domain a modern designer of machines, devices and technological systems realizes the need to use the most favourable methods and techniques. These methods have to be based on scientifically described logical ergonomic criteria (K_{E0}) which constitute a logical consequence of postulated ergonomic criteria (K_{EP}), norms, instructions, etc., used so far,

$$K_{E0} = f(K_{EP})$$

The projects results (WP_E) will be the logical function of possible solutions (MR) and optimum criteria K_{E0} .

$$WP_E = f(MR, K_{E0})$$

Rationalization of a project process will consist, first and foremost, in selecting adequate criteria arrangement (and methods based on these criteria) on the basis of selected optimum data, it is then possible to form a series of ergonomic indices which will characterize definite criteria attesting a machine. The indices can be formulated in such a way that they will all be contained in the interval $\langle 0, 1 \rangle$.

Then for

$$W_{A1}, W_{A2}, W_{A3}, \dots, W_{AN}$$

where N is the number of criteria in consideration and W_{AK} is the partial index describing attesting criterion for $1 \leq k \leq N$, the aggregated attestation index can be formed as follows:

$$W_{AZ} = \left\{ \frac{\sum_{k=1}^N W_{AK}^2}{N} \right\}^{1/2}$$

where:

$$W_{AK} = \frac{K_{E0K}^R}{K_{E0K}^T}$$

K_{E0K}^R is the actual estimation according to K optimum criterion, K_{E0K}^T is the theoretical estimation according to K optimum criterion and W_{AK} is the attestation index for K criterion. If $1 \leq k \leq N$ $W_{AK} \rightarrow 1$ then the aggregated attestation index for N criteria (W_{AZ}) will also aim at 1. In this case ergonomic attestation of projects, machine or device will be beneficial.

Research carried out on the problem of optimum criteria and attestation methods at the Technical University in Poznań, Poland, enabled a precise methodological statement supporting design and an ergonomic attestation process concerned with the distribution of controlling devices to be formulated.

The optimum criterion was formulated as follows:

$$K_{EOUS} = \sum_{j=1}^N \sum_{i=1}^N S[i,j] W[i,j] L[i,j]$$

and $K_{EOUS} \rightarrow \min$ where $S[i,j]$ is the matrix of the number of connections from i and j devices; $W[i,j]$ is the matrix of significance of connections between i and j devices; $L[i,j]$ is the matrix of distance between i and j devices and N is the number of controlling devices.

An optimization programme of the above function was worked out for numerical machines of Odra 1305 type in ALGOL 1900. The following norms, standards and exploitation data constitute the basis for control optimization; number of operations, distance length, significance of connections between controlling devices, introductory division into functional group norms of distance between devices, measurements of devices and plane, maximum and minimum upper limb reach.

As a result of input data processing by mathematical machine the project of allocation of controlling devices is obtained with ergonomic criteria taken into consideration.

It constitutes the so-called theoretical estimation K_{EOUS}^T . In order to calculate a partial attestation index relative to optimization criterion of controlling devices distribution the actual estimation of target function should be counted.

The attestation index according to this criterion is as follows:

$$W_{AUS} = \frac{K_{EOUS}^R}{K_{EOUS}^T}$$

Japanese Population Stereotypes for Nuclear Power Plant Control Room Operators and Engineers

By R. M. KANE, J. FARBRV, Jr., and S. FLEGER

Essex Corporation, 333 North Fairfax Street, Alexandria, Virginia 22314, U.S.A.

Over 150 Japanese control room operators and engineers completed a questionnaire designed to assess population stereotypes for nuclear power plant control panels. The questionnaire, written in both Japanese and English with primarily pictorial types of response alternatives contained 46 items covering control panel components and CRT displays. These items were directed to issues such as control-display integration, colour coding, handle shape coding, label arrangement for annunciators and control board components, and display symbology. Confidence intervals for many items indicated a high degree of agreement among respondents, suggesting strong population stereotypes. Operators and engineers agreed on most items, although certain items showed large differences in degree of preference.

A Problem in Applications: An Investigation into Methods and Materials for Upgrading Nuclear Power Control Boards

By D. SMITH

P.O. Box 504, Orgn. 62-91, Building 538, Sunnyvale, California 94086, U.S.A.

This paper reports on a year-long investigation identifying materials and methods which can be realistically recommended by human factors engineers to upgrade control panels in nuclear power control rooms.

The study was divided into two parts, (1) an identification of the most workable enhancement approaches, given the constraints of the control room and operational control boards and (2) an evaluation of the materials used in implementing the various approaches for their compatibility with the control room environment.

Issues which were addressed included: the necessary engineering and development effort for each approach, manufacturing costs, ease of applying enhancements, ease of future modification to the enhancement and durability and wearability.

VAD—A Video-aided Ergonomic Design System

By P. FRIEDRICH

National Board of Occupational Safety and Health, S-171 84 Solna, Sweden

To fulfil the tasks of anthropometric design and evaluation of systems hardware more efficiently, techniques are needed which are able to accommodate a wide range of subjects in all design spheres.

Video-Aided-Design (VAD), based on the use of video technique, provides such an ergonomic tool for designers and engineers.

The anthropometric evaluation of a working place by means of a video is attained by superimposing one video picture upon that of another video source in a special vision mixer. Thereby the picture of a drawing of a working place is superimposed upon the picture of a subject. The superimposed video signal (subject working at a working place, which is just a drawing) is recording on a VCR or transmitted to a monitor, from where it could be photographed.

To give the subject the impression of working in a real working situation, we put a monitor with the superimposed picture on it in front of her. In our experiments we always used two camera systems (four cameras), one for the side view and one for the top view.

The VAD system has been used in Sweden for ergonomic evaluation of 'office working places' and of the cabs of forestry machines.

The VAD system has also been used for computerized biomechanical analysis of working postures by means of a digitizer-table. In this case the picture of a subject is superimposed upon the digitizer-table. The subject's working posture (the position of the joints) is, by means of a special recording device, transmitted to a microcomputer, where biomechanical analysis is carried out.

Video-Aided-Design as an anthropometric and biomechanical evaluation method can be used at any stage in the design process, but is most effective in the early preconcept and prototype stages before design finalization.

B9. Remote Control Systems

The Use of Operator Workload Measures in the Evaluation of Different Telemanipulators

By J. RICHARDSON, N. FIORI-SAVARY, D. XIRAU and D. ACQUAVIVA-LISCOAT

Laboratoire de Physiologie de Mouvement, Université de Paris XI, 91405 Orsay, France

Telemanipulators are increasingly being used in working environments that are hostile for the human operator; examples include the nuclear power industry, in space, on the sea bed as well as in more traditional industries such as foundry work and forging. Even with new developments in teleoperation which offer the possibility of computerized control to aid the human operator, master-slave telemanipulators (with direct human control) are continuing to be installed. As more models become available, each with different characteristics, it is important that ergonomics as well as engineering criteria should be taken into account when choosing a telemanipulator for a particular workplace.

This study proposes an ergonomics evaluation procedure which can be used to test different models of telemanipulator. The procedure consists of: an analysis of each telemanipulator's technical specifications, relevant to its operation in different industrial tasks, in terms of the operator's physiological and biomechanical capacities (forces required to move the master arm, to operate the grip, possible adjustments to individual workplaces, ...) and an evaluation of operator workload with a sample of operators carrying out a standard task using each telemanipulator.

Results from the comparison of two different types of telemanipulator are presented together with a discussion on the relevance of the use of workload indices in this type of testing procedure.

Advanced Teleoperator Technology: Visual System Research

By R. L. PEPPER and D. C. SMITH

Naval Ocean Systems Center

R. C. COLE

University of Hawaii

NOSC is engaged in a programme of research aimed at developing advanced general purpose teleoperators and supervised robots capable of extending man's complex problem-solving capabilities into hostile, dangerous or otherwise inaccessible areas.

The major research efforts to support this developmental programme have been in the perceptual motor realm, where concern is directed towards the camera-display systems employed and measures of performance.

Recent research efforts have been directed towards improving viewing systems in order to enhance perceptual information available to the operator (see reviews of Smith *et al.* 1979 and Cole 1980). One of the most promising developments has been TV systems which present image pairs to the observer in a binocular disparity configuration which produces stereopsis. Smith *et al.* (1979) present evidence to indicate significant improvements in task performance utilizing stereo TV, the degree of improvement being dependent on visibility conditions and the amount of manipulator positioning required in the depth plane.

The present study was designed to evaluate the influence of head motion parallax cues on measures of stereoacuity under direct-viewing and under TV-viewing conditions. Results of the study indicate that stereoacuity measured with a Howard-Dolman task is neither enhanced nor degraded by the pseudo-movement parallax cues associated with stereo TV. However, these cues have yet to be tested under conditions most likely to show enhanced performance (i.e., where scene ambiguity is great and objects are unfamiliar).

B10. Efficiency and Work Load of VDT Work

A Study on Visual Function of VDU Operators

By M. OHASHI

Division of Health Care Services, Computer Services Corporation, 2-6-1, Nishi-shinjyuku, Shinjyuku-ku, Tokyo, Japan

and K. AKOI

Department of Health Administration, Faculty of Medicine, University of Tokyo, Tokyo, Japan

Recently, complaints on visual fatigue and decreasing visual activity among display operators have increased in Japan. However, we have no exact information on the actual situation in Japan and so we studied the present situation at Institutions using visual display terminal instruments.

Visual functions of 11 female operators (19 to 24 years old) were measured before work in the morning, at noon and after work in the evening. The data observed are (1) visual acuity, (2) visual accommodation, and (3) eye movement. The results are as follows: (1) The range of amplitude of the visual accommodation is extended at noon and the tendency is contracted after work. (2) The average time of accommodation of the right side and left side is different among workers. (3) The patterns of eye movement are varied among workers. (4) The frequency of blinking is increased 5 min after the beginning of work and is stable after 15 min. (5) The ratio of complaints on eye fatigue is different according to the type of display equipment and ergonomic problems within clerical working systems. The ideal care system has not been developed in Japan, and we have tried to develop the model pattern of care system for them.

Visual Loads at VDT Workplaces

By T. LÄUBLI, E. GRANDJEAN and W. HÜNTING

Institut für Hygiene und Arbeitsphysiologie, Clausiusstrasse 21, ETH-Zentrum, CH-8092 Zurich, Switzerland

Four groups of office tasks were studied: data entry terminals, conversational terminals, traditional office work and typing.

Eye impairments were observed in every group of office employees but the impairments were more frequent in VDT operators. The impairments persist during leisure time. Some vision screening tests showed the same incidence of functional eye impairments in office tasks with and without VDTs.

High luminance contrasts between screen, source document and surrounding space are associated with an increase in eye troubles. Increased oscillating luminance of characters is associated with lower visual acuity, and with a higher incidence of subjective and objective symptoms of eye irritation, including more frequent use of eye drops. The degree of luminance oscillation of characters must be considered as an important factor for eye strain at VDT workplaces.

Employees with eye defects (glasses, lowered visual acuity, uncorrected eye defects) have, in general, a somewhat higher incidence of eye complaints. But eye defects do not explain the observed effects of high contrasts and of increased oscillating luminance.

Accommodation Responses in CRT Display Task

By M. TAKAHASHI

The Institute for Science of Labour, 1544 Sugao, Takatsu-ku, Kawasaki, Kanagawa 213, Japan

There has been increasing concern recently about visual fatigue of operators working with Cathode Ray Tube (CRT) display in a computer system. Some researches have shown that accommodation fatigue by keeping watch on a CRT display placed at a near distance would account for developing visual fatigue. The distance between the eye and the CRT display for most Japanese operators is found to be between 30 and 50 cm, resulting in not a little accommodation load in continuous work. The aim of this research was to examine dynamically the extent of this accommodation load in near CRT display work. Twenty subjects conducted a visual search task for 3 hours at two different conditions of near and moderately far CRT positions. Measurements of the dark focus using a laser refractometer (optometer) were made at intervals of 15 min during the task period, and each subject was asked to report the state of fatigue by the method of magnitude estimation. Immediately before and after the search task, the refractive state of the eyes were measured in focusing on a test target located at various visual distances. The results showed that most subjects exhibited decrement of refractive power in the near CRT condition. It was suggested that the eye-CRT distance should be carefully arranged in accordance with improved display and limitation of work duration.

Visual Ergonomics and Existing Person-Display Design Guidelines

By R. A. BENEL and D. C. R. BENEL

Essex Corporation, 333 North Fairfax Street, Alexandria, Virginia 22314, U.S.A.

Recent evidence has accumulated on the natural tendency of the eye to assume an intermediate focal distance in the absence of patterned stimulation (e.g. in the dark). This distance has become known as the dark focus and is the direct manifestation of the intermediate resting position for visual accommodation. The data refute the previously assumed distant resting position (i.e. relaxed accommodation at the individual's far point). The dark focus appears to be normally distributed in the population with an estimated mean between 0.4-0.6 m (16-24 in). Therefore, the inertial point for accommodation is vastly different from that which had been assumed when the original design guidelines were being developed.

Many design guidelines for display distances in person-machine system design were promulgated prior to our more recent understanding of visual capabilities. These previous standards have been adapted to newer display technologies without the empirical basis of those prior standards. The majority of these design standards have been developed by various government agencies, but the recent proliferation of human factors textbooks and handbooks produced by commercial publishers assures wider dissemination of these standards and their derivatives. This phenomenon coupled with the growth of visual display terminal sales provides the impetus for an examination of this area.

The present paper examines the design guidelines currently in use for person-display design distances. These distances will be compared to the recent evidence for the 'preferred' intermediate state of accommodation, the effect of which is evident even while observers view adequate stimuli. There is a measurable lead or lag of accommodation as the display presentation distance departs from the dark focus distance. Important implications for visual information processing arise when there is poor correspondence between the observer-display distance and an observer's dark focus. Reduced acuity for information is one consequence, but the increased effort to maintain clear focus is likely to be a source of subjective discomfort and/or visual fatigue.

Physiological Effects of Oscillating Luminances in Reversed Display of VDTs

By K. NISHIYAMA, U. BRÄUNINGER, H. DE BOER, R. GIERER and E. GRANDJEAN

Swiss Federal Institute of Technology, Department of Hygiene and Ergonomics, ETH Zentrum, CH-8092 Zurich, Switzerland

We developed special equipment to simulate VDTs with reversed presentation (dark characters on a bright background). In our experiment the decay time and mean luminances are constant while oscillating frequency varies. During one experiment the subject had to read aloud the projected text twice for 30 min. Before and after the experiments we measured:

- (1) Binocular visual acuity (near and far).
- (2) Lateral heteroforia (near and far).
- (3) Contrast sensitivity (far).

- (4) Near accommodation.
- (5) Critical flicker fusion frequency (CFF).

In addition subjects had to report on questionnaires about different eye symptoms. The number of subjects was 30. The following experimental conditions were used: 0, 30, 60, 180 Hz and a normal printed text with a luminance of 75 cd/m².

The main result is a strong decrease of CFF at an exposure of 30 and 60 Hz. All other measured variables did not show clear changes.

Lighting Characteristics of Visual Display Terminals of Different Makes

By V. BRÄUNINGER, E. GRANDJEAN, R. GIERER and T. FELLMANN

Swiss Federal Institute of Technology, Department of Hygiene and Ergonomics, ETH Zentrum, CH-8092 Zurich, Switzerland

A field study at 162 VDT workstations in two large banks showed that the incidence of eye troubles was associated with excessive luminance contrasts in the visual field of operators as well as with some lighting characteristics of the VDTs. A significant difference regarding eye troubles was observed between two groups of operators, each one using a different type of VDT characterized by marked differences in sharpness, stability and oscillation degree of characters (Läubli *et al.* 1981).

These observations induced us to develop an apparatus for measuring lighting characteristics of luminance characters. We measured the following parameters:

- (1) Oscillating luminances of characters.
- (2) Sharpness of characters.
- (3) Contrast between characters and background.
- (4) Stability of characters.
- (5) Luminance of VDT surface.
- (6) Glaring effects of screen surface.

The different VDTs showed essential differences for all parameters, which might partially be responsible for eye strain. It can be concluded that customers should pay more attention to ergonomic qualities when choosing a VDT.

Eyestrain and Muscle Fatigue of Data Entry Operators Using Visual Display Terminals

By N. ONISHI and T. KUROE

Institute for Science of Labour, 1544 Sugao, Takatsu-ku, Kawasaki 213, Japan

Operation of computer-controlled visual display terminals (VDT) in office work presents the operators with particular problems such as eyestrain, neck pain and monotony. We studied workloads of 10 VDT operators of age 19-27 on the basis of polygraphic records, fatigue reports and visual function tests. The study aimed at proposing ergonomic improvements and examining efficacy of the work-rest schedules. The operators were working six work sessions a day, each consisting of a 50-min work period and a 10-min break and a lunch break lasting for 60 min. Work of each session comprised almost exclusively of VDT operations with little chance of doing other kinds of work. The visual loading was significant enough to increase eye complaints, with the accommodation capacity and the flicker fusion threshold declining and the pupil diameter changing between sessions. Electromyograms showed a tendency by shoulder muscles and forearm extensors to keep continuous contraction of a static nature. These intermittent static contractions often reached the 20-40% level of the maximal force. This explained why neck and shoulder fatigue became predominant in the afternoon sessions. The frequency inserted breaks seemed to be useful, but apparently they could not prevent eye and muscle fatigue from developing, due primarily to poor ergonomic design of the VDTs.

Constrained Postures at VDTs

By W. HÜNTING, T. LÄUBLI and E. GRANDJEAN

Institut für Hygiene und Arbeitsphysiologie, Clausiusstrasse 21, ETH-Zentrum, CH-8092 Zürich, Switzerland

In a field study of 162 VDT and 133 control workplaces it was found that constrained postures of VDT workplaces in full-time typists were sometimes associated with physical impairments in the hands, arms, shoulders and neck. The reported complaints were confirmed by medical findings on muscles, tendons and joints.

The incidence of impairments was increased when the distance from the surface of the keyboards to the desk was large; the height of the keyboard from the floor was low; there was insufficient space to rest the forearms and hands; the lateral abduction of the hands operating keyboards was great; and there was pronounced inclination or turning of the head.

Several recommendations for the proper design of VDT workstations were deduced from the present study.

Some Health Hazards Associated With Word- (or Text) Processing and Similar Data-Terminal Equipment. How to Avoid Them

By A. E. HAUGAN

Pay & Brinck A/S, Engineering Division, Dyno Industrier, Box 65, Risløkka, Oslo 5, Norway

Another complicated issue in our chemical-process and engineering industry is the increasing use and design lay out of data terminal work stations. I have worked out a little 'book' or pamphlet for use in the industry: *A Guidance to Forming Good Data Terminal Stations*. The pamphlet, on which I have held speeches in IEA management in Norway, is followed by slides and overheads. From p. 3 of the 'book' I translate some of the contents: The relation between illumination, luminescence, contrast and eye-blending; The most common trouble and possible causes including static electricity; How and where in the room should data-terminal stations be placed; The eye and what we demand of it when screen-reading; Glasses, working glasses, people over 40, the employers responsibility; General illumination in the room and especially around the data-terminal, etc.; Anthropometrical measurements of the human body and adjustments to data-terminals; How the chair, the table, the keyboard, the support to the wrist, the screen, the copy-holder, ... should be; How to organize the equipment; Noise and climate, static electricity (skin trouble); Check-list as a guide to establishing an ergonomically satisfying data terminal station, etc.

A Study of the Adaptability of Operators' Ageing Characteristics to VDU Works

By S. YAMAMOTO, M. YOSHIOKA and K. NORO

University of Occupational and Environmental Health, 1-1 Iseigaoka, Yahatanishi-ku, Kitakyushu-shi, 807 Fukuoka, Japan

A. KOMATSUBARA,

Waseda University, 6-1 Nishiwaseda 1-chome, Shinjuku-ku, Tokyo 160, Japan

and Y. HAYASHI,

Keio University, Mita 2-chome, Minato-ku, Tokyo 108, Japan

The Japanese aged population will be increasing in the near future. We need to develop work for aged persons. The problem then is to investigate the adaptability of operators to VDU work, and to consider, as the final object, the possible design of VDUs for aged persons.

The experiment focusing on the operator's performance, character size of displays, and visual accommodation was conducted to clarify the relationship between ageing characteristics and the above three items. A VDU called 'Name Search Test' was used in the experiment, this test was designed for data retrieval simulation work. Subjects were directed to search for the object name which had been indicated prior to the session from the list on the display. The control experiment was made using conventional paper documents. Three groups were examined, that is teen-aged, middle-aged and old-aged, each group constituting nine subjects.

The results of the experiment are summarized as follows: (1) the old-aged group made more mistakes than the teen-aged group; however, the error rate of the old group was almost the same as the younger group in the control experiment. (2) The error rates of the large character size were less than the small character size. (3) Of the three groups, indexes of the visual accommodation showed significantly different changes during the session. We also found that the manner of recovery in visual accommodation was different among the three groups.

Ergonomic Development of a New Keyboard Design

By M. NAKASEKO, W. HÜNTING, R. GIERER and E. GRANDJEAN

Institut für Hygiene und Arbeitsphysiologie der ETH, Zürich, Switzerland

Many of the features found on typewriter keyboards and visual display terminals have had a quite similar keyboard design since 1873. The keyboard layout is arranged in four parallel rows, one for numeric keys, the other three for alpha keys.

Keyboards require an operator to take an inadequate posture of the hands. It is frequently the parallel arrangement of the keyboard that keeps the hands taking pronation as well as ulnar abduction with static muscular efforts of the arms, and the reason that keying operations are associated with constrained postures of the hands, arms and shoulders.

The aim of the present study was to develop a new keyboard design in order to reduce inadequate postures of the hands as well as postural fatigue of the arms, shoulders and neck. In this study the following keyboard arrangement was used.

- (a) Experimental model keyboard with large forearm and hand support.
- (b) Experimental model keyboard with small forearm and hand support.
- (c) Traditional keyboard with large forearm and hand support.

The experimental model keyboard with large forearm and hand consisted of two half-keyboards which completely divided the QWERTY keyboard at a line of the G and H keys. The two half-keyboards were inclined at 10° in the lateral and frontal directions. The open angle (V°) between the two half-keyboards was 25° and distance between the G and H keys was 6.5 cm.

A 30 min typing task was carried out on each of the keyboards by 31 subjects. Impairments and fatigue as well as working postures of the hands, arms, shoulders and neck, performance of keying work and pressure of the hands and forearms on the support were compared among the three keyboard experiments.

Ergonomic Investigation of Interkey Time Distributions of Touch-keying Operators of 10-key Numeric keyboard: Systems Design Implications

By G. F. RABIDEAU

University of Waterloo, Ontario, Canada

R. P.-J. LEE

NCR Canada Ltd., Waterloo, Ontario, Canada

and P. G. MEGUIRE

NCR Corp., Ithaca, New York, U.S.A.

This experimental study is concerned with the ergonomic aspects of the keying behaviour of experienced, touch-keying operators in rapidly entering numeric data via a widely-used 10-key keyboard. The related system of particular interest is one by means of which financial amounts, e.g. from bank documents, are processed using such keyboards. Daily operators typically require both high, sustained keying speed, e.g. > 8000 keystrokes/hour and low error rates (< 1%).

The study's objective was to experimentally sample operator performance at the above-mentioned task and to calculate interkey times as a function of successive pairs of keys used. Such times comprise the lags (in milliseconds) between actuation of successive key pairs. Hence their magnitudes are determined by the required motion (or movement), by the key's function and by individual operator technique. Ergonomic optimization of keyboard design and specification of operators' skills/training objectives require detailed analysis of such keying motions.

A widely-used 10-key keyboard was utilized throughout the study. Intensive screening of potential subjects resulted in the selection of four touch-key trained operators whose performances were most typical of those of high-speed bank proof operators. Each subject was given 3 hours of training during a given week, followed by three (data collection) trials consisting of 1000 'amounts' (digital strings having mean lengths of 3.96 numerals/amount). Visual presentation of the subject amounts in standard ASCII characters displayed on a CRT. The typical task required entering a given amount via the keyboard, followed by depressing the AMOUNT key. This terminal response would bring the next amount to the CRT screen.

Because the constrained number of subjects was too limited (and their keying styles were too heterogeneous) to support a generalizable description of the subject keying behaviour, only one 1000-amount batch for each of the subjects was subjected to detailed analysis. An approximate number of 4×10^6 interkey diagrams were obtained. Those diagrams which were analysed were categorized according to finger motion element and function executed. The former were classified in terms of row and column location and

identity of keys of each diagram involved (lateral vs. medial motion) and in terms of 'distance', e.g. 'repeat digit' = 0, 'reach' = 1, 'hurdle' = 2 keys distant. Those relatively rare diagrams which involved incorrect digit entry were omitted from analysis because they would have greatly inflated their respective interkey time variances.

Results of the analysis support the following interferences and conclusions:

- (1) Interkey times are symmetrically distributed, approximately normal (Gaussian) distribution, hence permitting characterization via simple statistical measures.
- (2) Interkey times can be used by systems designers to calculate burst rates and/or determine machine pacing requirements.
- (3) Inter subject variability with respect to observed (and recorded) interkeying techniques strongly suggest that a survey of current operator training practice, e.g. within various banks, could lead to appreciable performance gains; such gains could even exceed those obtainable via hardware/software design improvements.
- (4) Related to (3) above, only one of the subjects (the fastest) utilized a 'rollover' technique, i.e. use of whole hand rotation to actuate adjacent pairs of keys; this also offers a potentially valuable candidate for training technique improvement.
- (5) The paper also presents interkey time tabulation, graphics and the results of significance tests of differences among subjects, interkeying motions and the total 10-key interkey matrix.

B 11. Design of Computer Systems

Ergonomics of a Hybrid Japanese Text Entry Method

By M. KUROSU and T. NAKAYAMA

Central Research Laboratory, Hitachi Ltd., P.O. Box 2, Kokubunji, Tokyo 185, Japan

An ergonomic research of a hybrid input method for Japanese text was conducted. This method consists of three components: the display-and-choice method, the mnemonic-code method and the instruction function that links the former to the latter.

In the display-and-choice method, the user first enters the reading of the Kanji character with a JIS Kana-keyboard and then selects one of the displayed candidate Kanji characters by striking the numeric ten-key that is located at the corresponding position to the displayed area. Though this method is rather easy for the novice user, its maximum input speed is not high (the average is about 65 characters per minute). On the other hand, the mnemonic code method, where the user can directly enter the Kanji characters by keying pre-determined two-stroke codes such as 44 for 漢 makes it possible for the trained operator to input more than 180 characters per minute. The problem of this method is the requirement of the paired-associate learning between the two stroke codes and the Kanji characters.

In the proposed hybrid method, we have combined the two methods so that the user can optimize his ability and use the high-speed mnemonic-code method for the Kanji characters for which he remembers the code and use the easy display-and-choice method.

The instruction function enhances the connection between the two. When the user selects the display-and-choice method, the mnemonic codes are shown beside the candidate Kanji characters (visual instruction function), and when he selects a necessary Kanji character by hitting the numeric key he can hear the synthesized voice telling the mnemonic code of that Kanji character (acoustic instruction function).

Ergonomics of Computer Commands in Restricted Natural Language

By D. L. SCAPIN

Institut National de Recherche en Informatique et en Automatique, Domaine de Voluceau, Rocquencourt, B.P. 105, 78153 Le Chesnay, Cedex France

In modern interactive computer systems, computer technology has changed its character. The computer terminal is no longer handled by computer specialists but by a broad range of naïve and occasional users. For those users, computer commands have been built from natural language words because they are immediately significant and, consequently (says the computer specialist), easy to use. In this paper that last assumption is questioned though different aspects.

The results of the evaluation of an electronic mail language support the idea that a command language may be accurate for the designer himself (in our case, a specialist in computer data base) or for users of similar experience, but not for the broad range of users that are concerned with such mailing operations. That

experiment shows that experienced users have some kind of ability for 'conventionality' (or in other words the ability of establishing correspondence between commands and function concepts), which naïve users do not have. Some reasons why the existing command language does not readily match with the operations are pointed out.

In another experiment, it was found that naïve users have different requirements than do more experienced users. The experienced users' information processing is more semantic and more flexible whereas the naïve ones' is more lexical. The experienced users are also more influenced by the number of different words used to label the same computer function than naïve users. Surprisingly, it appears computer oriented command words are better recalled by naïve users than more usual words. This last finding challenges many existing beliefs on cognitive behaviour and requires further research for clarification.

In a simulation of a small office system, the results support the evidence of a generation effect: the subjects recalled better commands they invented than commands that were supplied by the experimenter. Also, an important result reveals that the recall of commands is better when the subjects intuitively structures the commands into groups of labels than when they do not, and best when the subjects are told to structure

Some human factors recommendations are given for the design of commands and a framework is supplied to model the user's cognitive behaviour.

Design of Human-Computer Dialogues

By R. C. WILLEGES

130 Whittemore Hall, Blacksburg, Virginia 24061, U.S.A.

To maximize performance, designers are becoming increasingly aware of the need to consider the human-computer dialogue interface especially in computer-based systems involving novice users. Various human factors considerations for interface areas dealing with data organization, dialogue modes, user input devices, command language and command processing, feedback and error management, security and disaster prevention and multiple user communications are reviewed. Several human factor research issues directed towards obtaining empirically-based design guidelines will be discussed and results of recently conducted behavioural research studies will be presented. Studies dealing with both data entry and text editing will be described.

Empirical studies conducted on data-entry tasks were concerned with both defining multivariate metrics of the human-computer interface and using automated data entry error detection and correction procedures. Results of these studies are described to show the utility of multivariate empirical models of human performance based on polynomial regression procedures as a means of isolating fundamental dimensions of the human-computer dialogue interface. Additionally, data are presented to describe the efficacy of automated error detection procedures as a means of reducing source data entry errors.

The research studies dealing with the text-editing dialogues are concerned with user models of command languages, design of 'help' information and the use of fast-time file searching procedures. Specifically, user models of text editing were developed using clustering algorithms and then empirically validated. Both user- and computer-initiated and elected help displays were evaluated as a means of enhancing procedures for retrieving information from computerized displays. And, finally, fast-time search procedures involving visual skimming and skipping techniques to improve location performance of alphanumeric information on interactive displays are discussed.

The results of all of these research studies are presented as examples of empirically-based studies which can be used to define human factors dialogue design considerations. Principles of this type which are related to generic human-computer tasks are stressed as central ingredients in the design of improved human-computer dialogues for the novice user.

Language and Computer Systems

Work Analysis and Cognitive Load

By A. WISNER

Conservatoire National des Arts et Métiers, 41 rue Gay-Lussac, 75005 Paris, France

The expanding number of computers used in tertiary activities has raised working condition problems. Usually, these questions have been approached from the viewpoint of the qualities of the screen and environmental conditions. The different teams of the work physiology and ergonomics laboratory of the CNAM have mainly considered the cognitive activity, using the concepts of psycholinguistics and information processing in relation with some behavioural and physiological measurements such as those of eye movements and evoked potentials.

If some aspects of the work at computer terminals have been studied in laboratory, most of the researches have been performed in real situations: different journals printing shops, an international news agency, the French census analysis centre, a new telecommunication terminal, the control room of an oil refinery, ...

All these studies have shown a very wide range of cognitive loads explaining why some situations are rather easily accepted by workers and why others need such an hyperexcitation of the brain that some neurotic phenomena can be observed and some effects on consecutive sleep demonstrated.

A very precise relation can be established between the density of the text read, measured by linguistic techniques and the frequency of eye fixations, and between the complexity of the codifications and the duration of eye fixations. With the same type of techniques it is possible to show why the reduction of news agency dispatches are different when VDTs are used from the former redaction with paper and pencil.

More 'intelligent' VDTs may help to come back to a better redaction quality taking into account the different macrostructures of the original papers from which the dispatch is built.

Semantics is another important question to be considered not only for the professional users but also for the public who will use more and more complex computer systems. How far is the semantic field prepared inside the memory of the computer analogous to the semantic fields of the different users and how can the very special retrieval mechanism of human memory be simulated in the future computers?

Many answers have been elaborated in this new field of relations between linguistics and ergonomics.

The Use of Ergonomic Computer Equipment

By T. HOUGHTON

ERGOS: Société d'Etudes et Réalisations en Ergonomie, B.P. 42, 77201 Marne-La-Vallee, France

As computer systems play an increasing part in working life, more and more attention is being paid by manufacturers, management, unions and, in particular, users to the ergonomic features of equipment.

In response to the demand, so-called 'ergonomic' equipment is now appearing on the market. In the case of tables, a trend towards complexity is noted with various sections of the table capable of separate adjustments for the VDU, the console and the papers.

A recognition of the physical differences of human beings is indeed essential. However, these tables have to be used and the adjustment mechanisms are often difficult, necessitate physical displacement and too many. In addition, the advantages of such a table have to be balanced with the consequent limitations in choice of placement of equipment and accessories as well as possible misuse.

No table is in itself 'ergonomic'. While a certain number of recommendations exist for any table in any work situation, the choice of a particular table must take into account its compatibility with other system equipment, the physical environment, the work performed and above all the users themselves in order that:

- (1) the appropriate table will be chosen,
- (2) it will be used correctly

and that the objectives of ergonomics, the enhancement of the well-being of the person and effectiveness of the system, will be attained.

The Development of User Hostility Towards Computer Systems

By T. HOUGHTON

ERGOS: Société d'Etudes et Réalisations en Ergonomie, B.P. 42, 77201 Marne-La-Vallee, France

Much literature is available concerning the ergonomic characteristics of computer equipment, workplace and physical work environment. However, much equipment does not incorporate these features, equipment which responds to man's physiological needs is often expensive, complicated and too tiresome to use and ergonomic equipment has to be used correctly. Problems arising from non-ergonomic equipment or incorrect use create hostility which is generalized towards the system. Resulting physiological and psychological symptoms when removed do not alleviate this generalized hostility. Consideration of psychological factors is essential in the conception of a system, in order to avoid the development of generalized hostility, and in the correction of a system, to avoid the displacement of hostility and to assure an effective solution.

Two case studies illustrate this process and a possible approach. A simple treatment of symptoms is insufficient. User involvement is essential in the conception or correction of a system in order to assure:

- (1) A complete analysis of working conditions profiting from the user's 'on the job' knowledge.
- (2) The acquisition by the user of the necessary ergonomics knowledge to rationally and constructively consider his working conditions and thus participate in the definition of future changes.
- (3) The appropriate modifications to working environments; their acceptance and their correct use.

A case study illustrates a possible approach with, as its major element, the education of personnel in elementary computer ergonomics:

- (1) A preliminary observation by the analyst permits the definition of course content and the necessary pedagogic aids.
- (2) A 2-hour information session is held.
- (3) A follow-up in the workplace puts this knowledge into practice and enables the joint determination of modifications to the working environment.

Adult Age and Human-Computer Interaction: Implications for a Model of Performance in Menu-driven Systems

By B. SOMBERG and G. BOGGS

GTE Laboratories, Inc., 40 Sylvan Road, Waltham, Massachusetts 02254, U.S.A.

In recent years there has been an emergence of a considerable amount of research and guidelines relevant to the design of human-computer interfaces. While these efforts are of great benefit, unfortunately they have been mainly directed towards specifying a system which is compatible with a relatively young user population. Behavioural gerontologists have discovered a variety of ways in which the information processing capabilities of older adults differ from those of their younger counterparts. It is thus necessary to apply these data to the design of human-computer interactions.

As an indication of how this approach is possible, a model of human interactions with menu-driven systems is discussed and it is shown how results from the psychology of ageing literature may be incorporated into the model. In general, the model describes the interaction as a process involving visual scanning, deciding upon the appropriate item, response selection and execution. It also demonstrates how performance will vary as a function of the experience of the user with the system and whether the user is operating on the top or the bottom of a menu hierarchy. It has been shown that older adults are significantly slower than young adults in performing each of the processes described in the model and there is some evidence to suggest that the magnitude of the age difference for a process is directly proportional to the time it takes young subjects to complete that process (Cerella *et al.* 1980). This implies that although a manipulation of a given variable in the model may have an inconsequential effect on the performance of a young user, the effect on an older user may be quite dramatic. Specific predictions relative to the ability of individuals of varying ages to interact with menus will be advanced.

Ergonomics Training for Computer Users

By T. HOUGHTON

ERGOS: Société d'Etudes et Réalisations en Ergonomie, B.P. 42, 77201 Marne-La-Vallee, France

The installation of computer terminals in the office has not been without human problems. User complaints concern, on the one hand, the physical aspects of the workplace and, on the other, feelings of mental fatigue, loss of dignity and monotony.

That these should exist is a source of bewilderment to many who do not themselves work before a terminal. The causes of these complaints are often difficult or impossible to trace. Indeed, the original problem, when found, may well have been resolved long ago, and yet, antagonism remains.

Complaints should be considered as symptoms: a multitude of possible causes create hostility which is generalized towards the system. Resulting physiological and psychological symptoms, when removed, do not alleviate this generalized hostility. It is merely displaced to other aspects of the system.

Simple treatment of symptoms is insufficient. User involvement is essential in the conception or correction of a system in order to assure: complete analysis of working conditions profiting from the user's 'on the job' knowledge; acquisition by the user of the necessary ergonomics knowledge to rationally and constructively consider his working conditions and thus participate in the definition of future changes; and appropriate modifications to working environments—their acceptance and their correct use.

A case study illustrates a possible approach with, as its major element, the education of personnel in elementary computer ergonomics: a preliminary observation by the analyst permits the definition of course content and the necessary pedagogic aids; a 2-hour information session is held; and a follow up in the workplace puts this knowledge into practice and enables the joint determination of modifications to the working environment.

The Influence of System Response Time and Memory Load on Problem-solving Behaviour

By H. BERGMAN

Psychological Laboratory, University of Utrecht, Varkenmarkt 2, 3511 BZ Utrecht, The Netherlands

An important factor in man-computer interaction is the duration of the System Response Time (SRT). In a previous study (Bergman *et al.* 1981), the influence of this factor on problem-solving efficiency and strategy was investigated by controlling the interval between the moment a subject presses the last key of a computer input command, and the moment the first character of the computer response is displayed on the terminal. The subjects carried out a problem-solving task equivalent to the selection concept learning task as employed by Johnson (1971, 1978). In this task, a subset of elements from a larger population of elements is defined by three rules, called 'the concept'. It was the subject's task to determine which concept defines this subset of elements by sequential information selection. This selection results in a progressive reduction of uncertainty with regard to the concept as the subject sequentially eliminates potential concepts. Bruner *et al.* (1956) proposed a number of strategies that can be used in this type of problem-solving task. Johnson developed and validated these strategies, and designed algorithms for objective identification. In our studies, the subject's performance is reflected in a number of efficiency measures and, by applying Johnson's rules, the specific problem solving strategy used is established. In the previous experiment, four conditions were used:

- (1) A zero SRT.
- (2) A 10-s SRT.
- (3) A mean SRT of 10s, with standard deviation of 2.5 s (gamma distributed).
- (4) A mean SRT of 10s, with a standard deviation of 7.5 s (gamma distributed).

Conditions 3 and 4 are used because it has been found (e.g. Martin 1973, Shneiderman 1979) that SRT variability is an important factor.

The data of this experiment showed that differences in SRT duration do not give rise to different strategies, nor does it influence the speed of performance. However, subjects in condition 1 performed significantly less efficiently than subjects in the other conditions.

In the present study we used the same SRT conditions as in the previous experiment, but we also increased the subjects memory load by presenting only limited amounts of information on the history of the problem-solving process. By means of this technique we simulate the use of single line or three line displays. Preliminary analysis of the data (by means of multivariate methods) indicate that increase in memory load results in the use of less efficient strategies, regardless of the SRT condition employed. The data are in agreement with the data of the previous study in the sense that a decrease in SRT results in a decrease of subject efficiency. Again, SRT variability does not (contrary to commonly held beliefs) seem an important factor in SRT research.

REFERENCES

- BERGMAN, H., BRINKMAN, A., and KOELEGA, H. S., 1981, System response time and problem solving behavior. In: *Proceedings of the Human Factors Society—25th Annual Meeting*, pp. 749–753.
- BRUNER, J., GOODNOW, J., and AUSTING, G., 1956, *A Study of Thinking* (New York: Wiley).
- JOHNSON, E. S., 1971, Objective identification of strategy on a selection concept learning task. *Journal of Experimental Psychology Monograph*, **90**, 167–196.
- JOHNSON, E. S., 1978, The validation of concept learning strategies. *Journal of Experimental Psychology*, **107**, 237–266.
- MARTIN, J., 1973, *Design of Man-Computer Dialogues* (Englewood Cliffs, New Jersey: Prentice-Hall).
- SHNEIDERMAN, B., 1974, Human factors experiments in designing interactive systems. *Computer*, **12**, 9–19.

Response Time Discrimination

By R. M. WU, C. R. BROWN and P. D. PAGEREY

IBM, System Products Division, Neighborhood Road, Kingston, New York 12401, U.S.A.

The response times of a computer system are the key to user satisfaction. These response times are generally statistical distributions each characterized by both mean and variance. This paper is a study of the ability of a user to discriminate response time distributions of different characteristics. Knowledge from such a study is fundamental to the understanding of a user's relative satisfaction with different computer systems.

The experimental work was reported to the 1979 Congress of the International Ergonomics Association. The primary purpose of this paper is to present a mathematical model capable of quantifying user discriminability of response time distributions. The model being the result of new and more in-depth analyses of empirical data.

Briefly, the experiment consisted of a series of two-alternatives, forced-choice tasks. In each task, the subject sampled at will from a pair of response time distributions generated by the apparatus, eventually making a decision whether or not the two sample sequences originate from identical distributions. Data was recorded for three subjects, each made 100 decisions on each of 18 pairs of distributions. Despite the subjects' widely disparate strategies to reach the decisions, data showed considerable consistency in their ability to discriminate.

If the user's ability to discriminate is measured in terms of the probability of correctly recognizing a response time distribution difference, then the proposed model states that this ability is directly proportional to the difference in mean response time of the distributions and inversely proportional to the square root of the standard deviation. The unanticipated finding is that this ability is independent of the absolute values of the mean response time. The paper gives the constants of proportion that are applicable for mean response time differences in the range 0.1–1 s. Analyses leading to these conclusions are also detailed.

An Attempt to 'Harmonize' Human Operator and Computer Responsibilities in Complex Industrial Processes

By P. E. LARRIERE, J. LE QUERE and S. QUARIN
Elf France Cy, Ltd, Raffinerie, 44480 Donges, France

The flexibility of computer potential allows an adjustment to the operator's behavioural changes (inter and intra-individual variations). Our basic ideas are shift work (3 × 8), increase in the quantity of data and change of the operative mode based on the operator's point of view. From the technical point of view, the setting up of reliable and safe installations on a site of 1.2 sq. mile permits us to centralize and reduce data as well as general on site data feedback. Improvement of working conditions, data presentation, and a maximum use of live displays based on the potentiality of the different mental models are the main objectives of our ergonomic project. These live displays are based on the four following principles: coding, hierarchy, freedom of access, and adjustment to any operator. The four criteria of this man-machine interface are priority (vital points-safety), efficiency, frequency of use, and functionality (coherent geographical unit).

So that we can mainly operate the plant through computer consoles

We are able to perform safety sequences through programmed systems which are simulated and controlled by the computer, aiming at operator training and stress reduction. We also have developed complete computerized start-up, thereby simplifying the operator's task during long and difficult operations: but man is still the overall master. Due to their polyvalency, the inside and outside operator's have been able to maintain a team spirit between the control room and the site, either by the secondary or remote consoles in a supervision room or by means of very modern communication systems. In order to reach these objectives (performances) an 'osmosis' between operator, and management has been realized in job analysis, the setting up of operator-computer interface, and the computerized operator training system. The need to adapt the computer to mankind has led us to develop, by a group approach, software adaptable to the different personalities and behaviour of our operators. The impact of the project will have to be checked with the operators on the basis of day to day experience.

Back-to-Front Systems Design: A Guns and Butter Approach

By R. S. DIDNER
American Telephone & Telegraph Company, 1776 On The Green, Room 48-4A13,
Morristown, New Jersey 07960, U.S.A.

Often, information systems seem to be designed for the convenience of the designers instead of the users. Evidence of this tendency exists in the form of voluminous printouts that nobody uses, the numbers of times these systems are redesigned or abandoned, and the frequent dissatisfaction of managers of user organizations. This problem may be one of 'the tail wagging the dog'. That is, instead of the system being designed to support the users' activity, the users must modify their activity to conform to whatever the system confronts them with.

This paper offers a general approach, as well as some specific techniques for designing systems that not only avoid that problem, but actually enhance user activities, especially when those activities involve some form of decision making. The approach and techniques were developed as part of a requirements study for a telecommunication resource allocation system. In this study the information content and organizing principles for the computer system output reports was established. The number of different reports generated by this system was reduced to 5 as opposed to 50 reports (most of which were not used) generated by its

predecessor. Furthermore, the five reports were organized so as to support an idealized decision-making strategy, which could then be employed by the users of those reports. The resulting system outputs are expected to lead to decisions with superior outcomes, as well as a more expeditious, cost effective, decision-making process.

Evolution of Man/Computer Air Traffic Control Systems (The European Approach)

By H. DAVID
15 Ave. G d'Estrees, 91830 Le Coudray-Montceaux, France

The fundamental problem for the air traffic control authority is that, in spite of rising fuel costs and recessions, air traffic continues to increase steadily, while the physical space available is fixed, and the co-ordination problems rise as the square of the number of aircraft—or controllers. Added to this has been the low level of funding, leading to slow development of equipment.

Ergonomics has been called in to evaluate adaptations or extensions of existing equipment—control devices such as touch-wires, rolling balls or light-pens and displays—colour radar or data displays or radically revised displays. More recently, approaches have been made to tackle the control problem at source, by functional analysis, measures of mental load and batteries of co-ordinated studies.

ATC authorities in Europe have generally been sceptical about the application in practice of general theories of human behaviour, adopting empirical methods to resolve existing or anticipated problems. An example of the latter was the simulation of a prototype flow-control (traffic regulation) cell using a fast-time simulation model on a time-sharing interactive system—demonstrating that the limits in practice were those imposed by adjacent systems rather than that under examination.

Simulation, usually in real-time using computer controlled simulators, tends to be the preferred method of investigation. Much reliance is placed on the consensus of experienced-user's opinion (obtained by questionnaire or discussion), and relatively little importance attached to 'objective' measures of workload. Attempts are, nevertheless, being made to evolve practical, relevant measures of the difficulty of ATC tasks. The increasing involvement of computer systems in ATC offers hope that non-intrusive measures may be evolved or adapted from other man-computer systems.

B 12. Design of Production Systems

Ergonomical Correction of Working Conditions at the Stage of Working Station

By M. SPYCHATA
Oś Krajū Rad 2/114, 61-672 Poznań, Poland

There is practically no situation in the designing process where a functional dependence between analysed phenomena occurs. It is the dependence in which certain qualities of one value are ascribed to exactly determined qualities of another value.

As a rule in these phenomena a stochastic feature relationship occurs. It is based on the fact that a given form of an independent feature is accompanied by different varieties of a dependent feature.

Regression, the method of statistical mathematics, will be used to describe functional dependences between the set of variables. It will be the basis for constructing and estimating a model for evaluating the design realization in the domain of ergonomical requirements.

The subject of mathematical analysis based on the regression method will be the engine shop, with its fleet of vehicles and technology. The purpose of the objective analysis will be the construction of a synthetic meter showing the relationship between the accepted design and the expected working conditions. The character of their properties may be obtained as a result of comparative evaluations with existing norms, criteria and ergonomical recommendations. The selection of stepwise regression method (the best regression equation) to estimate a given model requires that:

- (1) Already existing objects, because of their similarity, unification of realization design parts, similar technology and equipment of a given industrial branch, may be the basis for constructing the meters for estimating the newly made objects (engine shop) within the same industrial branch.
- (2) the model of working conditions is a function of many variables

$$Y=f(X_1, X_2, \dots, X_n).$$

(3) The uniform community (engine shop) may be divided into subsets of high mutual similarity according to technological criteria as well as similarities between manufactured products (statistic features).

(4) The basic statistical unit within the sets and subsets of a community will be the working station.

The mathematical model of regression is:

$$Y = B_0 + \sum_{i=1}^m B_i X_i + \varepsilon, \quad i = 1, 2, \dots, m,$$

where Y is the model dependent variable, B_0, B_i are model parameters, X_1, X_2, \dots, X_m are dependent variables and ε is the random component. In order to obtain the complete record of the community in question and the factors estimating it, the quality features of dependent and independent variables should be ascribed.

The independent variables needed to construct the regression model may be achieved by analysing the statistical unit (work station). This is based on measurements and by other tests aimed at gaining information about the working conditions characteristic for a given work station (noise, lighting, dustiness).

The statistical community (engine shop) may, when it is necessary, be divided into subsets treated in the regression analysis as whole units. When the community in question is divided into subsets, several equations of regression illustrating mutual variation in subsets are obtained. The equation of regression referring to illustration of variations in the whole community is achieved by summing given multinomials (the equations of regression). This will mark the mathematical function of both variables.

Shaping (Size and Form) of Workrooms from the Viewpoint of Pleasant Working Environments and Humanization of the Work System

By H. F. MULDER

Albert van der Meerstraat 21, 7555 Le Hengelo (0), The Netherlands

In many ergonomically justified design processes the psychological influence of the shape (form, ratio length : width : height (L : W : H)) of the workplaces is neglected. This is remarkable because there are, most times, implicit and, some times, explicit questions from industries and administrations about this topic. For instance, for the sake of security of their operators some chemical industries want to make their control rooms as small as possible and without windows. What size is justified from an ergonomical point of view? Contrary is the tendency in the construction of office rooms: open and large. What are the ergonomical justified solutions here?

Old and new religions give ideas; for instance, the classical beliefs in Greece and Egypt. The golden rule for L:W:H is the best ratio. Antroposofy: give rooms and windows five or more corners. A social-psychological theory (Hall) gives rules for personal and social space.

Research is done in university study cells, libraries, canteens, elevators, computer terminal rooms, control-rooms in industry and in experimental rooms. The latter were changeable in size and height.

Results:

- build no room without a window with a view of the environment;
- the theory of Hall is useful;
- the golden rule is useful;
- the feelings of workers about their working place depends on their frame of reference;
- the effect of the shape and size of working rooms on task-performance and feelings depends on the characteristics of the room, task, person(s).

The Evaluation of Repairmen of Motorcars Using the RS-method

By S. NAKAYAMA

The Faculty of Science and Technology, Meijyo University, 69-49, Yagoto, Urayama, Tenpaku-cho, Tenpaku-ku, Nagoya, Japan

This paper shows the result of the work which is repeated many times, in numerical values and derives a new method which evaluates it relatively. The result is given by a work achievement Q which is a function of the ratio of variation δ , where δ is the dispersion of the data. We call the method the Researching and Review System method (RS-method). This method is better than the usual one, which uses the mean and deviation, because (i) computation is easy and (ii) the result is evaluated relatively in the interval [0, 1]. Thus, the method is useful for problems such as comparing more than three things and seeking the best of them, for example workers and machines that are making the same thing.

Further, we mention the method which evaluates the work relatively and dynamically, using tendency equation which is given by the work at successive times. This is also an extension equation which is given by the work at successive times. This is also an extension of the above method and an analysis considering the productivity of the work.

As an example of their applications we show the performance of some repairmen who are engaged by one motorcar company.

The Effects of Developments in Grocery Distribution Systems

By J. WILSON

Department of Engineering Production, University of Birmingham,
P.O. Box 363, Birmingham B15 2TT, England

The growth in the extent of the service sector of the economy has meant a concomitant increase in the potential application of ergonomics to the design of work systems in such industries. In parallel with this growth of the total service sector is the rapidly expanding deployment of new technology within it. Unlike office technology such new systems must serve both the staff and the public.

This paper presents the findings of two ergonomics studies of grocery retail outlets, one in Sweden and one in the U.K. In particular, the effects of such developments as unit palletization, in-shop information and documentation systems and laser-scanning check-outs were examined. Direct observation and interviews were used to produce task and workplace analyses and to assess staff and customer problems and complaints.

Problems associated with the recent developments in retail outlet systems were fewer than expected, most difficulties arising from traditional shop architecture, working systems and package design.

Some possible design recommendations and areas for further investigations are presented for retail outlet staff in general and for laser-scanner check-out operators in particular.

Synthetic Stress Profiles

By B. H. MÜLLER

Universitaet Wuppertal, Gauss-Strasse 20, 5600 Wuppertal 1, F.R. Germany

Many job situations in modern plants can be simulated in laboratory experiments and the results of ergonomic studies can often be statistically proved. In contrast, the stress situation, for example, in the iron and steel industry, is still given by many different stress parameters which influence the workers simultaneously. Working conditions change over the day, therefore the results of scientific studies show only an example of a possible situation. To use simple averages could be dangerous, because intensity and duration of every part of the stress situation differ from day to day, and sometimes even during the shift.

A method was developed, which determines a job-typical stress profile for jobs with a heterogeneous stress situation. Based on muscular work and heat-stress in the working situation, 'work-cycles' including the actual recovery-need are developed and statistically tested. The results after an ergonomic classification are shown as stress profiles, based on the results of ergonomic studies at a blast furnace.

This method allows the combination of results of several shift studies, performed with different workers, as well as comparison of similar work segments at different jobs concerning stress intensity. Used as a tool for job design, this method can help in estimating the stress situation of projected working systems.

Operator Response to Problems in Process Control Systems

By K. M. MALLORY, D. BENEL and D. McCAFFERTY

Essex Corporation, Process Control Systems Division, 333 North Fairfax Street, Alexandria, Virginia 22314, U.S.A.

Typically, main control rooms for process control plants (e.g. refineries, power plants) are equipped with systems to notify control room personnel when a problem occurs somewhere in the plant. These warning or annunciator systems may be hundreds or thousands of hard-wired indicator lights, each of which reports a different problem. In the more recent plants, annunciator functions may be supplied or augmented by integrated, software-driven displays which can present all annunciator messages and, on occasions, associated diagnostic or prognostic information.

The response of personnel to an incoming annunciator alarm is a function of: (a) the specific problem, (b) the condition of other plant systems and equipment at the time of the problem and (c) the immediate, near-term and long-term consequences of the problem. These three factors interact to produce millions of different conditions, each requiring a somewhat different response to cope with the problem.

The extraordinary size of the response set needed to react to problems, combined with the infrequency of the vast majority of these problems, seemingly precludes training operators to respond to specific problems. The following paper proposes a model comprising a small set of response types and a strategy for organizing response types into specific actions to correct specific problems.

Response types generally correspond to methods of compensating for failures or out-of-tolerance conditions designed into process control systems (e.g. by-pass failed equipment; direct control of a condition; substitute for failed equipment; reduce demand for services provided by failed equipment). The strategies for selecting and combining response types are based on the probable consequences of actions.

The model presented in this paper anticipates training requirements of manageable proportions; it emphasizes the ability to predict the outcome of specific actions as a process fundamental to successful plant operation; and, finally, it provides a means to identify educational, training, procedural and design features that improve operator performance in responding to failures or out-of-tolerance conditions.

Ergonomic Design of Press Working Places

By H.-J. BULLINGER, P. KERN and D. LORENZ

Fraunhofer-Institut für Arbeitswirtschaft und Organisation (IAO),
Silberburgstr. 119A, D-7000 Stuttgart-1, F.R. Germany

Even today, press working places are among the typical 'problem working places', where working conditions, e.g. with regard to possible circumstances or with regard to noise level, are often not suitable for man.

The problem for the work designer—especially in the metal working industry—is that a multitude of different kinds and types of presses can be found. In fact, even very different tasks are carried out with the same machine. In order to obtain design guidelines, if possible, for many different types of machine and working places, new methods are required. A separate investigation of all existing press working places has to be excluded, due to limited time and capacity; instead, representative working places have to be determined. In order to do this, the working places first have to be classified, divided into groups and the respective representatives determined. From the ergonomic point of view, a purely technical classification of presses must be eliminated, since in that case the human-related criteria would not be considered sufficiently. These criteria thus have to be obtained via extensive data collection on the scene, using corresponding election methods from ergonomics. Grouping is done using cluster-analytic methods, especially developed choice procedures for statistically uneven distributed data render the representative working places. These press working places are analysed in order to recognize deficits in design.

For representative working places, the results of the ergonomic analysis are presented, strain and stress situations are described and the design deficits shown. On this basis, design proposals are presented for the machine itself, the equipment of the working place, the tools used, the work environment and the work organization. Safety requirements play an especially important role in the ergonomic design of press working places. Questions of work safety have an absolute priority in the hierarchy of ergonomic design measures. It is shown how force postures and unnecessary stress for the working person can be avoided by ergonomically correct design.

An Ergonomic Method Diagnosing Complex Production Systems

By P. LESZEK

Politechnika Poznańska, Instytut Organizacji i Zarządzania,
ul. Strzelecka 11, 60-965 Poznań, Poland

An exact qualification of the scope of ergonomic problems and working-out co-operation methods for experts representing different fields of science seems to be the prerequisite for overcoming methodological and semantic difficulties characteristic of the present situation in ergonomics. Therefore it is necessary to work out methodological and objective ergonomic approaches which would make ergonomics and interdisciplinary applied science.

The ergonomic method diagnosing complex production systems is an attempt at such an approach. The systems are defined as static and dynamic combinations of human, physical and financial resources which transform input feed (work, means of work, objects of work and information) into output states exhibited in a material form (industrial goods, material services) or in a form of information. The main point of the paper is to present a basic methodological concept which would combine the analytic research procedure and ergonomics application into a methodological system. The method is based on a diagnostic approach and it is designed for use in specific circumstances of industrial activity. The analysis of the so-called diagnostic symptoms of production systems is based on a check-list designed by the author. Questions included in the list have been connected with detailed criteria of evaluation, e.g. standards and ergonomic requirements.

Formulation of the fundamental diagnosis of the system is executed by experts in a three-stage mode, and takes into consideration: (a) opinions of an ergonomic team, (b) opinions of workers in direct production and (c) results of measurements taken at particular facilities of the production system.

Investigations of three types, detailed, causal and comparative, make the basic diagnosis more profound and verify it. Results are registered in a form of alternative binary evaluation. Due to the interdisciplinary character of evaluation, made in a multi-object production system, a basic ergonomic diagnosis assumes the matrix form.

Computer processing of such an input matrix into the so-called matrix of ergonomic corrective activities makes it possible to determine both global indices of 'ergonomicity' of the production system and indices of particular facilities of this system (single man-machine units).

Practical application of the method allows control of the level of working conditions in a complex way. The scale of control would cover complex production systems of a plant during changes in the character of the technological process (machine and production facilities modernization, improving organization and equipping of work-stands and reforming production structures) and methods of present management of a production run.

A Critical Analysis of Techniques of Evaluation of Working Conditions and a Proposal for a Methodological Approach

By E. RICHARD

74 rue Pasteur, 69224 Lyon, Cedex 1, France

The author describes a range of experience with assessment techniques and methods applied by the C.R.A.E. to 70 different industrial job functions or work situations. The original approach of the C.R.A.E., relying on a thorough knowledge of the techniques employed, has always involved not merely the production of results, but also a systematic critical analysis of each application with a view to an *in situ* demonstration of its limitations as well as its advantages. The author re-examines each case study against such criteria as the form of the request, the technological level, etc., with a view to an evaluation. A contradictory discussion with constant references to ergonomic practice leads to a critical analysis of these techniques, even when they are used in syncretic combination.

We have, on the one hand, a utilitarian 'in-field' ergonomics, constantly under pressure from the opposite sides of industry, and, on the other hand, a purely 'academic' ergonomics. Is it possible to formulate an alternative approach?

The author goes further attempts to reply by proposing the outline for a global, interdisciplinary, participative approach. He suggests an essentially experimental methodology for an applied ergonomics based on a new approach. This would draw its inspiration simultaneously from biotechnological ergonomics and from an ergonomics geared to questioning the content of work, considered less in terms of a work function and more in terms of a work situation, so as to satisfy both individual and collective needs.

The Design of Man-Machine Systems from Human Role Consideration in Modernized Industrial Systems

By Y. IYAMA

Matsushita Electric Industrial Co. Ltd., 974-52 Shimofuda-cho, Chofu-shi, Tokyo 182, Japan

In operating and managing modernized industrial systems, persons who watch the panels and displays are expected to act as decision makers and system managers in spite of their nominal duties.

In these cases, designing a man-machine interface requires not only sufficient visibility and legibility, etc., but also rational man-machine information flow and useful supporting devices.

Studies of actual man-machine behaviour of the Shinkansen Railway as a typical large complex man-machine system solved the problems of interactive man-machine behaviour of that system and decision-making process. Results also pointed out the weak points of the system design.

Two essential ergonomical approaches in designing large complex man-machine systems are suggested one is the improvement of man-machine matching on a component level, and the other is on a 'nervous-system' level considering the stability and toughness of the system under various abnormal system situations

A Comprehensive Long-range Human Factors Plan for Nuclear Power in the United States

By C. O. HOPKINS
University of Illinois, Illinois, U.S.A.

The major reason for the occurrence and the severity of the nuclear power plant accident at Three Mile Island-2 (TMI-2), Pennsylvania, was a complete disregard for human factors in the design and operation of the plant. The TMI-2 unit was not unique in this respect. Prior to 29 March 1979 the human factors, discipline was unknown or ignored throughout the United States nuclear power community.

The United States Nuclear Regulatory Commission (NRC) asked the Human Factors Society (HFS) for assistance. The HFS Executive Council, as a public service of the human factors profession, authorized the formation of a Study Group to develop a comprehensive long-range human factors plan for nuclear reactor regulation.

NRC awarded a 12-month contract for a three-phase programme to the HFS. The objective was to develop a 10-year plan to meet the diverse requirements for human factors imposed by the different regulatory requirements and responsibilities of the NRC Program Offices and to identify needed human factors, programmes throughout the NRC.

The Study Group used a systems approach to identify problem areas and to develop recommended actions. Current and planned programmes throughout the nuclear power industry were reviewed and evaluated.

A long range plan was developed for NRC that covers a wide range of areas of human factors, concerns. Specific recommendations are made in the areas of human engineering, procedures and operator aids, personnel and staffing, and training and training equipment. An additional group of recommendations is concerned with problems that are common to several of the areas listed above or that do not otherwise fit into one of the major categories. The recommendations include statements of the technical requirements, ratings of relative importance and urgency, estimates of resources required including scientific/technical personnel and facilities, duration of programme, and dependencies upon other programmes, if any.

Japanese Robotization and Human Factors Researches

By Y. OKADA, I. KATO and K. NORO
University of Occupational and Environmental Health, 1-1 Iseigaoka,
Yahata Nishi-ku, Kitakyushu 807, Japan

Human factors research in Japan dates from the 1920s. Japanese human factors research has followed labour science approaches and systems approaches for improving man-machine systems. European influences are recognized in the former approaches, while American influences are noticeable in the latter. Since its foundation in 1964, the Japan Ergonomics Research Society had been working as the base for human factors studies and activities. The professional fields of the society's members are greatly different from those of their American counterparts. Activities related to the automobile and steel industries and to the Shinkansen Line are described as characteristic examples in the Japanese human factors field. The system capabilities and lifetime employment institution peculiar to Japan have made great contributions to these research activities. One of the major problems which face Japanese human factors specialists is how to assign to humans and machines the jobs which call for intellectual and sensory functions. Today we are standing on the starting point of the third industrial revolution. Industrial robots are the main promoting power to the revolution. For the sake of a proper introduction of flexible automation and robotization, human factors' research should play an important role.

Development of Ergonomic Methods for Productivity Improvement

By K. NORO
University of Occupational and Environmental Health, 1-1 Iseigaoka, Yahata Nishi-ku, Kitakyushu 807,
Japan

Japan achieved rapid economic growth and realized a high degree of prosperity in the 1960s. Such an enormous economic development was unquestionably enabled by highly advanced industrialization in various fields of manufacture. Although many reasons may be cited for the industrial development accomplished in Japan, one of the most important reasons is a very large improvement in productivity thanks to labour savings and equipment automation.

Ergonomic methods for productivity improvement comprehensively grasp human behaviour by measuring it in the following aspects:

- (1) Time aspect of human reaction.
- (2) Error aspect of human reaction.
- (3) Subjective response of human reaction.
- (4) Spatial factor of human beings—human body measurement and angle measurement.
- (5) Forces on and in the body.

The ergonomic method is reviewed and the future direction of research in the above field proposed.

B 13. Management and Humanization

Cognitive Complexity, Conceptual Systems and Organizational Design: Implications for Ergonomics

By H. W. HENDRICK
849 Hahaione Street, Honolulu, Hawaii 96825, U.S.A.

During the past two decades, a body of research has been accumulating on the topic of cognitive complexity. This social psychology literature, which is largely unknown among ergonomics specialists, does much to explain not only individual behaviour, but the functioning of organizations and the nature of their design. Among other findings, cognitive complexity research had led to the identification of at least four fundamentally different ways of conceptualizing reality and consistent, systematically related personality characteristics, such as the degree of authoritarianism, internal fate control, relativism, interpersonal focus and skills, cue utilization, principled moral reasoning, teamwork in problem solving, need for structure and order, creativity and the valuing of innovation and change (see, for example, Harvey *et al.* 1966, Hendrick 1979). In England, Elliot Jaques and his colleagues at Brunel University (see, for example, Jaques 1976, Stamp 1981) have shown systematic relationships between the degree of cognitive complexity within a work force and the nature of hierarchical structure within organizations. Hendrick (1981) has related demographic changes in cognitive complexity in industrialized societies to on-going and projected changes in organizational design and functioning.

The proposed paper summarizes the research, noted above, and points out its implications for human factors and ergonomics specialists in designing workstations, workstation networks and organizations. The paper stresses the point that too often human factors and ergonomics research has focused on improving human-machine interface efficiency without adequately considering psycho-social variables or taking a true sociotechnical systems approach. The paper provides an approach for how this might be done. In addition, it highlights the rapid demographic change in abstractness level occurring in industrialized nations, the known reasons for this change, and the need that this change creates for more adequately considering psychosocial variables in ergonomics research and application within organizations.

REFERENCES

- HARVEY, O. J., HUNT, D. E., and SCHRODER, H. M., 1966, *Conceptual Systems and Personality Organization* (New York: Springer).
- HENDRICK, H. W., 1979, Differences in group problem-solving behavior and effectiveness as a function of abstractness. *Journal of Applied Psychology*, **64**, 518-525.
- HENDRICK, H. W., 1981, Abstractness, conceptual systems and the functioning of complex systems. In *Functioning of Complex Organizations*. (New York: Oelgeschlager, Gunn & Hain), Chapter 2.
- JAQUES, E., 1976, *A General Theory of Bureaucracy*. (London: Heinemann).
- STAMP, G., 1981, Levels and types of managerial capability. *Journal of Management Studies*, **18**, 277-297.

Experiments in the Organization of Work in Germany—A Survey of Major Tendencies, Results and Problems

By H. PORNCHLEGEL
Sozialakademie Dortmund, Hohe Strasse 141, D-4600 Dortmund 1, F.R. Germany

Since 1974 the Federal Ministers for Labour and Social Order, as well as for Research and Technology, sponsor a research and development programme, 'Humanization of Working Life', covering mainly reduction of stress and strain, improvement of the quality of work and transfer of relevant knowledge into

practical application. More than a quarter of the funds (appr. 120 million DM p.a.) went into experimentation in the field of organization of work. Some major projects are completed; a major study of non-publicly-funded schemes of 'new forms of organization of work' is published.

Major emphasis was originally on experimentation with the 'classical' models of job rotation, enlargement, enrichment and semi-autonomous groups, as well as different forms of participation. Early projects were started by major companies. Over time, the scope of such projects was extended to flexible forms of work technology, such as buffers, handling machinery, flexible workstations, and various combinations of such models, eventually to whole establishments. Qualification programmes were frequently introduced as supporting systematic measures. A whole range of interdisciplinary research went along with these sponsored projects normally covering ergonomic, psychological, sociological, pedagogic and medical aspects.

Findings published relate to layout and flexible technology, stressors and stress reactions, qualification, acceptance of new systems, formal and informal participation, feasibility and wage problems. This paper presents some major findings.

Some of the major problems appear to be:

- (a) the degree of integration of such schemes into the whole organization;
- (b) the high dependence of organizational changes in the units concerned and the larger systems;
- (c) increased stress coping problems unless counteracted by systematic qualification;
- (d) need to anticipate repercussions of changes in the wage sphere; and
- (e) increased problems of participation under legal, collectively bargained and informal auspices.

A Study on the Motivation of a Manager by Canonical Correlation Analysis

By S. Y. LEE

Department of Industrial Engineering, College of Engineering,
Korea University, 1, 5-ka, Anam-dong, Sungbuk-ku, Seoul, Korea

This study analyses how reciprocal relations between the temperament and motivation of managers are interacted.

In addition, to find the relationships between achievement, this study also examines whether or not familiar-achievement motivation and non-familiar-achievement motivation manifested in the manager group of Japan are present in this tested group.

To perform this study, the author obtained the data by testing 578 male managers employed in domestic enterprises with a Y-G Character and Motivation Test. A structure vector is obtained and applied and a canonical correlation analysis method is applied as a means of interpreting the data.

From the study, the following results are obtained.

First, familiar and non-familiar-achievement motivation appeared in the domestic sampled group.

Second, a manager with familiar-achievement motivation is shown to have an extroverted character, high social accommodation, high emotional stability, whereas one with a non-familiar-achievement motivation has an introverted character, a somewhat low social accommodation and low emotional stability.

Further study can be concentrated on whether or not these results reappear in a bilingual group.

Adjustment of Work to People and Humanization of the Production Line

By M. A. V. PAREŽANIN

Mechanical Engineering Faculty, University of Belgrade, Belgrade, Yugoslavia

At the beginning of this paper the introduction and development of the application of the production line, i.e. flow production, in Yugoslavia, with the aspects which brought about this development, are discussed. The results obtained show that out of 85 000 production workers from 100 organizations of associated labour (factories) from 12 branches of industry (metalworking, electrical, food processing, shoemaking and leather processing, chemical industry, etc.) 35 000 workers or 41.8% work on production lines. That is a very indicative figure when it is known that about 2.5 million production workers are employed in the industries of Yugoslavia.

Detailed studies made on representative production lines in 25 organizations of associated labour (within the project 'The Study of Human Factors in Work on Production Lines under Self-management Conditions' which is being carried out by the Ergonomic Research Centre of the Technical Sciences Institute of the Serbian Academy of Sciences and Arts with the support of the Trade Union Council of Yugoslavia and the Republic Community for Science of Serbia) helped to reveal the effects which divided and simplified jobs have on the behaviour of workers on the production line.

One of the possibilities for the humanization of the production line is seen in the organization of work groups depending on the technological content and suitable organizational solution and the application of mechanical hands in cases of highly manual and simple operations.

Task Allocation Based on Human Needs as a Tool in the Humanization of a Work System

By M. MULDER

Albert van der Meerstraat, 7555 Le Hengelo (O), The Netherlands

In an ergonomically justified design process it is common to use data of human sizes, forces, movements and psychological capabilities. But for decisions in the allocation process the use of human needs and motives is also relevant. Research performed on several production-line functions shows that it is possible to construct satisfactory functions. That can in reconstruction situations (corrective ergonomics) and in new designs (preventive ergonomics). Several instruments are useful for the recommended approach, for instance, the list of Turner and Lawrence. This list can be used by unexperienced subjects.

Factors in the Quality of Working Life: Two Case-Studies

By S. BAGNARA and R. MISITI

Institute of Psychology, CNR, Via dei Monti Tiburtini 509, 00157 Roma, Italy

D. MAZZONIS

CNEN, Viale Regina Margherita, Roma, Italy

M. ROLLIER

Ires-CGIL, Corsia Italia, Roma, Italy

The meaning of the quality of working life is manifold. Various factors can come into play, and they may, or may not, be considered: (a) socio-cultural determinants (industrial relations systems, workforce characteristics, social and psychological needs, attitudes towards work); (b) technological determinants (type of industry, level of automation, information technologies) and (c) economic determinants (trends in the economic market, workforce availability).

However, the quality of working life can be conceptualized according to different categories, such as psychophysical well-being, job satisfaction or 'participation'; each of these categories is stressed differently depending on the socio-cultural climate in the various industrialized areas. As far as 'participation' is concerned it has to be underlined that there are at least two meanings. In the first sense 'participation' is intended as the capacity to exercise a control on the production process from outside the process itself, or through a 'right' established by law or state regulations, or through power derived from the capacity of promoting and controlling conflicts in the workplace. In the second sense, 'participation' means that the workers are able to use the technical knowledge in the work process and organization. This type of 'participation', based on the sharing of technical expertise among workers, allows groups on work autonomy also at the 'planning' level.

There are social, economic and cultural factors which force the conception of 'technical power' as a determinant of the quality of working life. These factors will be apparent in the analysis of two case-studies which can provide an overall idea of the Italian scene in this field.

Brief Description of a Complex Work Organization Change in a Big Steel Company in Italy Involving Ergonomics and a Socio-technical Approach to Improve the Quality of Working Life

By S. MICHELI

Nuova Italsider S.p.A., Via Corsica, 4 Genova, Italy

The purpose of the report is to present a detailed description of the experimental initiatives to design new forms of work organization carried out by the biggest Italian steel company during the seventies.

The context. Such initiatives were inserted in a context characterized by a deep lack of balance where interlace and overlap production difficulties, changes in the social environment and in industrial relations, organizational crisis and pressures to the renewal of technology and products were significant.

Methodology. The methodology for carrying out the intervention was based on supervisors, foremen, technicians and workers' participation. It consisted of an ergonomics group, with the purpose of analysing the department, in a multidisciplinary way, as a socio-technical system, in order to identify main critical points (physical, psychological, social and technical), to propose organizational changes, design new forms of jobs and improving ergonomics conditions.

Results. New organization requires:

- (1) A new approach defining practically, and not through simple rules, the roles of supervisors and workers.
- (2) Groups, characterized by a homogeneous professional level, enable to achieve required output with higher autonomy and responsibility.
- (3) A wider integration of the different functions.
- (4) Worker participation as a part of the methodology and a basic mean for the industrial relations system related with the changed programme.

Ergonomics for Pure Efficiency or for Humanization?

By G. OLSSON

Department of Human Work Sciences, University of Luleå, S-951 87 Luleå, Sweden

In Sweden the concept work environment, as a comprehensive expression for the total effect of work on man in physiological, psychological and social sense, was established in the late sixties. The technological and economical progress after World War II combined with an active governmental policy of income distribution, supported by strong labour unions, had given most people in the country high prosperity and social welfare in leisure time life.

This progress had, however, made evident the differences in living conditions between working time and leisure time: leisure time comfort was paid by a higher degree of work strain and stress. From a survey ran by LO, the Swedish Confederation of Trade Unions, in 1968 we learned that 80% of Swedish blue-collar workers experienced inconveniences at work. Dissatisfaction with work conditions also led to a big wild-cat strike among mine workers in 1969, wild-cat strikes so far almost an unknown phenomenon in the Swedish labour market.

These two events have been declared the alarm-clock for setting up an ambitious programme for better work environment in the early seventies, comprising both legislation and a special fund for research and development. Also professorships in industrial ergonomics were founded at Swedish universities of technology. In this context ergonomics in Sweden has two characteristics: (1) research and teaching have the expressed goal to create better work environments and (2) ergonomics has a very broad but not very exact definition, also including work organization factors. As a methodological consequence field studies have also dominated compared to laboratory experiments, resulting in solving problems of the real world.

Dealing with problems of computerization and automation processes in industry and offices this tradition becomes of vital importance. According to international ergonomic journals and conference proceedings much ergonomic work has been spent on man-machine interface problems, problems well suited for laboratory experiments. Our field-studies have lead us to the opinion that the very big problems are much deeper than this, like problems concerning man's role in the systems, job content, involvement and participation, problems practically not mentioned in ergonomic literature. But if, to quote Chapanis (1979) in *Quo Vadis, Ergonomia (Ergonomics, 22, 599)*, 'our real problem as ergonomists and as citizens of the world is to try to maximize the good and to minimize the bad', we have to extend our interest to these more sophisticated and controversial areas.

In my paper based on studies of process operators in modern pulp mills and rolling mills I will develop some thoughts about these problems. In a man-machine systems approach I will give some arguments concerning (1) allocation of functions between man and machine and (2) allocation of man's functions between different men in a work organization, with the main object to create human work for human beings, while still considering the efficiency of the systems.

B 14. Agriculture

Safe and Easy Coupling of Tractor Implements

By L. SJØFLOT

Norwegian Institute of Agricultural Engineering (LTI), Box 65, N-1432 Ås-NLH, Norway

The paper gives results from a project of co-operative work between the five Nordic countries, Denmark, Finland, Iceland, Norway and Sweden, dealing with coupling to a tractor a three-point hitch, drawbar and hitch hook; and with control of implements outside the tractor. The main reasons for the project were the high rate of accidents and injuries, the unpleasant and troublesome working situation and the time consumption of the coupling operation. The goal was to find coupling systems (quick couplers), construction details and ways of operation that would increase safety, well-being and efficiency for the tractor operator through utilization of the results in design and marketing, standardization and a well-founded information and advisory service.

The increase in size of both tractors and implements has made the coupling operation heavier and more dangerous. For small farms having only one tractor and a spread production, implements have to be changed often, which takes a long time and causes a lot of trouble with a conventional coupling. In the project different types of quick couplers (Accord, A-draget, Axa, Walterscheid, CB) have been studied, along with aids such as telescopic links and hydraulic cylinders. The coupling operation has been studied in experiments using different implements and tractors, simulated implements and several 'drivers'. Working posture, forces exerted to connect, disconnect, lock and unlock the different systems and equipment have been measured and described; and the 'drivers' own assessment of the systems have been recorded.

Farmers in other countries, having had the different couplers and systems in use for some time, have been interviewed about their experiences and considerable work has been done to adapt quick couplers to all common implements. Some new development has also been made.

The results show that the Accord and A-draget quick-couplers have clear advantages concerning working posture, required forces and time for coupling. The biggest problems for practical application are adaptation to some implements and costs. Through standardization (preferably international), improvements of details and manufacturing and information to the farmers/users, these obstacles may be lowered or taken away, and thus open the way for considerable improvement in the working situation of tractor operators.

Assessment of Mental and Physical Workload for Some Agricultural Tasks

By C. CANAN

Fakulti Kejuruteraan Jentera, University Technology Malaysia, Jalan Gurney, Kuala Lumpur, Malaysia

The objective of this study is to establish a field technique for the assessment of physical and mental workloads of some agricultural workers and to investigate the effect of the workload on labour productivity. The study is composed of two stages. In the first stage a mental and physical workload measuring technique, which can be used easily and reliably in field studies is developed as result of laboratory simulation experiments. The laboratory studies have indicated that physical workload can be estimated by heart rate charges (ΔHR) before and after the exposure to workload, while mental workload can be estimated by changes in the critical flicker fusion values of the subjects (ΔCFF) before and after work. During the study, a telemetric cardiogramme and a flicker fusion measurement instrument are used to record heart rates and CFF values.

In the second stage of the study the following agricultural activities are investigated by the measurement technique developed in the laboratory: ploughing, sowing (wheat), harvesting (wheat by a combined harvester), harvesting (clover) and loading (manure by a front loader).

The field studies revealed that sowing has the highest average energy requirement (3.00 kcal/min) among the activities. On the other hand when straight drives (effective work) and the turnings are compared, the combined harvester has the highest energy requirement in drives (2.90 kcal/min) and the sowing machine has the highest energy requirement in turnings (3.35 kcal/min). In all of the above mentioned jobs energy consumptions are below 5 kcal/min, which is the physiologically tolerable maximum energy expenditure level.

The study revealed that none of the above-mentioned tasks cause heavy mental loading. Even the most demanding task (ploughing) generates a mental load which is approximately equivalent to processing 30 bits of information per minute.

Prevention of Occupational Injuries in Greenhouses

By B. GUSTAFSSON and P. LUNDQVIST

The Department of Farm Buildings, The University of Agricultural Sciences,
Box 624, S-220 06 Lund, Sweden

In recent years working environment problems in greenhouses have begun to be given steadily increasing notice. In this paper emphasis has been placed on the findings in four recent studies on occupational accidents—one of the major working environment problems in greenhouses—carried out at The Department of Farm Buildings, The University of Agricultural Sciences, Lund, Sweden.

Accident frequency and accident patterns at work in greenhouses, as recorded in the new, nationwide Swedish Occupational Injury Information System (ISA), are presented and discussed by events, part of body injured and by types of machinery and implements involved.

A sample of about 140 greenhouse operations, owned by members of The National Swedish Association of Horticultural Producers, has been surveyed with respect to accidents and injuries occurring under different conditions. Back injuries due to lifting and problems caused by contact with chemicals are emphasized.

The use of and the attitudes towards personal protective equipment in greenhouse work has been investigated by interviewing 47 greenhouse safety officers in different parts of the country. Their experience is of particular interest since they are all actively involved in the preventive aspects of safety and health at work in greenhouses, i.e. work with pesticides.

The fourth study reported is a study of the risky situations at work in greenhouses using the so-called near accidents technique. For preventive work it is of interest to study not only the manifest accidents resulting in injuries and absence from work but every sudden incident which deviates from the expected course of work. An analysis is presented of data on such incidents (or near accidents) collected from 86 greenhouse workers (55 men and 31 women) by interviewing each individual every second day during a 14-day period.

The Postural and Health Problems of Workers in Pear and Apple Orchards

By H. SAKAKIBARA, M. MIYAO, T. NAKAGAWA, F. KOBAYASHI, S. KANADA,
K. TAKIHI, S. YAMADA and K. MASUDA

Department of Public Health, School of Medicine, Nagoya University,
65 Tsurumai-cho, Showa-ku, Nagoya 466, Japan

Elevation of arms at overhead levels is frequent during work in pear and apple orchards, for example, attaching pollen to flowers, selecting good buds, covering fruits with paper bags, etc.

We studied the relationship between the work posture and complaints. The complaints of workers were examined on each final day of selecting good buds and covering pear and apple fruits with paper bags. We examined with a goniometer the angle of forward flexion in shoulders and in part both the angle of forward flexion in shoulders and extension in the neck. Complaints and the angle of flexion in shoulders were compared with selecting good buds or in covering pear fruits with covering apple fruits.

The incidence of complaints in neck, shoulders, and arms is more frequent in selecting good buds and covering pear fruits than in covering apple fruits. The rate of flexion of more than 90 degrees in shoulders is more frequent during selecting good buds and covering pear fruits than during covering apple fruits. Those results suggests that work postures demanding elevated arms in work are a significant factor of complaints in neck, shoulders, and arms.

A Systems Approach to the Aetiology of Human Injury in Livestock Building Design

By G. A. BRAMALL

The Scottish Farm Buildings Investigation Unit, Craibstone Bucksburn, Aberdeen, Scotland

This paper deals with the application of a systems approach to solving problems relating to human welfare in livestock environments. The philosophy is not new but its application to the design and evaluation of livestock environments is rare. The paper will illustrate the benefits to be gained and the problems to be encountered in applying such a technique. It will demonstrate the scope of such research in solving problems in livestock building design.

The solution to any problem involves the simultaneous examination of more than one of the factors causing that problem. A fragmented ordering of factors to investigate will not bring a satisfactory solution. An understanding of the interaction of a number of variables can be achieved by constructing a simulation of the system within which the problem lies. Control can then be exercised over features pertinent to the

problem. The simulation uses a multi-dimensional analytical procedure to handle the large number of variables involved.

Having developed a systematic means of obtaining and listing all the combinations of compatible options for a complete set of decisions and an optimum set can then be identified. The greatest emphasis will be placed on the subsystem of the environmental factors because these are considered to be most capable of manipulation.

Anthropometry in Relation to Ergonomics of Walking for Work Study Application in Indian Agricultural Workers

By R. N. SEN

11A Mohan Bagan Lane, Calcutta-700004, India

The scale of rating in work study application practices is based on the walking speed of workers. Different research workers have attempted to specify relationships between walking speed and different anthropometric and physiological parameters, but there are differences and variation of opinions.

The present paper attempts to correlate the walking speed, with selected anthropometric measurements and physiological parameters, of a group of control and a group of agricultural workers, during their usual work while walking with and without loads. From the measurements various simple linear and multiple correlations and regression equations were computed to identify the best possible parameters to be used for assessment of the scale of rating for work study application in agricultural workers.

The different anthropometric measurements taken were stride length, the segmental dimensions of the upper and lower extremities, body height, body weight, etc.

As the anthropometric measurements of Westerners differ from those of Indians, the application of the scale of rating in work study based on studies on Westerners is not suitable in Indian situations, especially in agricultural work. From the results it was observed that Indian agricultural workers with a lower body stature and body weight and lower segmental weights have different patterns of gait of walking, especially while carrying loads on the head or while using a yoke. The standard scale of rating based on different objective measurements was suggested for application in work study in cases of Indian agricultural workers.

Ergonomics in Agricultural Engineering in India

By B. G. YADAV and L. P. GITE

Central Institute of Agricultural Engineering, Nabi Bagh, Berasia Road, Bhopal 462 010, India

India is a vast agricultural country and so are its problems. It has a total cultivated area of 139 million hectares and the human workforce involved in agriculture is 196 million. Traditional agriculture utilized mainly manual and animal power whereas the use of mechanical power has also evolved in the recent past. Agricultural equipment for different operations is commercially available in the country. A large amount of improved agricultural equipment has also been developed in many institutions and has given proven results with respect to performance and efficiency. Often it is found that human beings are not considered as a part of the system which deteriorates the system's performance. In other words no emphasis has been laid on ergonomic aspects during the design and testing of agricultural equipment.

Based on the various tests conducted in the country as well as outside, it is well understood that the performance of the equipment could be improved considerably if ergonomic aspects were given due consideration.

In this paper an effort is made to identify the various ergonomic problems in the few selected agricultural implements. An attempt has also been made to give possible solutions to these problems. A test procedure for evaluating various farm equipment, based on ergonomic considerations, is suggested.

The Central Institute of Agricultural Engineering at Bhopal in India has considered the various shortcomings in farm equipment and launched a few projects in ergonomics to improve the system's performance.

Ergonomics in Agriculture and Forestry—the Present and Future State

By Ir. J. ZANDER

Agricultural University, Wageningen, The Netherlands

1. Introduction

The introduction of mechanization and automation causes many changes in working methods and working conditions. Sometimes it makes the work easier and more congenial, in many cases, however, the

workload changes. A decrease of the physical load is coupled with an increase of the perceptual and mental load.

The various components and processes in a man-task system are mentioned and discussed, including the criteria belonging to them.

2. Ergonomics in agriculture and forestry

The recent progress in many fields of technology has also affected agriculture and forestry. Technology can release the agricultural worker from much unpleasant and heavy work, but with this technology inconvenient and damaging factors can often be introduced.

2.1. Present state

Considering that 70% of the working population of the world is working in agriculture and forestry—using mainly hand tools, animal traction and, in limited cases, machines—the workload and the dreariness of daily routine can be reduced by applying ergonomic knowledge and experience.

Ergonomics can and must contribute to improve the living and working conditions in these fields; in the meantime productivity can often be substantially improved.

The present state of ergonomics in agriculture and forestry is described and discussed.

2.2. Future state

In the near future full attention must be given to the human and environmental aspects of the living and working conditions in agriculture and forestry all over the world. It is also necessary to concentrate on ergonomics in tropical countries to develop optimum working and living conditions, considering the worker's health, safety and well-being, as well as the safety and productivity of all working methods or systems.

Some recommendations to find adequate solutions for these problems are given and discussed.

3. Summary

The intention of this paper is not to discuss all the changes in the world that have important consequences for the working and living conditions in agriculture and forestry. Rather, the intent of this paper is focused around certain, more modest, objectives, in particular the present and future state of ergonomics—including its contributions, developments and results—in agriculture and forestry.

This paper illustrates the ways in which human abilities and other characteristics are related to the agricultural worker's health, safety and well-being, as well as the problems arising therefrom.

B15. Potpourri B

Safety Work on a Small Fishing Boat Operated by One Man

By A. HATTORI and N. OHASHI

Maritime Labour Research Institute, 4-5-1 Kojimachi, Chiyoda-ku, Tokyo 102, Japan

In Japan, we have a lot of small fishing boats operated by one man. For example, in Hokkaido, a northern area of Japan, they still play a vital role in fisheries. But, recently, accidents in such boats are increasing. According to statistics of such accidents occurring in the Hokkaido area, 111 cases were officially reported for 1978–80, including 37 fatal accidents. In 1981 a research project was started to find the causes and ways of decreasing such accidents, especially fatal accidents. But as in fatal accidents there is no observer or witness, it is very difficult to find out the real causes. The most common cause was attributed as lost overboard but no one really knows. Sometimes we can find some trace of the accident from the discovery of a drifting boat, for example, trouble with a net or line hauler, anchor or other deck machinery.

A boat is very small and complicatedly equipped with various gear. Also when a boat is operated by one man, he is obliged to perform various operations at the same time, such as ship handling, operation of fishing gear and so on. It is clear that in these situations, accidents easily occur.

We have to point out here that in order to find the real causes of accidents occurring on one-man controlled fishing boats and the urgent need to design effective safety devices and equipment, it is necessary to approach the problem by developing case studies by means of collecting, investigating and describing in detail: (1) cases of accidents, (2) cases of new accidents, (3) real and actual working condition of fishing activities at sea and (4) the social background of most fishermen.

Human Factors in Ship Collision in Narrow Waters

By N. OHASHI

Maritime Labour Research Institute, 4-5-1 Kojimachi, Chiyoda-ku, Tokyo 102, Japan

Information processing for ship manoeuvring work is based on verbal communication among navigation staff, and communication proved to be a vital role in the work by decreasing the uncertainty and indeterminacy of relevant information. The navigation staff are finally obliged to make important decisions by deductive work, as we pointed out in the 1st International Conference of Human Factors in Ships in 1977 in Sweden. However, when we analyse judicial precedents of the Maritime Court in cases of ship collisions from the aspect of human factors, it is suggested that real working situations of ship manoeuvring is not understood and no ergonomical consideration is paid to find the real causes of collisions. Most causes are attributed as negligence of navigation staff, though we found various disturbing factors relating to information processing.

Judges of the Maritime Court have demanded stricter observation, more correct decisions by navigation staff, as if ship collisions were only caused by misinformation or inattention to them. Also, we found relevant laws and regulations seem to ignore present traffic conditions, navigation facilities, manoeuvrability of ships and, especially, human factors in ship manoeuvring work.

From these analyses we have to point out here that the most important ways to decrease ship collisions are: (1) to eliminate the deductive work from information processing for ship manoeuvring, (2) to prepare systems where navigation staff can obtain needed information certainly and quickly and (3) to establish fact-finding systems of the real causes of ship collisions.

A Statistical Analysis of Values of WBGT Factor in Complex Production Systems

By P. LESZEK

Politechnika Poznańska, Instytut Organizacji i Zarządzania, ul. Strzelecka, 11, 60-965 Poznań, Poland

The subject of these studies comprises three groups of several work-stands remaining in direct production. These groups were isolated in three different production divisions in industrial engineering, e.g. the railway system, agriculture and building machines.

To select each of these three systems, premises originating from the character of the technological process together with organizational structure of a production division have been adopted.

In terms of the theory of systems the selected groups of several single man-machine units may be included in a group of complex probabilistic systems.

The aim of the studies was to define regularities which govern the scheme of wet bulb globe temperature (WBGT) values in a complex production system. Recognition of these regularities will allow, among other aspects, control of microclimatic conditions, e.g. temperature, wetness, the speed of air movement and thermal radiation. The scale covers a complex production system during:

- changes in the character of the technological process;
- machines and modernization of production facilities;
- improving organization and equipping work-stands;
- reforming production structures and the method of present management of the production course.

By apparatus measurements representative WBGT values have been determined within the scale of the whole shift for each object (single man-machine units) of a complex production system.

Three numerical sequences obtained from several WBGT values have been statistically analysed.

Right-side open value classes have been fixed for measured values of variables set in increasing order.

Next a non-parametric hypothesis has been verified. The hypothesis deals with the type of spread of the feature under examination in a general population.

Three methods have been used as follows:

- chi-squared Pearson test of compatibility;
- Kollmogorow test of lambda-compatibility;
- graphic method according to lambda-test.

The zero hypothesis has been verified on the level of 1% error risk.

Having used three different methodical approaches it has been proved that the scatter of WBGT values is not incidental but exhibits resemblance to the normal scatter of Gauss, valid for each of the production systems under examination.

The representative character of complex production systems selected for examination leads us to believe that the regularity demonstrated is generally efficient in plants in the engineering industry.

C. HUMAN FACTORS IN EVERYDAY LIFE

C 1. Home Life and House Design

The Evaluation of Each Daily Human Activity by the Instrumentation of a Continuous Heart-rate Measurement

By S. ADACHI

School of Medicine, Keio University, 35 Shinanomachi, Shinjuku-ku, Tokyo 60, Japan

In this paper, each human activity in daily life was evaluated by recording heart-rate measured by a portable heart-rate memory system. At the same time, note was taken of each event of everyday life in time series, those events were sorted into similar phases of activities and were evaluated by the character of distribution of heart-rate scores.

In low-power activity, the curve of its distribution figure has the longer tail of the curve to the right, namely positive skewness. In the middle-power activity, its configuration is symmetrical. In high-power activity, it has the longer tail of the curve to the left, namely negative skewness.

Next, as one of the dynamical processes, everyday life has been studied.

During complex activities, the curve of its distribution figure, which is constructed by rates of change in heart-rate scores, has the wide tail of the curve to both sides. During simple activities, the curve of its distribution of the rates of change is a narrow peaked figure.

Further, the transient character from one activity to another has been studied.

The Warmth-to-Touch of Building Materials

By I. MATSUI and Y. KANAI

College of Industrial Technology, Nihon University, Izumicho, Narashinoshi, Chiba 275, Japan

This paper describes the estimation of warmth caused by touching building materials with the palm of the hand. A testing apparatus was developed in order to estimate the warmth. The apparatus has two copper cylinders substituted for the palms. One of the cylinders is heated to the same temperature as the palm and the other one contacts the material. The change in temperature of the heated cylinder is measured when it contacts the material. The warmth-to-touch of the materials was investigated by a method of successive categories with 20 subjects and 15 materials in a room at various temperatures (10, 20, 36, 40 and 50°C). The conclusive results were as follows.

- (1) In the room at 10 and 20°C, the warmth-to-touch of materials with a large thermal diffusivity feels cool. In the room at 36°C, the warmth-to-touch of all of the materials feels a little warm. In the room at 40 and 50°C, the warmth-to-touch of materials with a large thermal diffusivity feels warm.
- (2) The rate of change in temperature of the copper cylinder is slightly different from that of a palm of the hand, however, it can estimate the warmth to touch of materials.
- (3) Sensation is discriminated between warm and cool at θv (the rate of change in temperature of the cylinder) = -0.025°C/s . In the sensation of warmth, it feels a little warm at $\theta v = 0^\circ\text{C/s}$, pretty warm at $\theta v = 0.075^\circ\text{C/s}$ and the sensation of warmth is saturated at more than $\theta v = 1^\circ\text{C/s}$. In the sensation of coolness, it feels a little cool at $\theta v = -0.054^\circ\text{C/s}$, pretty cool at $\theta v = -0.135^\circ\text{C/s}$ and the sensation of coolness is saturated at approximately $\theta v = -0.2^\circ\text{C/s}$.

The Relation Between Physical Elements and Visual Effects in Living Rooms. Part 1. On the Wall Colour

By T. YANASE

Nara Women's University, Kitauoya-nishimachi, Nara 630, Japan

The quantification of visual effect values of wall colour applying to interior colour design was investigated. Each of the 1/10 scale models (presented as slides) that were different from the wall colour was judged in the same order on each bipolar semantic scale of sixteen adjectives. The results were analysed by factor analysis and quantitative analysis.

Using analysis of variance, it was shown that the subjects responded differently to some scales, 'warm-cool' 'fine-gloomy' 'hot-cold' 'broad-narrow' 'lively-lifeless' in different environmental temperatures.

Three dimensions were produced. Dimension 1 would seem to relate to how inspiring the room is, and was named the factor of 'activity (pleasantness and liveliness)'. The second dimension related to how much harmony the room has; how controlled it is, and was named the 'evaluation (friendliness and satisfaction)' factor. The third group was clearly a warmness group, and was named the factor of 'warmness'.

Using the quantitative analysis of Hayashi, dimension 1, 'activity', was influenced to a greater degree by brightness than the other factors of wall colour, 'evaluation' was influenced by saturation and 'warmness' was influenced by hue. The higher the value of brightness, the more the living room had pleasantness and liveliness, and the higher the value of saturation, the less the living room has friendliness and satisfaction.

$\tan^{-1} b/a$, L , $\sqrt{a^2 + b^2}$ on 'the ab-chromaticity diagram' were representative of hue, brightness, and saturation, respectively, and the results were similar to that described above.

The Relation Between Physical Elements and Visual Effects in Living Rooms.

Part 2. On the Wall and Light

By M. KUNISHIMA

Nara Women's University, Kitauoya-nishimachi, Nara 630, Japan

The factor which affected the atmosphere of living rooms was investigated.

Five factors were adopted: the wall colour, the wall texture, the horizontal illumination on the desk, the kinds of light source and the area of surface source of light in living rooms.

The combination, $2^5 = 32$, of two levels in the respective factor were examined. Twenty-five subjects, the students of the course dwelling in the women's university, judged the semantic scale.

The results were analysed by means of analysis of variance, factor analysis and quantitative analysis of Hayashi.

The results for the two methods, one judged using 1/10 scale models and the other using 1/5 scale models, were not significantly different.

The repeats of the judgements were similar, and the relationship between before and after measures was not significant beyond $p < 0.05$.

From the above-mentioned treatment, the following dimensions were induced: activity evaluation and lightness.

Further, the factor which affected the respective dimension was explained.

Dimension 1, 'Activity', was influenced to a greater degree by the area of surface source of light and the horizontal illumination on the desk than other factors, 'Evaluation' by the lighting factor.

Studies on Subjective Sensations on Air Movement for Creating a Comfortable Indoor Climate

By H. KUBOTA

Department of Architecture and Building Engineering, Muroran Institute of Technology,
27-1 Mizumoto-cho, Muroran, Hokkaido, Japan

It is believed that the fresh and comfortable sensation produced in well-ventilated rooms is due in part to air movement. The movements that give comfort under ordinary room conditions seem to lie somewhere near the threshold of perceptibility. In the first place, experiments on threshold air velocity which evoke the sensation of air movement were conducted and it was found that thresholds varied with variability of air velocity. Second, the difference limens were tested and the results showed that (a) the Weber ratio decreased with air velocity and (b) the difference of cooling power of air movement seemed to evoke the sensation of the difference of air velocity.

The invigorating effect of air currents on subjective impressions depends not only on their average velocity but also on their variability and the characteristics of oscillation (spectrum) of air velocity, and the strong influence of temperature on the feeling of freshness is also apparent. However, we sometimes found it difficult to describe our impressions of the air current. In order to get ideas for expressing impressions, the method of factor analysis was applied to the sensations of air movement. Seven normally dressed subjects attended tests in which 81 different-conditioned air currents were rated on 21 seven category rating scales defined by polar-opposite adjectives, over a range of air temperature from 25 to 32°C. As a result of factor analysis, four groups of expressions, (1) sensation of coolness, (2) sensation of air current strength due to cooling effect, air pressure and stimuli by the variability of air velocity, (3) sensation of air velocity oscillation and (4) sensation of comfort.

A Survey on the Effects of Involuntary Smoking and Attitudes to Smoking Among School Children and Students

By S. MURAMATSU, T. MURAMATSU and A. WEBER

Department of Hygiene and Ergonomics, ETH-Center, CH-8092 Zürich, Switzerland

We have investigated the effects of involuntary smoking and attitudes to smoking among school children and students in Zürich in December 1981. One hundred and eighty-three 13-year-old children, 203 16-year-old children and 367 22-year-old students of the Swiss Federal Institute of Technology were interviewed by questionnaire. Of the students 20.2% are regular smokers, as are 10.3% of the elder children, whereas only 3.8% of the younger children smoke occasionally. Thirty-two per cent of their fathers and 17% of their mothers are regular smokers.

The most interesting results are as follows:

- (1) Significantly more of the younger children (81%) than the elder children (70%) and the students (70%) dislike involuntary smoking.
- (2) Non-smokers dislike involuntary smoking significantly more than smokers.
- (3) The subjects whose parents smoke dislike involuntary smoking less than the subjects whose parents do not smoke.
- (4) Eighty per cent of the students, 64% of the elder children and 82% of the younger children complain of one or more irritations due to involuntary smoking. The most common impairment is eye irritation, followed by cough and nose irritation.
- (5) Non-smokers complain of irritations more than smokers.
- (6) There is no significant difference between girls and boys of reactions and effects of involuntary smoking.

An Experimental Study on Irritations and Annoyance Due to Passive Smoking

By T. MURAMATSU, A. WEBER, S. MURAMATSU and F. AKERMANN

Department of Hygiene and Ergonomics, ETH-Center Clausiusstrasse 21,
CH-8092 Zürich, Switzerland

Forty subjects were exposed to cigarette smoke produced by a smoking machine in a climatic chamber. The degree of air pollution due to cigarette smoke corresponded to 2 p.p.m. CO and 1 p.p.m. CO. The concentrations of particulate matter, NO and NO₂ were measured. With a questionnaire, we determined the degree of annoyance and of subjective irritations of eyes, nose and throat; eye blink rate was measured as an objective indicator of eye irritation. Annoyance about air quality or about smell and the desire to open the window or to leave the room increased significantly 10 min after the beginning of exposure. Especially after 30 min of exposure at the higher tobacco concentration (2 p.p.m. CO) the percentage of subjects who desired to open the window remained at a nearly constant level of 80%. As far as eye irritations are concerned, the intensity of eye itching was the most sensitive criterion, followed by the wish to close the eyes. Eye itching increased significantly after 20 min of exposure. Among nose and throat irritations, cough increased significantly after 30 min and nose itching after 50 min of exposure. Eye blink rate also increased significantly after 40 min at the higher tobacco concentration and 50 min at the lower concentration (1 p.p.m. CO). Annoyance and irritations due to tobacco smoke are both more marked for non-smokers and for subjects with sensitive eyes than for smokers and people without sensitive eyes.

Passive Smoking at Work

By A. WEBER

Swiss Federal Institute of Technology, Department of Hygiene and Ergonomics, ETH Zentrum,
CH-8092 Zurich, Switzerland

Air pollution due to tobacco smoke and its effects on employees were investigated in 44 workrooms. For this purpose, the concentrations of CO, NO, nicotine and particulate matter were determined, and 472 employees were interviewed about annoyance and irritations.

The mean values of the concentrations of the components due to tobacco smoke were: CO, 1.1 p.p.m.; NO, 32 p.p.b.; nicotine, 0.9 µg/m³ and particulate matter, 133 µg/m³. One-third of the measured CO values exceeded a critical threshold of 2 p.p.m. CO due to tobacco smoke.

One-quarter of the persons reported eye irritations at work. One-third of the employees qualified the air with regard to smoke at the workplace as bad. Forty percent of the interviewed persons were disturbed by smoke.

As preventive measures for the protection of non-smokers at work, the following possibilities are available:

- (1) Organizational measures, such as a separation into smoking and non-smoking rooms, or the prohibition of smoking (75 and 49%, respectively, of the interviewed employees are in favour of these measures).
- (2) Sufficient air ventilation: according to calculations, it can be shown that a fresh air supply of 33 m³ per hour and per smoked cigarette is necessary; this corresponds to a fresh air supply of 20-45 m³ per hour and per person, depending on the number of persons in the room.

Addenda

The following abstracts were received too late for inclusion in the main text. They are grouped under their appropriate sub-section headings.

A 2. Muscular Stress and Physical Response

Experimental Thermoesthesiometer

By H. MITO

Kinki University School of Medicine, Sayama-cho, Minamikawachi-gun, Osaka 589, Japan

The experimentally developed thermoesthesiometer facilitates the setting of a constant rate of temperature shift. It is capable of measuring the skin temperature of the body. It also facilitates the measurement of thermoesthetic warmth threshold in the rising temperature sequence. It enables one to measure the thermoesthetic cold threshold measurement from the same skin temperature in the temperature declining sequence. Further, by changing the skin temperature by immersion of the hand in cold water, the warmth/cold thermoesthetic thresholds are measured. The relation between the skin temperature and thermoesthesia has been studied.

A 5. Noise and Vibration

Vibration Absorbing Handle

By K. T. KONGSKOLAN

The Laboratory of Construction Ergonomics, Royal Institute of Technology,
S-100 44 Stockholm, Sweden

The main purpose of this idea has been to produce a vibration restraining gadget in order to reduce low-frequency vibrations (< 100 Hz) as well as high-frequency vibrations. Furthermore, we have aimed at producing a vibration restraining device, which reduces vibrations in all directions and is easy to adapt to all kinds of vibrating hand tools, no matter how they operate or perform. This has been achieved by a change in the design and construction of the handle. In principle the result produced consists of three parts, that is: the core which is directly attached to the vibrating tool, and the grip, which is separated from the handle by a pressurized gas chamber.

A 9. Manual Tracking Task

Visual Lead Compensation in Manual Compensatory Tracking

By S. HARA and K. HANADA

Japan Ergonomics Research Society, Technological University of Nagaoka, Kamitomioka,
Nagaoka 949-54, Japan

In manual control, quickened displays and preview displays, etc., which give predicted information to human operators, have been proposed to compensate for their inherent delay. These are useful for undamped controlled processes of second or higher order. In these displays, the compensatory type, such as quickened displays, had merit in its compactness.

In this paper, a new compact display of compensatory type, which aids operators in predicting future errors of time, is proposed. The display indicates not real error $e(t)$ but predicted error $\hat{e}(t)$ given by $\hat{E}(s) = (1 + T_2s)/(1 + T_1s)E(s)$, where $E(s)$ and $\hat{E}(s)$ are Laplace transformations of $e(t)$ and $\hat{e}(t)$ respectively and $T_2 > T_1$. We call this display a visual lead compensator (VLC), because the transfer function is the same as that of the lead compensator in servo controllers. We clarify properties of compensatory type displays with prediction functions by comparing the characteristics of VLC with that of the conventional signal quickening technique (SQ) both theoretically and experimentally.

The results obtained are as follows:

- (1) Two experiments for random reference inputs made up of ten sinusoidal waves (0.19–17.9 rad/s and 0.19–1.9 rad/s) lead to the following properties:
 - (i) In the low frequency domain (~ 2 rad/s), $e_{VLC}^2 < e_{SQ}^2 \approx e_{NO}^2$, where e_{NO}^2 , e_{VLC}^2 , and e_{SQ}^2 are mean square errors in the case of the no-compensator, VLC, and SQ respectively.
 - (ii) In the high frequency domain (~ 2 rad/s), $e_{SQ}^2 < e_{NO}^2 \approx e_{VLC}^2$.
- (2) The above properties can be explained theoretically by an optimal control approach with quadratic performance. This model accounts for the experimental results of the low and high frequency phase-drop phenomena by VLC and SQ respectively.
- (3) The optimum values of VLC parameters are $T_1 = 1.2-1.5$ and $T_2 - T_1 = 0.6 \sim 0.8$ for both single and double integrators.
- (4) The superiority of VLC in the low frequency domain is also verified by experiment for step reference inputs.

B.2. Productivity and Occupational Health in Various Industries

Trade Studies of Occupational Environments An Analysis Based on a Survey of the Profession of Electrician

By C. SCHRÖDER

Department of Building Technology Construction Management and Industrial Engineering, Lund University, P.O.B. 725, S-220 07 Lund 7, Sweden

The purpose of the dissertation was firstly to analyse and discuss different methods of studying the working environment of an occupational group. Secondly, it was aimed to describe the occupational environment of electricians from a mental as well as physical viewpoint.

A review of the literature in the subject leads to the conclusion that an occupational environment should be described from complementary perspectives. The occupational environment of electricians was studied with the help of technical measurements and expert advice and direct and indirect interviews with electricians. The direct interviews were made at work places and the indirect by mail inquiry. The electricians safety representatives and supervisors were also used as sources of information. Furthermore, existing medical data on construction workers in general were analysed to establish the presence of possible 'electricians' diseases'.

The result of the environmental study has shown that electricians have problems with muscular strain injuries due to improper working posture. They also have a high frequency of eye injuries and allergies. The lighting is often too dim, bright, glaring or reproduces colours poorly. Hazards such as noise and dust stem often from other activities on the premises than from wiring duties. The climatic problems of draft and chill are evident and can even be traced in the electricians' health status through increased frequency of cystitis.

The psycho-social environment is relatively good, mainly because the content of the working assignments is viewed as meaningful and varied. Considerable responsibility, a high level of qualification and personal freedom are other positive aspects. Dissatisfaction with the salary, particularly with its size and meagre future opportunities for wage increases, is a common vexation. Inconsistent availability to work assignments and a far too strong dependence on other occupational categories are also ranked as negative sides of the profession.

B.3. Field Studies of Safety and Occupational Health

A Study on the Difference of Attitudes to Work Feelings of both Japanese and Chinese Female Workers who are Engaged in Light Repetitive Work

By T. OHKUBO, M. AOKI and Y. HORIE

Human Performance Laboratory, Faculty of Industrial Engineering and Management, College of Industrial Technology, Nihon University, 1-2-1 Izumicho Narashino Shi, Chiba 275, Japan

With the increase in automation, the application of ergonomic principles to work design has become of increasing importance. With skilled and semi-skilled work people could self-pace their task and derive pleasure and take pride in the results. But as automation has grown many such tasks have become, for the

workers, simple and monotonous work involving only a small part of the finished product. At the present stage in advanced automation the workers seem to a large extent to be losing the pleasure and satisfaction in their task. Although automation has substantially reduced workers' work load, it has produced various psychological or mental stresses more markedly than before. A series of subjective assessments, using questionnaires, were carried out on 800 Japanese and Chinese female workers who are engaged mainly in various types of light repetitive work in manufacturing industries to investigate the difference of the attitudes to work due to the difference of their cultural, social and geographical background. As the results show no fundamental differences of attitudes to work can be seen in either country and consideration of such factors as duration of work, rest pauses, human relationships between workers and working environments becomes of increasing importance for females doing monotonous work in order to maintain desirable conditions for their health and working efficiency.

B.12. Design of Production Systems

Contribution of Human Automatics to Man-Machine System Analysis

By N. MALVACHE

Directeur du Laboratoire d'Automatique Industrielle et Humaine, Université de Valenciennes, Le Mont Houy, 59326 Valenciennes Cedex, France

The conception of a system, of which the primary goal is to contribute to human development, should be a priority of research, reconciling technical innovation and social innovation. The development of computerization and automation means in many sectors more and more in direct relationships with man, not only technico-economic modifications but also human modifications, related to the new methods of task distribution at work stations equipped with new means of communication. This evolution in work and technology also has new psychological and sociological consequences, and brings on evolutions in qualifications and work organization, where human beings acquire and treat more and more information.

Automatics is more and more concerned with complex systems with an evolutive structure, systems interconnected with command methodologies the tools of description and operating safety; and the essential finding, for this author, is to observe that even highly automated systems must integrate the human-function. The concept of 'system' is evolving towards that of 'man-machine system', where man cooperates with the machine in order to reach a goal. Automatics should contribute to improving working conditions, and make work again worth while in our society, where all human actions are based on a part of the subjective that the automatician is ill-advised to underestimate in his activities: he should avoid the oft-committed error of confusing the task and the human activity at a work station to be computerized. The object of this paper is not to go deeply into a particular aspect of this vast subject of research, nor to skim over it; rather, we wish to illustrate, by certain examples of research, some activities of recent years that bring out the interest of deepening the analysis of man-machine systems.

The first part, using general considerations, illustrates the introduction of the ergonomics of conception into activities depending on engineering sciences, and emphasizes the importance of man-machine communication. The second stresses the role of the interface, in the wide sense, depending on the degree of automation and on man-machine cooperation, notably in the event of exceptional or accidental circumstances. The third part, contrary to the generality of the preceding parts, sets out two particular examples that attempt to research the model for good working conditions. One deals with the phenomenon of the fatigue of a human operator face to face with a screen and keyboard system of visualization. The other shows some of a human driver's reactions under perturbed operating conditions in a transportation system. The fourth and last part attempts to formalize human subjective data, using concepts taken from the theory of fuzzy sets. These four, seemingly distinct parts, intend only to bring to system analysis the contribution of human automatics.

B.13. Management and Humanization

Accuracy of Leaders' Perceptions of Self and Others, and Actual Group Status as Functions of Cognitive Complexity

By H. W. HENDRICK

Department of Human Factors, University of Southern California, U.S.A.

A group of 113 male undergraduate students in an advanced leadership course viewed the first 38 min of the film *Twelve Angry Men*, which depicts the deliberations of a jury at the end of a murder trial. Each student

The results obtained are as follows:

- (1) Two experiments for random reference inputs made up of ten sinusoidal waves (0.19–17.9 rad/s and 0.19–1.9 rad/s) lead to the following properties:
 - (i) In the low frequency domain (~ 2 rad/s), $e_{VLC}^2 < e_{SQ}^2 \approx e_{NO}^2$, where e_{NO}^2 , e_{VLC}^2 , and e_{SQ}^2 are mean square errors in the case of the no-compensator, VLC, and SQ respectively.
 - (ii) In the high frequency domain (~ 2 rad/s), $e_{SQ}^2 < e_{NO}^2 \approx e_{VLC}^2$.
- (2) The above properties can be explained theoretically by an optimal control approach with quadratic performance. This model accounts for the experimental results of the low and high frequency phase-drop phenomena by VLC and SQ respectively.
- (3) The optimum values of VLC parameters are $T_1 = 1.2-1.5$ and $T_2 - T_1 = 0.6 \sim 0.8$ for both single and double integrators.
- (4) The superiority of VLC in the low frequency domain is also verified by experiment for step reference inputs.

B.2. Productivity and Occupational Health in Various Industries

Trade Studies of Occupational Environments An Analysis Based on a Survey of the Profession of Electrician

By C. SCHRÖDER

Department of Building Technology Construction Management and Industrial Engineering, Lund University, P.O.B. 725, S-220 07 Lund 7, Sweden

The purpose of the dissertation was firstly to analyse and discuss different methods of studying the working environment of an occupational group. Secondly, it was aimed to describe the occupational environment of electricians from a mental as well as physical viewpoint.

A review of the literature in the subject leads to the conclusion that an occupational environment should be described from complementary perspectives. The occupational environment of electricians was studied with the help of technical measurements and expert advice and direct and indirect interviews with electricians. The direct interviews were made at work places and the indirect by mail inquiry. The electricians safety representatives and supervisors were also used as sources of information. Furthermore, existing medical data on construction workers in general were analysed to establish the presence of possible 'electricians' diseases'.

The result of the environmental study has shown that electricians have problems with muscular strain injuries due to improper working posture. They also have a high frequency of eye injuries and allergies. The lighting is often too dim, bright, glaring or reproduces colours poorly. Hazards such as noise and dust stem often from other activities on the premises than from wiring duties. The climatic problems of draft and chill are evident and can even be traced in the electricians' health status through increased frequency of cystitis.

The psycho-social environment is relatively good, mainly because the content of the working assignments is viewed as meaningful and varied. Considerable responsibility, a high level of qualification and personal freedom are other positive aspects. Dissatisfaction with the salary, particularly with its size and meagre future opportunities for wage increases, is a common vexation. Inconsistent availability to work assignments and a far too strong dependence on other occupational categories are also ranked as negative sides of the profession.

B.3. Field Studies of Safety and Occupational Health

A Study on the Difference of Attitudes to Work Feelings of both Japanese and Chinese Female Workers who are Engaged in Light Repetitive Work

By T. OHKUBO, M. AOKI and Y. HORIE

Human Performance Laboratory, Faculty of Industrial Engineering and Management, College of Industrial Technology, Nihon University, 1-2-1 Izumicho Narashino Shi, Chiba 275, Japan

With the increase in automation, the application of ergonomic principles to work design has become of increasing importance. With skilled and semi-skilled work people could self-pace their task and derive pleasure and take pride in the results. But as automation has grown many such tasks have become, for the

workers, simple and monotonous work involving only a small part of the finished product. At the present stage in advanced automation the workers seem to a large extent to be losing the pleasure and satisfaction in their task. Although automation has substantially reduced workers' work load, it has produced various psychological or mental stresses more markedly than before. A series of subjective assessments, using questionnaires, were carried out on 800 Japanese and Chinese female workers who are engaged mainly in various types of light repetitive work in manufacturing industries to investigate the difference of the attitudes to work due to the difference of their cultural, social and geographical background. As the results show no fundamental differences of attitudes to work can be seen in either country and consideration of such factors as duration of work, rest pauses, human relationships between workers and working environments becomes of increasing importance for females doing monotonous work in order to maintain desirable conditions for their health and working efficiency.

B.12. Design of Production Systems

Contribution of Human Automatics to Man-Machine System Analysis

By N. MALVACHE

Directeur du Laboratoire d'Automatique Industrielle et Humaine, Université de Valenciennes, Le Mont Houy, 59326 Valenciennes Cedex, France

The conception of a system, of which the primary goal is to contribute to human development, should be a priority of research, reconciling technical innovation and social innovation. The development of computerization and automation means in many sectors more and more in direct relationships with man, not only technico-economic modifications but also human modifications, related to the new methods of task distribution at work stations equipped with new means of communication. This evolution in work and technology also has new psychological and sociological consequences, and brings on evolutions in qualifications and work organization, where human beings acquire and treat more and more information.

Automatics is more and more concerned with complex systems with an evolutive structure, systems interconnected with command methodologies the tools of description and operating safety; and the essential finding, for this author, is to observe that even highly automated systems must integrate the human-function. The concept of 'system' is evolving towards that of 'man-machine system', where man cooperates with the machine in order to reach a goal. Automatics should contribute to improving working conditions, and make work again worth while in our society, where all human actions are based on a part of the subjective that the automatician is ill-advised to underestimate in his activities: he should avoid the oft-committed error of confusing the task and the human activity at a work station to be computerized. The object of this paper is not to go deeply into a particular aspect of this vast subject of research, nor to skim over it; rather, we wish to illustrate, by certain examples of research, some activities of recent years that bring out the interest of deepening the analysis of man-machine systems.

The first part, using general considerations, illustrates the introduction of the ergonomics of conception into activities depending on engineering sciences, and emphasizes the importance of man-machine communication. The second stresses the role of the interface, in the wide sense, depending on the degree of automation and on man-machine cooperation, notably in the event of exceptional or accidental circumstances. The third part, contrary to the generality of the preceding parts, sets out two particular examples that attempt to research the model for good working conditions. One deals with the phenomenon of the fatigue of a human operator face to face with a screen and keyboard system of visualization. The other shows some of a human driver's reactions under perturbed operating conditions in a transportation system. The fourth and last part attempts to formalize human subjective data, using concepts taken from the theory of fuzzy sets. These four, seemingly distinct parts, intend only to bring to system analysis the contribution of human automatics.

B.13. Management and Humanization

Accuracy of Leaders' Perceptions of Self and Others, and Actual Group Status as Functions of Cognitive Complexity

By H. W. HENDRICK

Department of Human Factors, University of Southern California, U.S.A.

A group of 113 male undergraduate students in an advanced leadership course viewed the first 38 min of the film *Twelve Angry Men*, which depicts the deliberations of a jury at the end of a murder trial. Each student

then ranked the jurors in terms of the order in which he thought they would change their verdict from guilty to not guilty during the remainder of the film. Prior to the experimental task, each student had ranked the members of his class section, including himself, in terms of the effectiveness of their participation in prior class discussions and leadership exercises. Each section then developed a consensual ranking. All of the students had taken the Abstract Orientation Scale, a measure of cognitive complexity, during the previous school year. Analysis of variance showed both cognitive complexity and the accuracy of one's self perception of class effectiveness to be related to behaviour prediction accuracy on the experimental task ($p < 0.05$). The linear correlation of behaviour prediction accuracy with cognitive complexity was 0.38 ($p < 0.001$). Class effectiveness ranking and the accuracy of self perception of effectiveness also varied as a function of cognitive complexity ($p < 0.02$), and were found related to one another ($p < 0.001$). Implications of the findings for the understanding of leadership behaviour and effectiveness are discussed.

Assessment Centre Ratings as an Interim Criterion Measure in Leadership Research

By H. W. HENDRICK

Department of Human Factors, University of Southern California, U.S.A.

One of the major difficulties in leadership research historically has been the lack of relevant, reasonably uncontaminated criterion measures of performance. One approach to evaluating leadership in organizations has been the 'management assessment centre'. During the past two decades this methodology has emerged as the most effective means of assessing potential for managerial promotion across a broad range of organizations and settings (for example, see Huck 1973 for a review of over 50 studies). In the present study it was hypothesized that global assessment centre ratings of leadership would provide an easily obtainable, valid measure of leadership performance for experimental studies. To test this hypothesis, 545 entering cadets at the United States Air Force Academy received global assessments of leadership performance, using the Academy's Group Reaction Course as an assessment centre. These assessments, based on a five-point rating scale, were used to predict three independent measures of actual leadership performance, which were obtained 10 months later. The predictive utility of the assessments was statistically significant at beyond the 0.01 level for all three independent criterion measures, and for a composite rating. It was concluded that the global assessments of leadership based on using assessment centre methodology provide a very useful and valid interim criterion measure of leadership performance.

To further demonstrate the utility of assessment centre leadership ratings, the cadet sample also was administered the 16 PF. Based on the small group research literature, eight of the 16 PF factors were hypothesized as related to leadership performance, six of the eight factors were found significantly related both to the assessment centre ratings and to the subsequent performance measures ($p < 0.05$), and for one of the remaining two, the trend was in the expected direction, none of the other eight factors was found related.

REFERENCE

- HUCK, J. R., 1973, Assessment centres: A review of the external and internal validities. *Personnel Psychology*, **26**, 191-212.

Organizational and Technological Aspects of the Operation of Production Lines in Yugoslavia

By V. PAREŽANIN and R. PAREŽANIN

Mechanical Engineering Faculty, University of Belgrade, Belgrade, Yugoslavia

In the struggle for humanization of work on production (assembly) lines, which is now spreading in Yugoslavia and which has been current for years in the most developed Western countries, various organizational and technological solutions can be great contributions.

Studies made in 25 organizations of associated labour gave insight into the organizational and technological structure and operation of production lines in Yugoslavia. Based on these studies a conclusion can be drawn that the production lines in industry do not operate in accordance with projected solutions. Some of the main reasons are unsatisfactory organization of production and bad adjustment of this system of work to operators, which shows the presence of their tendency to solve the difficulties arising in the operation of the production line within their own influences (unofficial rest breaks and absenteeism). So the man, when better operation of the organization of work on production lines is in question, appears to be the cause of disorganization in trying to protect himself from unfavourable affects.

The authors of this work are in favour of designing such organizational and technological solutions which will enable actual and full application of the production lines on the one hand and on the other hand to give satisfaction to those who work on them.

C2. Goods and Tool Design

The Interaction Between Ergonomic Criteria and Industrial Design

By V. POPOVIC

Senior Lecturer in Industrial Design, School of the Built Environment, Queensland Institute of Technology, Brisbane, Australia

The paper describes the methodology of developing ergonomic criteria and how they interact with industrial design parameters. It outlines the recommendations for organization of the application of the criteria to product design. The aim is to develop basic standards as a framework from which design ideas of physical objects can be generated. It is seen that the starting point ought to be through industrial design education programmes. The practical benefits of such approach are oriented towards the improvement of the quality of physical objects and their interactions with the user and the environment.

Index to Authors

- A**
 Abe, M. 510
 Acquaviva-Lescoat, D. 553
 Adachi, S. 580
 Akamatsu, M. 482
 Akermann, F. 590
 Akoi, K. 554
 Ando, N. 457
 Andoh, M. 497
 Anzai, Y. 490
 Aoki, K. 491, 493, 532, 533, 549, 582
 Aoki, M. 512, 542, 543, 594
 Aoki, T. 491, 493, 532, 533, 549
 Aoyama, H. 526
 Aoyama, T. 500
 Aramaki, S. 478
 Arjunan, M. 585
 Asai, K. 543
 Asfour, S. S. 452
 Attwood, D. A. 531
 Ayoub, M. A. 521
 Ayoub, M. M. 452, 453
 Azuma, T. 464
- B**
 Bagnara, S. 485, 573
 Benel, D. C. R. 555, 567
 Benel, R. A. 505, 555
 Bergman, H. 563
 Bergman, M. H. 487
 Beshir, M. Y. 528
 Björkstén, M. 535
 Boggs, G. 562
 Boles, D. B. 485
 Borg, G. 457
 Bramall, G. A. 576
 Bräuninger, U. 555
 Bräuninger, V. 556
 Brown, C. R. 563
 Bubb, H. 477
 Bullinger, H.-J. 568
 Burford, C. L. 528
 Burloui, P. 504
- C**
 Cabarkapa, M. 513
 Canan, C. 575
 Candas, V. 466
 Caple, D. 535
 Carapancea, M. 508
 Carlsöö, S. 535
 Carter, R. J. 484
 Chai, C. P. 465
 Chashi, M. 525
 Christensen, H. 526
 Cole, R. C. 553
 Colquhoun, W. P. 512
 Cuny, X. 547
 Currier, D. P. 454
- D**
 Daltorn, E. 526
 David, H. 565
 Davis, H. D. 584
 Davis, P. R. 454
 Dazord, N. 517
 de Boer, H. 555
 De Keyser, V. 529
 Didner, R. S. 564
 Drury, C. G. 548
 Ducrocq, J. 469
- E**
 Ekkers, C. L. 519
 Elwany, M. H. 546
 Endoh, T. 481
- F**
 Farbry, J. 552
 Fellmann, T. 556
 Fiori-Savary, N. 553
 Fleger, S. 552
 Flores, J. L. 517
 Formánek, J. 458
 Francesco, B. 522
 Friedrich, P. 535, 553
 Fuchs, A. 518, 520
 Fujiie, K. 455
 Fukada, K. 481
 Fukuba, Y. 455, 462
- Fukuchi, Y. 469
 Fukuda, T. 484
 Fukunaga, T. 456, 460
 Furukawa, T. 491, 493, 532, 533, 549
 Furumatsu, E. 492
 Furumatsu, Y. 492
- G**
 Gallwey, T. T. 546
 Gantchev, N. G. 458
 Garg, A. 452
 Gierer, R. 555, 556, 558
 Gite, L. P. 577
 Gloss, D. 492, 529, 583
 Grandjean, E. 472, 554, 555, 556, 558
 Gustafsson, B. 576
 Gyr, S. 472
- H**
 Haga, S. 541
 Hagberg, M. 459
 Hanada, K. 593
 Hanayasu, S. 528
 Haneishi, K. 531
 Hansson, J. E. 535
 Hara, S. 593
 Hasegawa, T. 503, 511, 514
 Hashimoto, K. 542, 543
 Hata, S. 489, 509, 550
 Hattori, A. 578
 Haugan, A. E. 549, 557
 Hayashi, Y. 490, 543, 557
 Hendrick, H. W. 504, 571, 595, 596
 Heydenreich-Adloff, B. 520
 Hirata, F. 510
 Hirata, T. 456
 Hirayanagi, K. 493
- Hirsch-Pasek, K. A. 483
 Hisashige, A. 526
 Holmér, I. 587
 Honkasalo, A. 475
 Honkasalo, M.-L. 516
 Hopkins, C. O. 570
 Horie, Y. 512, 542, 594
 Horii, K. 544
 Horino, S. 451, 455, 536
 Hosaka, R. 474
 Houghton, T. 561, 562
 Huang, B. K. 538
 Hünting, W. 554, 556, 558
- I**
 Ichikawa, K. 502
 Ihara, M. 490
 Iiyama, Y. 569
 Ikeda, M. 476
 Ikeda, T. 539
 Ikeda, Y. 457, 489, 509, 550
 Ikegawa, S. 456
 Ilmarinen, J. 518, 524
 Inaba, S. 474
 Ishida, Y. 589
 Ishii, Y. 490
 Isu, N. 499
 Ito, F. 502
 Ito, K. 488, 496
 Ito, N. 493
 Itow, H. 471, 493
 Iwanaga, K. 464, 465
 Iwasaki, A. 454
 Iwata, K. 495
 Izumitani, Y. 462
- J**
 Jasiak, A. 517
 Jensen, R. C. 528
 Johansen, A. 530
 Joseph, T. K. 480
 Jørgensen, K. 526

- K**
 Kamada, K. 583
 Kamøy, J. I. 531
 Kanada, S. 481, 576
 Kane, R. M. 552
 Kapecka, E. 500
 Kasai, Y. 580
 Katahira, K. 495
 Kato, A. 496
 Kato, I. 570
 Katsuura, T. 461, 463, 464
 Kautto, H. 475
 Kawahara, H. 499
 Kawahara, Y. 480
 Kawano, T. 495
 Kawarabayashi, T. 510
 Kawashima, Y. 488
 Kern, P. 568
 Khaleque, A. 515
 Kikuchi, S. 474
 Kikuchi, Y. 463, 464
 Kimotsuki, K. 467
 Kimura, A. 451, 455
 Kingsley, E. 507
 Kinoshita, S. 491, 493, 532, 533, 549
 Kira, S. 456, 461
 Kirchner, J.-H. 508
 Kishida, K. 451, 455, 511, 514
 Kitagaki, I. 586, 587
 Kobayashi, F. 481, 576
 Kodama, H. 479
 Kogi, K. 506, 512, 534
 Koh, Y. 583
 Koichi, Y. 461
 Komatsubara, A. 521, 557
 Kondo, S. 473
 Kondo, T. 512
 Kongskolan, K. T. 593
 Koningsveld, E. A. P. 520
 Kose, S. 582
 Kosugo, R. 472
 Koya, Y. 455, 464, 465
 Koyano, E. 476
 Kozuki, S. 527
- Krüger, H. 478, 486
 Kubota, H. 581
 Kubota, Y. 532
 Kukkonen, R. 515
 Kumar, S. 453, 454
 Kumer, A. 454
 Kumashiro, M. 513
 Kume, Y. 526
 Kunishima, M. 581
 Kuorinka, I. 451, 515
 Kurabayashi, T. 545, 547
 Kuroe, T. 556
 Kurokawa, T. 496
 Kurosu, M. 559
 Kusano, K. 487, 500
 Kuwabara, N. 468
- L**
 Larriere, P. E. 564
 Läubli, T. 554, 556
 Launis, M. 524
 Lazar, M. T. 462
 LeCocq, A. D. 551
 Lee, R. P.-J. 558
 Lee, S. Y. 572
 Le Masson, Y. 467, 584
 Le Quere, J. 564
 Leskinen, T. P. J. 451
 Leszek, P. 568, 579
 Libert, J.-P. 466
 Lippert, S. 509
 Lorenz, D. 568
 Louhevaara, V. 524
 Lucas, R. L. 584
 Lüdersdorf, R. 520
 Lundqvist, P. 576
 Luopajarvi, T. 515
- M**
 McCafferty, D. 567
 Machida, N. 471, 472
 Maeda, K. 525
 Magee, D. 453
 Makikawa, M. 544
 Mallory, K. M. 567
- Malvache, N. 595
 Manninen, O. 470
 Manuaba, A. 539, 583
 Marek, T. 475, 500, 507
 Martin, P. L. 524
 Masada, W. 511
 Masahiro, Y. 496
 Masakazu, I. 542
 Masuda, K. 576
 Masuyama, E. 491
 Mateja, B. 507
 Matsui, H. 549
 Matsui, I. 580
 Matsumoto, T. 526
 Matsuo, A. 456, 460
 Matsuoka, K. 544
 Matthews, M. L. 477
 Mayer, P. 518
 Mazzonis, D. 573
 Mecacci, L. 481
 Megaw, E. D. 550
 Meguire, P. G. 558
 Michalek, R. 507
 Micheli, S. 574
 Micko, H. C. 480
 Middendorf, L. 520
 Mikami, K. 513
 Miki, R. 472
 Milošević, S. 513
 Misiti, R. 573
 Mital, A. 452, 454
 Mito, H. 593
 Miyao, M. 481, 576
 Mizuki, K. 483
 Mori, Y. 584
 Morikawa, S. 589
 Morioka, M. 451, 455, 543
 Morimoto, S. 501
 Morisada, C. 497
 Moriwaki, T. 495
 Morooka, K. 589
 Mulder, H. F. 566
 Mulder, M. 573
 Müller, B. H. 567
 Müller-Limmroth, W. 523
 Muramatsu, S. 590
 Muramatsu, T. 590
 Muro, M. 455
- Muroya, H. 476
 Muto, H. 492
- N**
 Nagai, S. 502
 Nagamachi, M. 503
 Nagasawa, Y. 478
 Nagashio, S. 588
 Nagata, A. 455, 582
 Naitoh, P. 506
 Nakagawa, T. 481, 576
 Nakamura, M. 487
 Nakaseko, M. 558
 Nakaya, M. 510
 Nakayama, H. 468, 559, 566
 Nakazawa, S. 588
 Nariyai, T. 462
 Niihara, T. 487
 Nilsson, C. 529
 Nishikawa, M. 531
 Nishiyama, K. 555
 Noma, K. 543
 Nomura, T. 466
 Noro, K. 501, 503, 548, 557, 570
 Noworol, C. 475, 507
 Noy, Y. A. 531
 Nudelman, S. 483
 Nygård, C. H. 518, 524
- O**
 Ogata, M. 474
 Ogawa, T. 526
 Oguro, Y. 496
 Ohara, H. 526
 Ohashi, J. 462
 Ohashi, M. 554
 Ohashi, N. 578, 579
 Ohga, T. 481
 Ohkubo, T. 594
 Ohnishi, N. 501, 502
 Ohno, H. 510
 Ohsuga, M. 498
 Okabe, M. 499
 Okada, A. 463, 464
 Okada, Y. 501, 570
 Okai, O. 471
 Okubo, T. 512
 Olsson, G. 574

- O'Neill, N. E. 494
 Onishi, N. 534, 556
 Ono, Y. 527
 Ootake, H. 539
 Osaki, H. 474
 Oshima, M. 429, 473
- P**
 Pacholski, L. 507, 517, 551
 Pagerey, P. D. 563
 Parežanin, M. A. V. 572
 Parežanin, R. 596
 Parežanin, V. 596
 Pasmooij, C. K. 536
 Peacock, B. 513
 Pepper, R. L. 553
 Pesonen, I. 524
 Peters, H. 518
 Petrovskiy, V. 461
 Popovic, V. 597
 Pornschlegel, H. 571
- Q**
 Quarin, S. 564
 Queinsec, Y. 514
- R**
 Rabideau, G. F. 540, 558
 Raheja, D. 585
 Ramsey, J. D. 465, 528
 Raouf, A. 480, 492
 Richard, E. 517, 569
 Richardson, J. 547, 550, 553
 Rieper, O. 530
 Roemer, J. M. 586
 Rollier, M. 573
 Rouhet, J. C. 542
 Rouhet, J.-E. 498
- S**
 Saiki, H. 510
 Saito, K. 513
 Saito, M. 451, 486, 511, 514
 Saito, S. 545
 Saito, Y. 473, 501
 Sakai, K. 506, 534
 Sakakibara, H. 481, 576
- Sakamoto, K. 454
 Sakamoto, M. 493
 Sakurai, T. 469
 Salvendy, G. 435
 Sano, M. 534
 Sato, H. 456, 459, 465
 Sato, K. 479, 497
 Sato, M. 464, 465
 Sato, S. 492
 Sawada, T. 533
 Scapin, D. L. 559
 Schäcke, G. 518, 520
 Schlegel, R. 513
 Schneider, M. 483
 Schröder, C. 594
 Seki, K. 454, 468
 Sen, R. N. 577
 Sen Gupta, J. 460, 462
 Shaefer, P. M. 483
 Shibahara, T. 525
 Shimizu, Y. 502, 586
 Shindo, H. 534
 Shinhachi, N. 530
 Shioda, K. 510
 Simion, F. 485
 Singleton, W. 505
 Sjöflot, L. 575
 Smith, D. 552
 Smith, D. C. 553
 Smith, G. 540
 Snyder, H. L. 486
 Somberg, B. 562
 Spychata, M. 565
 Stålhammar, H. R. 451
 Strasser, H. 516, 523
 Sudoh, M. 510
 Suenaga, O. 490
 Suetake, K. 586, 587
 Sugimoto, T. 535
 Suzuki, Y. 498
 Swain, A. D. 449
 Szczebeliski, S. 551
- T**
 Tada, A. 489
 Tajima, N. 497
 Takahashi, M. 555
 Takahashi, T. 547
 Takashi, K. 482
 Takasaki, Y. 462
 Takashima, Y. 509
 Takata, T. K. 470
- Takeda, H. 489, 509, 550
 Takihi, K. 481
 Tamura, H. 544
 Tanaka, A. 499
 Tanaka, H. 491, 493, 532, 533, 543, 549
 Tanaka, K. 499, 541, 544
 Taniguchi, T. 497
 Takihi, K. 576
 Tani, K. 453
 Tamagawa, C. 494
 Taya, Y. 468
 Terashima, M. 481
 Terayama, K. 510
 de Terssac, G. 514
 Tochiwara, Y. 466
 Togami, H. 545
 Tomoda, Y. 544
 Triggs, T. J. 532
 Troup, J. D. G. 451
 Tsuchiya, F. 540
 Tsuchiya, K. 492
 Tsuchiya, K. 496, 501, 502
 Tsunoda, N. 456
- U**
 Uchida, K. 455
 Ueno, S. 531
 Umemura, M. 522
 Umilta, C. 485
 Undeutsch, K. 519
 Uno, H. 582
 Usui, T. 454
 Utsuki, N. 478
- V**
 van der Grinten, M. P. 536
 Vogt, J. J. 466
 Vokac, Z. 482
 von Laer, A. 518
- W**
 Watanabe, A. 486, 534
 Watanabe, S. 469
 Watanabe, T. 480
 Watanuki, S. 455, 461, 465
 Weber, A. 590
 Wilson, J. 567
- Willeges, R. C. 560
 Winkel, J. 523
 Wirths, W. M. 514
 Wisner, A. 560
 Wu, R. M. 563
- X**
 Xirau, D. 553
- Y**
 Yadav, B. G. 577
 Yagi, A. 477
 Yajima, K. 491, 493, 532, 533, 549
 Yamada, M. 585
 Yamada, S. 481, 576
 Yamagata, A. 585
 Yamamoto, M. 526
 Yamamoto, S. 557
 Yamanoi, N. 491, 493, 532, 533, 549
 Yamasaki, K. 456, 461, 465
 Yamashita, T. 491, 497
 Yamazaki, N. 585
 Yanagishima, T. 534
 Yanase, T. 580
 Yasukouchi, A. 464, 465
 Yata, H. 456, 460
 Yokomizo, Y. 503, 521
 Yokoyama, S. 459
 Yoshida, K. 459
 Yoshida, T. 485
 Yoshida, Y. 471, 472
 Yoshimoto, K. 488
 Yoshimura, I. 487
 Yoshioka, M. 557
 Yoshizawa, M. 489
 You, M. L. 540
- Z**
 Zander, J. 577
 Zakay, D. 479
 Zani, A. 481
 Zink, K. J. 504
 Zorbas, Y. 461
 Zwaga, H. J. 537



Taylor & Francis Ltd

Publishers to the scientific community since 1798

4 John Street
London WC1N 2ET
Tel.: 01-405 2237/9
Telex: 858540

Physics journals

Advances in Physics
An international review journal
Bi-monthly

Contemporary Physics
A review of physics and associated technologies
Bi-monthly

Molecular Physics
Theoretical and experimental research on atomic and molecular systems
18 issues per annum

Optica Acta
Theoretical and applied optics. Published in collaboration with the Institute of Physics and under the auspices of the International Commission for Optics
Monthly

Philosophical Magazine (A & B)
Physics of condensed matter:
A. Defects and mechanical properties
B. Electronic, optical and magnetic properties
Monthly

Engineering journals

International Journal of Control
Theoretical aspects of machine and process control and automation
Monthly

International Journal of Electronics
Research in active electronic components and systems
Monthly

International Journal of Production Research
Published in association with the Institution of Production Engineers, American Institute of Industrial Engineers and Society of Manufacturing Engineers
Bi-monthly

International Journal of Remote Sensing
An official journal of the Remote Sensing Society
Quarterly

International Journal of Systems Science
Theory and practice of mathematical modelling, simulation and control
Monthly

Journal of Automatic Chemistry
An international journal on the use and practice of automation in chemistry
Quarterly

Life Science journals

Annals of Human Biology
Journal of the Society for the Study of Human Biology
Bi-monthly

International Journal of Radiation Biology
and related studies in physics, chemistry and medicine
Monthly

Journal of Medical Engineering and Technology
Promoting engineering and technology in clinical medicine
Bi-monthly

Journal of Natural History
An international journal of taxonomic and general biology
Bi-monthly

Medical Informatics—Médicine et Informatique
Information handling in medicine
Quarterly

Xenobiotica
The fate of foreign compounds in biological systems
Monthly

Ergonomics journals

Behaviour & Information Technology
An international journal on the human aspects of information processing
Quarterly

Ergonomics
Human factors in work, machine control and equipment design
Monthly

Ergonomics Abstracts
Published in association with the Ergonomics Information Analysis Centre
Quarterly

History journals

Annals of Science
A review of the History of Science and Technology since the 13th century
Bi-monthly

History and Philosophy of Logic
An annual volume of articles, to be published twice per annum from 1982

History of Photography
Reviews and research in photographic history
Quarterly

Journal of Garden History
A new international journal on the architectural history of gardens
Quarterly

Education journals

Environmental Education and Information
An international journal of research, practice and information
Quarterly

European Journal of Science Education
A medium for communication between researchers, teachers and administrators in science education
Quarterly

History of Education
The Journal of the History of Education Society
Quarterly

International Journal of Mathematical Education in Science and Technology
Mathematical education studies
Bi-monthly

Journal of Curriculum Studies
The theory and practice of curriculum and teaching
Quarterly

The Cambridge Review
The journal of university life and thought
Six issues per annum

 **The Falmer Press**

Educational Analysis
Thematic analyses of educational issues
3 issues per annum

Insight
The journal of the National Conference of Teacher Centre Leaders
Quarterly

International Journal of Lifelong Education
An academic approach to the principles and practice of lifelong education
Quarterly

School Organization
Practical and contemporary perspectives on school organization
Quarterly

Transport journals

Maritime Policy and Management
Research into ship and port operation
Quarterly

Transport Reviews
An international, interdisciplinary approach to transport
Quarterly

Further information, subscription details and sample copies are available on request.

Taylor & Francis Ltd have an active book publishing programme, run in conjunction with their journals; a complete catalogue is available.

Copyright

All rights reserved. Copyright in articles published in this journal is the property of Taylor & Francis Ltd.

Authors are themselves responsible for obtaining permission to reproduce copyright material from other sources.

Authors are required to sign a form for agreement of the transfer of copyright.

The appearance of a code before the copyright line at the bottom of the first page of an article in this journal indicates the copyright owner's consent that copies of the article may be made for personal or internal use, or for the personal or internal use of those clients, in the USA, who are registered with the Copyright Clearance Center. This consent is given on the condition that the copier pays the stated per-copy fee through the Copyright Clearance Center, Inc., 21 Congress Street, Salem, Massachusetts 01970, for copying beyond that permitted by Section 107 or 108 of the U.S. Copyright Law. This consent does not extend to other kinds of copying, such as copying for general distribution, for advertising purposes, for creating new collective works, or for resale. Fees for past articles are the same as those shown for current articles.

INSTRUCTIONS TO CONTRIBUTORS

1. Papers for publication should be sent to the appropriate subject editor. The author must give his FULL postal address.

2. Papers must be in English, French or German. Every paper must be accompanied by a brief summary, in the language of the paper and, if this is not English, also in English. Papers should be as short as possible.

3. Authors should submit **two copies** of their articles: one an original typescript, double-spaced, on one side of the paper only; the second a legible carbon or photocopy. Footnotes should be avoided. The summaries, the titles of the tables and the captions to the illustrations must each be typed on a separate sheet. Authors must ensure that the lay-out of mathematical and other formulae is clear. The typescript must be set out in sections subtitled Introduction, Methods, Results, Discussion, or other appropriate numbered headings in conformity with the layout of the Journal. **Authors may be charged for any alterations they make in proof other than to printer's errors.**

4. Diagrams must be drawn in black ink on white card or tracing paper large and bold enough to allow reduction in printing. **All lettering should be up to draughtsman-ship standard, suitably drawn in Indian ink to allow for reduction in size.** Only one set of original drawings is required, marked in pencil on the back with the author's name, abbreviated title of the article and figure number. Photocopies of these originals may be used to illustrate the second copy of the typescript. Diagrams not suitable for reproduction may be redrawn at the author's expense.

5. References in the text should be given thus: Bartlett (1943). References must be listed alphabetically at the end of the paper as follows:

BARTLETT, F. C., 1943, Fatigue following highly skilled work. *Proceedings of the Royal Society B*, 131, 247-254.

BEDFORD, T., 1948, *Basic Principles of Ventilation and Heating* (London: H. K. LEWIS).

LE GROS CLARK, W. E., 1954. The anatomy of work. In *Symposium on Human Factors in Equipment Design* (Edited by W. F. FLOYD and A. T. WELFORD) (London: H. K. LEWIS), pp. 5-15.

Journal and book titles should not be abbreviated in the list of References.

6. Symbols, abbreviations and conventions in papers must follow the Système International d'Unités (SI Units). See Royal Society of Medicine, May 1971, *Units Symbols and Abbreviations, A Guide for Biological and Medical Editors and Authors*.

7. Consideration for publication will gladly be given to papers which have previously had a limited circulation as research reports. Submission of a paper implies, however, that it has not been published and will not be published elsewhere without the permission of the General Editor and the Publishers. Copyright in material accepted for publication is retained by the Journal and reproduction in whole or in part is forbidden except with the written permission of the Publishers. Authors are required to make an explicit transfer of copyright to the publishers so as to safeguard their rights in the U.S.A. under the 1976 Copyright Act (see first page). Authors are responsible for ensuring, **before submitting their articles**, that permission to reproduce examples of test material, etc., held in copyright by other publishers, has been obtained in writing. A copy of this approval should be submitted with the article and the copyright holder's agreed form of acknowledgment should appear at an appropriate point in the text.

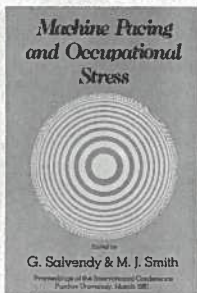
8. **Fifty offprints will be sent to the author or principal author without charge.** Additional offprints may be ordered. An order form will accompany the proofs.

9. The Editors cannot accept responsibility for damage to or loss of papers submitted to them.

10. **The Editors cannot consider for publication papers seriously deficient in presentation.**

Machine Pacing and Occupational Stress

Edited by G. Salvendy
(Purdue University)
and M. J. Smith
(NIOSH)



1981 0 85066 225 7
380pp Cloth £19.75

This book consists of papers presented at the First International Conference on Machine Pacing and Occupational Stress, held at Purdue University in March 1981. The conference was sponsored by the National Institute for Occupational Safety and Health (NIOSH) and the Human Factors Program, Purdue University.

Sitting Posture/Sitzhaltung/Posture Assise

Edited by E. Grandjean
(Swiss Federal Institute of Technology, Zurich)

This book deals with the problems of sitting posture and its anthropometric, physiological and orthopaedic aspects; surveys the present knowledge and conveys to industry and to designers the biological principles for the construction of seats. English language summaries are attached to all French and German papers.

1976 0 85066 029 7
262pp Cloth £10.00

Ergonomics of the Home

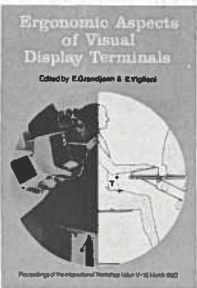
E. Grandjean
(Swiss Federal Institute of Technology, Zurich)

Ergonomics of the home is the science of analysing the normal operations of the human body under domestic conditions, in the design of buildings, rooms, structures and fittings.

1978 0 85066 067 X
344pp Cloth £12.00

Ergonomic Aspects of Visual Display Terminals

Edited by E. Grandjean
(Swiss Federal Institute of Technology, Zurich)
and E. Vigliani
(Permanent Commission and International Association on Occupational Health, and Carlo Erba Foundation, Milan)



1980 0 85066 211 7
300pp Cloth £18.00

Proceedings of an International Scientific Workshop, held in Milan in March 1980, called to examine the effects of the increasingly widespread use of VDUs by non-specialist operators. Psychological and physiological problems are discussed along with possible solutions.

Measurement of Man at Work

Edited by W. T. Singleton
(University of Aston in Birmingham),
J. G. Fox and D. Whitfield
(University of Birmingham)

The symposium at which these papers were presented, had its origin in a wish to evaluate and compare the utilization of physiological and psychological techniques and criteria in the study of man-machine systems, in the light of the different traditions of European ergonomics and American human factors engineering.

1973 0 85066 041 6
268pp Cloth £10.00

Search and the Human Observer

Edited by J. N. Clare
(Kenneth Craik Laboratory, Cambridge)
and M. A. Sinclair
(Department of Human Sciences,
Loughborough University of Technology)

This book contains 16 papers presented at the 'Search and the Human Observer' seminar held in Loughborough in 1979. The papers consider basic and applied research, methods and applications, psychological and neurophysiological operations research, and design and experimental aspects of visual search.

1979 0 85066 193 5
196pp Paper £8.00

Design for Work and Use

Case Studies in Ergonomics Practice - Volume 2

Edited by H. G. Maule and J. S. Weiner
(University of London)

This volume has been chosen to illustrate how 'curative' or 'preventive' ergonomics measures can be used to solve a variety of problems.

1981 0 85066 208 7
147pp Cloth £12.00

**Fitting the Task to the Man
An ergonomic approach**

E. Grandjean
(Swiss Federal Institute of Technology, Zurich)



1980 (3rd edn.)
0 85066 191 9
379pp Cloth £14.50
0 85066 192 7
379pp Paper £9.50

This third edition has been considerably revised and expanded to include the latest information on work physiology and its place in the science of ergonomics. The organization of work geared to man, and the central features of this work.

Measurement of Human Resources

Edited by W. T. Singleton and P. Spurgeon
(Department of Applied Psychology,
University of Aston in Birmingham)

Report of a symposium, sponsored by NATO. Twenty-seven papers are reproduced, arranged in four main groupings: Taxonomies of Resources; Development of Resources; Planning of Resources; Summary Papers.

1975 0 85066 068 8
368pp Cloth £12.00

The Human Operator in Process Control

Edited by F. Lees and E. Edwards
(Loughborough University of Technology)

This is a collection of readings on the human operator in process control assembled during the tenure by the editors of an industrial research fellowship offered by the Institution of Chemical Engineers.

1974 0 85066 069 6
480pp Cloth £15.00

Studies of Shiftwork

Edited by W. P. Colquhoun
(University of Sussex)
and J. Rutenfranz
(University of Dortmund)



1981 0 85066 210 9
468pp Cloth £16.50

A unique collection of original reports and research on the advantages and problems associated with night and shiftwork. Much material that was previously inaccessible to those without recourse to a large research library, is presented here in its original form, allowing the reader to learn his own lessons and draw his own conclusions.

Satisfactions in Work Design: Ergonomics and Other Approaches

Edited by R. G. Sell
(Work Research Unit, Department of Employment) and
P. Shipley
(Department of Occupational Psychology,
Birkbeck College, University of London)

This book contains papers commissioned from leading authorities on ergonomics and job satisfaction. It is a practical book, with the emphasis on actual situations, including industrial case studies. 'This is important reading for specialists and personnel managers' *Industrial Society*.

1979 0 85066 180 3
220pp Cloth £10.50

Other titles still available

Human Reliability in Quality Control

Edited by C. G. Drury and J. G. Fox
1975 0 85066 088 2 Cloth £11.00

Methodology in Human Fatigue Assessment

Edited by K. Hashimoto, K. Kogi and E. Grandjean
1975 0 85066 049 1 Cloth £8.00

Man Under Stress

Edited by A. T. Welford
1974 0 85066 073 4 Cloth £7.00

Performance Under Sub-Optimal Conditions

Edited by P. R. Davis
1971 0 85066 044 0 Paper £7.00

Contemporary Problems in Perception

Edited by A. T. Welford and L. Houssiadis
1975 0 85066 039 4 Cloth £8.00

The ORASA Texts, published in association with the Operational Research Society

Articulate Intervention

H. Boothroyd
(University of Warwick)

This book is about what can and cannot be meant by the idea of intelligently directing human affairs, about the place of articulating our thoughts before acting, the role of consultants in business, industry and commerce, and the usefulness of formal models.

1978 0 85066 171 4
154pp Cloth £6.00

Operational Distribution Research

A. Mercer, M. Cantley and G. Rand
(University of Lancaster)

Distribution is increasingly regarded as an important part of a company's total capacity to serve its chosen markets and operational researchers play a vital role in making this activity more effective. There has been a marked lack of good case studies and the present work is designed to fill this gap.

1978 0 85066 168 4
196pp Cloth £8.00

Research Games

K. C. Bowen
(Ministry of Defence)

This is the first book on games as a research tool to be published in the U.K. It discusses the value and limitations of such games. Plans for further developments in the use of games for research, including games for involving the public in social planning, are summarized.

1978 0 85066 169 2
126pp Cloth £6.00

Modelling Large Systems

P. C. Roberts
(Department of the Environment and Transport, U.K.)

This is a book about world modelling by a scientist and practising modeller. It sets world modelling in the context of scientific activity—approaching the methodology, the accuracy and the potential through the eyes of a scientist.

1978 0 85066 170 6
120pp Cloth £6.00

Ergonomics

devoted to the scientific study of human factors in relation to working environments and equipment design

General Editor R. Goldsmith (Chelsea College, London)

Scope

The journal is the official publication of the Ergonomics Society, and the International Ergonomics Association. Universities and scientific institutes concerned with the human factors affecting performance and efficiency of work, whether from the psychological, engineering, physiological or anatomical points of view, will find ERGONOMICS an authoritative guide to research in these fields.

1983 subscription rates £77.00 \$235.00 DM365.00
Volume 26, published monthly, 12 issues per volume

Ergonomics Abstracts

published in association with the Ergonomics Information Analysis Centre

Editor C. Stapleton (University of Birmingham, U.K.)

Scope

As an annotated bibliography, ERGONOMICS ABSTRACTS aims to meet the need for those whose concern is the current literature in psychology, physiology, biomechanics and engineering relevant to man at work; the design of his equipment, work place and physical environment; and man-machine systems.

1983 subscription rates £75.00 \$238.00 DM350.00
Volume 15, published quarterly, 4 issues per volume

Behaviour and Information Technology

Editor T. F. M. Stewart (Willis Faber & Dumas Ltd, London)

Scope

BEHAVIOUR AND INFORMATION TECHNOLOGY deals with the human aspects of information technology in three broad areas: computing, telecommunications and office automation. The journal covers research and development related to the design, use and impact of information technology. The subject concerns a wide readership, from systems analysts and electronic engineers to management information and personnel specialists.

1983 subscription rates £37.00 \$90.00 DM175.00
Volume 2, published quarterly, 4 issues per volume

International Journal of Production Research

sponsored by the Institution of Production Engineers, the Society of Manufacturing Engineers and the American Institute of Industrial Engineers

Editor R. J. Sury (University of Technology, Loughborough, U.K.)

Scope

The journal publishes papers dealing with research into various aspects of the efficient utilization of productive resources. It is concerned not only with the fundamental behaviour of such resources, be they human, financial or technical, but also with the complex and cross-disciplinary problems of the analysis and control of the combination of these resources into a production system, regardless of the technology or product.

1983 subscription rates £74.00 \$220.00 DM345.00
Volume 21, published bi-monthly, 6 issues per volume

ORDER FORM

Please send to your usual bookseller/ subscription agent or direct to the publishers



Taylor & Francis Ltd

4 John Street, London WC1N 2ET
Tel: 01-405 2237/9
Telex: 858540

Please enter my subscription for _____ copy/ies of* _____
beginning in January 1983 and continue until cancelled.* (Title of journal)

Please send me _____ copy/ies of* _____
(Title of book)

I enclose a cheque/money order* for _____ made payable to Taylor & Francis Ltd/please send me an invoice.*

Please send me further information on Taylor & Francis Ltd books and/or journals.*

*Please delete as appropriate, and enter the title/s of your choice.

NAME _____

ADDRESS _____

SIGNATURE _____ DATE _____

20m 882

ERGONOMICS

— HUMAN FACTORS



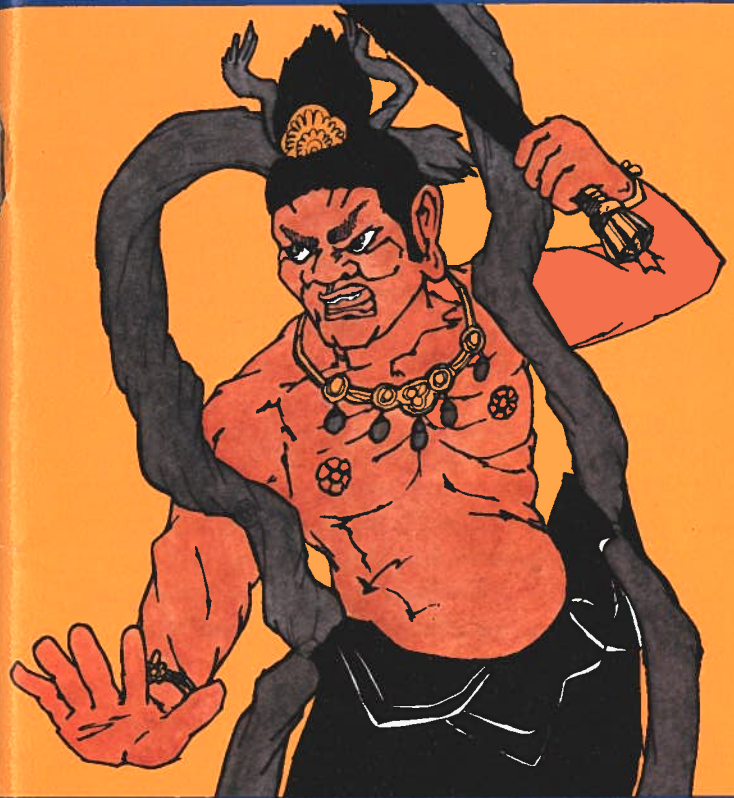
books and journals from



Taylor & Francis Ltd



IEA '82



**The 8th Congress of
The International Ergonomics Association**

August 23 ~ 27, 1982

Tokyo, Japan

Final Announcement

CONTENTS

	Page
WELCOME TO IEA '82 TOKYO	1
HOST.....	2
ORGANIZATION	2
CONGRESS INFORMATION	4
PROGRAM	6
EVENTS SCHEDULES.....	8
OPENING CEREMONY.....	9
SPECIAL LECTURES.....	9
SYMPOSIUM.....	9
WORKSHOPS	10
TECHNICAL SESSIONS	15
TECHNICAL SITE VISITS.....	39
SCIENTIFIC EXHIBITION	39
SOCIAL PROGRAMS.....	40
TRAVEL INFORMATION.....	42
HOTEL ACCOMMODATION.....	45
OPTIONAL TOURS.....	46
LOCATION MAP.....	48

WELCOME TO IEA '82 TOKYO

I recall an old saying now, "Time flies like an arrow". Since our Organizing Committee was established one year ago, we have been making every effort to make the 8th Congress worthy of your participation.

Our Program Committee is very glad to know that over 400 papers were submitted to the Technical Sessions. And it was most difficult to limit the number to 300. We have actually accepted 370, which thus increased the number of sessions. In addition, we have made a plan to set up Workshops and a Symposium.

Now, the overall Scientific Program is nearly finalized and is included herein. This Scientific Program will indicate the grand scale of this Congress. We have also included detailed information concerning travel and accommodation for the participants' benefit.

I sincerely hope that all of you will find IEA '82 scientifically rewarding as well as an enjoyable experience.

Go Computer

I look forward to seeing you soon.

- 1 MALAYSIA
- 1 BANGLADESH
- INDIA
- 1 KOREA
- 1 GREECE
- 1 INDONESIA

M. Oshima

Masamitsu Oshima, M.D.
Chairman
Organizing Committee

ASIA 9
except Japan. FRANCE 14

HOST

- Japan Ergonomics Research Society
- Research Foundation of Traffic Medicine

ORGANIZATION

International Ergonomics Association

President: J. Rosner (Poland)
Secretary General: H.L. Davis (U.S.A.)
Treasurer: H. Scholz (F.R.G.)

Advisory Board

(International) H.L. Davis (U.S.A.)
E.P. Grandjean (Switzerland)
B. Shackel (U.K.)
(Japan) Shizuo Asada
Kenji Ekuan
Junnosuke Kishida
Sakyo Komatsu
Naoki Toida
Eiji Toyota

Japanese Organizing Committee

Chairman: Masamitsu Oshima
Vice-Chairman: The Late Kunie Hashimoto
Secretary General: Toshiyuki Furukawa
General Affairs: Shingo Ogawa
Treasurer: Toshio Endo
Foreign Affairs: Hidemaro Nagano
Sadao Sugiyama
Scientific Liaison: Yuji Iiyama
Convention: Takao Ohkubo
Program: Akira Watanabe
Kazuyoshi Yajima
Registration: Kazuo Aoki
Proceedings: Kageyu Noro
Social Events: Kiyoshi Yamamoto
Exhibition: Kazuo Tsuchiya
Kiyoji Asai
Kazuhiko Atsumi
Sumiji Fujii
Yoshio Hayashi

Yujiro Hayashi
Masakazu Iguchi
Ichiro Kato
Haruo Kondo
Takeshi Kondo
Shigetaka Kubota
Isao Kuroda
Kinya Maruyama
Mitsuo Morioka
Hiroshi Motoaki
Junichi Nagumo
Kiho Nakao
Shinhachi Nishikawa
Masahiko Ohira
Masashi Okawa
Jun Osaki
Takeshi Ota
Hajime Saito
Hiroyuki Sakabe
Masahiko Sato
Eimatsu Takakuwa
Susumu Tsukahara
Genichi Watanabe
Sakae Yokobori
Katsumi Yokomizo
Masaaki Yoshida

CONGRESS INFORMATION

1. VENUE

Nihon Toshi Center
2-4-1, Hirakawa-cho, Chiyoda-ku, Tokyo, Japan
Phone: (03) 265-8211

(See the location map on Page 48)

2. DATE

August 23 (Mon.)~27 (Fri.), 1982

(Registration on 23.)

3. OFFICIAL LANGUAGE

The official languages of the Congress are English and Japanese. Simultaneous interpreting between two languages will be provided throughout the sessions.

4. REGISTRATION FEE

- (1) Congress participant ¥55,000
- (2) Accompany person ¥20,000
- (3) Farewell party ¥10,000

The enclosed official registration form must be returned to the Secretariat.

5. PAYMENT

All registration fees shall be paid in Japanese Yen by a bank draft or bank remittance to the following bank account. Neither personal nor traveller's checks will be accepted.

(1) Bank Remittance

Name of Bank:

The Kyowa Bank, Akasaka Branch
Akasaka, Minato-ku, Tokyo, Japan

Name of Account:

"IEA '82 Tokyo"

Number of Account:

No. 916302 (Ordinary Deposit)

Please send or bring a copy of bank remittance with your registration form for confirmation.

(2) Bank Draft

A bank draft should be payable to the order of "IEA '82 Tokyo".

Participants who have not paid their registration fee in advance should pay the fee in **Japanese Yen** at the "On-Site Registration Desk".

The Desk will start at 13:00 p.m. on August 23. No credit cards will be accepted at the Desk.

6. REGISTRATION CARD

The Secretariat has been sending a registration card and a receipt to those who have paid the registration fee to confirm their registration. Please present the Card at the Registration Counter.

7. CANCELLATIONS

In case you cancel your attendance, it shall be made in writing to the Secretariat. No part of the fee will be refunded. However, a copy of Proceedings of the Congress will be sent after the Congress concluded.

8. APPLICATION FORMS

The following forms are enclosed with this announcement.

[Form 1] Official Registration Form
(Mail to the Secretariat)

[Form 2] Application Form for Hotel Accommodation & Tours
(Mail to Japan Travel Bureau)

PROGRAM

Room		Hall A	Hall B	
Date				
Aug. 24 Tues.	9:00	Opening Ceremony	X	
	10:00			
	10:30	Special Lectures		
	12:00			
	13:00			
25 Wed.	13:00	< WORKSHOP I > Safety	Work Load: General ^①	
	17:30	< WORKSHOP II > Human Error	Work Load: Industrial Applications ^②	
	9:00	< WORKSHOP III > Productivity I — Automation & Robotization	Work Load: Muscle Activity ^⑩	
	12:30	< WORKSHOP IV > VDU & Operator	Work Load: Physical ^⑪	
	14:00	General Assembly		
26 Thur.	15:00	Special Lecture	X	
	15:00			
	16:00			
	9:00	< WORKSHOP V > Productivity II — Humanization & Workplace		Architecture ^⑫
	12:30			Work Load: Methodology ^⑬
27 Fri.		Technical Site Visits		
	9:00	< WORKSHOP VI > The Aged & Handicapped	Vehicle Driving ^⑭	
	12:00	X	X	
	13:00			< Symposium > Past, Present & Future of Ergonomics
	15:00			
15:00		Closing Ceremony		
16:00				

Hall C	Hall D	Hall E
X	X	X
Systems Design I — Keyboard & Others ^③	Anthropometry & Clothing ^⑤	Quality of Working Life ^⑦
Circadian Rhythm & Shift Work ^④	Motion & Gait ^⑥	Environment: Noise & Vibration ^⑧
System Evaluation Methodology ^⑫	Eye Movement ^⑭	Environment: Temperature & Physiological Responses ^⑮
System Design Methodology ^⑬	Education & Training ^⑮	Environment: Heat Stress Evaluation ^⑰
X	X	X
Evaluation of Human Activities ^⑳	Introduction of Ergonomics to Industry ^㉒	Work Load: Visual ^㉔
Systems Design II — Vehicle, Sign & Others ^㉑	Ergonomics of Computer Systems ^㉓	Visual Inspection & Vigilance ^㉕
Technical Site Visits		
Introduction of Ergonomics to Social Systems ^㉗	Posture ^㉘	Perception & Recognition ^㉙
	Work Load: Lifting ^㉚	
Work Performance ^㉛	Work Load on the Back ^㉜	Working Environment ^㉝
X	X	X

EVENTS SCHEDULE

	Aug. 23			Aug. 24			Aug. 25			Aug. 26			Aug. 27		
	Mor.	Aft.	Eve.	Mor.	Aft.	Eve.	Mor.	Aft.	Eve.	Mor.	Aft.	Eve.	Mor.	Aft.	Eve.
Registration															
Welcome Party															
Opening Ceremony															
Special Lectures															
General Assembly															
Workshops															
Technical Sessions															
Symposium															
Technical Site Visits															
Farewell Party															
Ladies Program															
Closing Ceremony															
Exhibition															

OPENING CEREMONY

August 24 (Tuesday) "Hall A"
8:45 ~ 10:00

- 8:45 ~ Music ~
- 9:00 •Declaration of Opening
Toshiyuki Furukawa, M.D.
Secretary General
Organizing Committee
- Opening Address
Masamitsu Oshima, M.D.
Chairman
Organizing Committee
- Presidential Address
Prof. Jan Rosner
President
International Ergonomics Association
- Address
(Japanese Guests)
- Awards & Address
Prof. Alphonse Chapanis (The Johns Hopkins Univ.)
Prof. Etienne Grandjean (Swiss Federal Institute of Technology)
- 10:00 ~ Music ~

SPECIAL LECTURES

1. August 24 (Tuesday) "Hall A"
10:30 ~ 12:00
"Modeling of Human Performance in Complex Systems with Emphasis on Nuclear Power Plant Operations and Probabilistic Risk Assessment"
Alan D. Swain
Statistics, Computing & Human Factors Division
Sandia National Laboratories
- "The Trends of Ergonomics in Japan"
Masamitsu Oshima
Chairman of Directors
The Medical Information System Development Center
2. August 25 (Wednesday) "Hall A"
15:00 ~ 15:40
"Ergonomics in the Year 2002"
Gavriel Salvendy
Chairman, Human Factors Program and Professor of Industrial Engineering, Purdue University

SYMPOSIUM

- August 27 (Friday) "Hall B" 13:00 ~ 15:00
"Past, Present and Future of Ergonomics"

WORKSHOPS

The following order is not the presentation order. It will be announced in the Final Program.

C Computer 40

August 24 (Tuesday)

13:00 ~ 15:15

Room Hall A

Workshop I: Safety

- Ergonomics of Safety
V.D. Keyser (Belgium)
- Life Stress and Occupational Injuries
D. Gloss (U.S.A.)
- One Method for Evaluating Safety Performance in Working Places
S. Hanayasu (Japan)
- Computer Methods in Safety Design with Highway-Vehicle-Object-Environment Simulation
B.K. Huang (U.S.A.)
- Multivariate Safety Assessment of the Level-Crossings with Automatic Full or Half Barriers
T. Ikeda, H. Ohtake (Japan)
- Human Factors in Ship Collision in Narrow Waters
N. Ohashi (Japan)
- Safety Work on Small Fishing Boat Operat by One Man
A. Hattori, N. Ohashi (Japan)
- Influences of Thermal Environment on Safety Behaviour
J.D. Ramsey (U.S.A.)
- Prevention of Occupational Injuries in Greenhouses
B. Gustafsson (Sweden)
- Towards Safer Consumer Product Design
J. Wilson (U.K.)

August 24 (Tuesday)

15:15 ~ 17:30

Room Hall A

Workshop II: Human Error

- Reliability of Human Operator in Man-Machine Systems
M. Iguchi (Japan)
- A Basic Study of the Prediction Method of Clerical Human Errors Based on Pulse Speed Variability
E. Koyano (Japan)

—10—

- Fuzzy Fault Tree Analysis for Accident Caused by Human Errors

K. Noma, H. Tanaka, K. Asai (Japan)

- Alpha Wave and Miss of Signal Detection
H. Kodama (Japan)

- An experimental Study on Human Behavior under the Sudden Hazardous Situation

W. Masada (Japan)

- Human Errors and the Safety of Nuclear Power Plant
G. Mancini, A. Amendola (Italy)

- A Case Study on a Plant Factory from the Human Factors Point of View

K. Hashimoto, M. Aoki, Y. Horie (Japan)

- Analytical Procedures on Causes of Human Errors in Plant Accidents

K. Hashimoto, M. Aoki, T. Endo (Japan)

- Hazard Analysis in the Japanese Chemical Industrial Complexes Especially on the Human Errors

Y. Hayashi (Japan)

- A Study of Human-Error Causing by Drug Naming

F. Tsuchiya (Japan)

August 25 (Wednesday)

9:00 ~ 11:00

Room Hall A

Workshop III: Productivity I — Automation & Robotization

- Ergonomics for Pure Efficiency or for Humanization?
G. Olsson (Sweden)

- The Designing of Man-Machine Systems Human Role Consideration in Modernize Industrial Systems

Y. Iiyama (Japan)

- Automation, Productivity and Stress in Inspection
C.G. Drury (Japan)

- Operator Response to Problems in Proc. Control Systems

K.M. Mallory (U.S.A.)

- Japanese Population Stereotypes for Nuclear Power Plant Control Room Operators and Engineers

R.M. Kane, J. Farbr, Jr., S. Fleger (U.S.A.)

- An Attempt to "Harmonize" Human Operate Job and Computer in Complex Industrial Processes

P.-J. Lariere (France)

- Evolution of Man/Computer Air Traffic Control Systems (The European Approach)

D. Hugh (France)

—11—

- Automation in the Office; on the Role on the Ergonomist with Regard to the Communication between Manufacturer and Customer

C.K. Pasmooij (The Netherlands)

- Japanese Robotization and Human Factors Researches

Y. Okada (Japan)

August 25 (Wednesday)

11:00 ~ 12:30

Room Hall A

Workshop IV: VDU & Operator

- Design of Human-Computer Dialogues

R.C. Williges (U.S.A.)

- An Ergonomic Study of Conversational Work with VDTs

S. Yamamoto, M. Yoshioka, A. Komatsubara, Y. Hayashi (Japan)

- The Influence of Visual Workload History Visual Monitoring Performance

M.L. Matthews (Canada)

- Study on the Evolution in the Field of Information Management and Working Conditions, as a Consequence of the Development of Digital Technology and Use of VDU Operator Stations in Steelworks

F. Bertuccio (Italy)

- Selecting a Color Monitor for an Interactive Graphics System Used to Design Integrated Circuits

A. LeCocq (U.S.A.)

- Research and Development of Airborne Integrated Display for NAL Qstol

M. Okabe, K. Tanaka (Japan)

- Some Health Hazards Associated with Word (or Text) Processing and Similar Data-Terminal Equipment. How to Avoid Them.

A.E. Haugan (Norway)

August 26 (Thursday)

9:00 ~ 12:30

Room Hall A

Workshop V: Productivity II — Humanization & Workplace

- Development of Ergonomic Methods for Productivity Improvement

K. Noro (Japan)

—12—

- Task Allocation Based on Human Needs as Tool in the Humanization of Work System

H. Mulder (The Netherlands)

- Human Interface Analysis to Assure Improved Product Performance

D. Raheja, M. Arjunan (U.S.A.)

- A Critical Analysis of Techniques of Evaluation of Working Conditions and a Proposal for a Methodological Approach

R. Edouard (France) RICHARD

- Experiments in the Organization of Work in Germany — A Survey of Major Tendencies Result, and Problems

P. Hans (F.R.G.)

- A Report about the Changes of Working Environment Conditions in Sweden

C. Nilsson (Sweden)

- Adjustment of Work to People and Humanization of the Production Line

V. Parežanin (Yugoslavia)

- Organizational and Technological Aspects of the Operation of Production Lines in Yugoslavia

V. Parežanin, R. Parežanin (Yugoslavia)

- Ergonomic Workstation Design for Supermarket Scanning Systems

P.L. Martin (U.S.A.)

- Check-Out Systems for Self Service Shops Standardization and Real Working Conditions

S. Helmut (F.R.G.)

- The Effects of Developments in Grocery Distribution Systems

J. Wilson (U.K.)

- Ergonomic Design of Press Working Places

H.-J. Bullinger, P. Kern, D. Lorenz (F.R.G.)

- Analysis of Film Copy Workplaces for Improving Job Design, Environmental and Ergonomic Conditions

H. Strasser (F.R.G.)

- The Apparel Workplace: An Ergonomic Case Study

L. Middendorf (U.S.A.)

August 27 (Friday)

9:00 ~ 11:30

Room Hall A

Workshop VI: The Aged & Handicapped

- Anthropometric and Biomechanic Measurements of Elderly Women and Men

P.R. Buzzell (Canada)

—13—

- Measurement of the Older Worker's Capability
K. Yokomizo (Japan)
- A Study of Procedure of Job Redesign for Older Workers
M. Nagamachi (Japan)
- Adult Age and Human-Computer Interaction: Implications for a Model of Performance in Menu-Driven Systems
B. Somberg, G. Boggs (U.S.A.)
- Development of Sensor Pegboard for Performance Test
Y. Okada, K. Noro, (Japan)
- Work Load of Disabled People at A Small Factory
T. Hasegawa, K. Noro (Japan)
- Ergonomics for the Mentally Handicapped-Motion Study
E. Kapecka, T. Marek (Poland)
- A Study on Handwork of the Mentally Handicapped
A. Tanaka, N. Ando (Japan)
- About the Weight Ratio of a Prosthetic Arm to an Amputated Arm Segment
N. Ohnishi (Japan)
- An Evaluation of Correlation between Amputated Limb and It's Dominancy Using Dammy Prosthesis
T. Aoyama, Y. Saito, H. Kasahara, T. Yamashita, K. Koyama, K. Tsuchiya (Japan)
- The Effect of Foot-Sole Pressure Sensory Feedback on the Activity of the Lower Limb Amputee
S. Morimoto, K. Tsuchiya, Y. Saito (Japan)
- Development of Transfer System for the Severely Handicapped
K. Ichikawa (Japan)

TECHNICAL SESSIONS

The following order is not the presentation order. It will be announced in the Final Program.

August 24

13:00 ~ 14:30

Room Hall B

Session 1: Work Load: General

- The Development of Ergonomic Solution Proposals by the Analysis of Task
H. Bubb (F.R.G.)
- Characteristics of Office Works
A. Komatsubara, Y. Yokomizo (Japan)
- Synthetic Stress-Profiles
B.H. Müller (F.R.G.)
- A Contribution to Methodology for the Evaluation of a Welder's Work-Load
N. Dazard, E. Richard, J.-L. Flores (France)
- Cumulative Fatigue Symptoms and Conditions of Work
R. Kosugo (Japan)
- The Methodological Problem of the Predetermination of Load and Possibilities of Its Solution
W. Laurig (F.R.G.)
- Information Load and Its Norming
A. Honkasalo (Finland)

August 24

14:30 ~ 17:20

Room Hall B

Session 2: Work Load: Industrial Applications

- On Work Study and Work Load of the Computer Operator
M. Umemura (Japan)
- Eyestrain and Muscle Fatigue of Data Entry Operators Using Visual Display Terminals
N. Onishi, T. Kuroe (Japan)
- Constrained Postures at VDTs
W. Hünting, T. Läubli, E. Grandjean (Switzerland)
- Fatigue and Health Problems of Workers in a Home for Mentally and Physically Handicapped Person
Y. Ono, K. Masuda, M. Iwata, N. Hisanaga, Y. Takeuchi (Japan)

- Health Survey on Plasterers (Stucco-Workers)
L. Ekkers Kees (The Netherlands)
- The Effects of Ergonomic Measures on the Health of the Neck and the Upper Extremities of Assembly-Line Packers — A Four Year Follow-Up Study
T. Luopajarvi, I. Kuorinka, R. Kukkonen (Finland)
- A Tendonitis Control Program for the Apparel Industry
M.A. Ayoub (U.S.A.)
- Assessment of Mental and Physical Work Load For Some Agricultural Tasks
M C. Canan (Malaysia)
- The Effects of Change in Transport Methods on Stress and Strain of Truck Drivers' Work
J. Ilmarinen, C.H. Nygard (Finland)
- Stress and Strain in Cleaners' Work
V. Louhevaara, J. Ilmarine, C.-H. Nygard, I. Pesonen (Finland)
- Influence of Mechanico-Assisted Blowing on the Fine-Myokinesis of the Forearms on Glass-Blowers
S. Gustav, A. Fuchs, A.v. Laer, P. Mayer (F.R.G.)
- Results of Fields Studies Concerning Stress and Strain at Three Different Blast-Furnaces
H. Peter (F.R.G.)
- Speed Skill in Short-Cycle Repetitive Work
B A. Khaleque (Bangladesh)

August 24

13:00 ~ 14:30

Room Hall C

Session 3: Systems Design I — Keyboard & Others

- Ergonomic Development of a New Keyboard Design
C M. Nakaseko, W. Huenting, R.G.E. Granjean (Japan)
- Ergonomic Investigation of Interkey Time Distributions of Touch-Keying Operators of 10-Key Numeric Keyboard: Systems Design Implications
C G.F. Rabideau, R.P.-J. Lee (Canada)
- Link Analysis of ECG Manipulation and Application for Design of ECG Equipment
N. Yamanoi, K. Yajima, T. Aoki, S. Kinoshita, H. Tanaka, T. Furukawa (Japan)
- An Educational Equipment for Learners of Keyboard Music and Consideration on the Characteristic of the Playing
I. Kitagaki, K. Suetake (Japan)
- Application of the Plane Switch Using a Pressure-Conductive Rubber Sheet to a Control Manipulator
Y. Ikeda, H. Takeda, S. Hata (Japan)

- Measurement of the Ticket-Selling Worksite-Accordig to Comfort Experiments
M. Launis (Finland)
- Teleoperator Systems, Considerations for Human Management of Remotely Controlled Tasks
N. Shield, Jr. (U.S.A.)
- The Influence of Camera Logic on Camera Ergonomics
H.L. Davis, R.L. Lucas (U.S.A.)

August 24

14:30 ~ 17:20

Room Hall C

Session 4: Circadian Rhythm & Shift Work

- Chronopsychological Approach to Human Factors
P. Naitoh (U.S.A.)
- Shiftwork Research at the UK Medical Research Council Perceptual and Cognitive Performance Unit
W.P. Colquhoun (U.K.)
- Psychophysiological Effects of Shift Work in a Small-Medium Sized Factory
M. Kumashiro, K. Miyake, K. Saito (Japan)
- A Case Study on Work Burden of Shift-Workers
T. Kondo, T. Okubo, M. Aoki, Y. Horie (Japan)
- Time-of-the-Day Effect on Human Performance in a Combined Manual and Decision Task
A. Raouf, T.K. Joseph (Canada)
- Circadian Rhythms of Body Temperature and Performance under a Weekly Rotating Shift System.
Y S. Milosevic, M. Cabarkapa (Yugoslavia)
- Apoarent and True Phase-Shifts of Circadian Rhythms after a Transmeridian Flight
V. Zdenek (Norway)
- Diurnal Variations of Reaction Time Performance in the Mentally Retarded Children
K. Kusano (Japan)
- Critical Flicker Fusion and Grammatical Reasoning in the Evaluation of Shift Schedules
P. Brian, R. Schlegel (U.S.A.)
- Changes in the Subjective Fatigue Scale Characteristic to the Post-Nightshift Period
KOGI K. Kogi (Japan) KOGI
- Interindividual Differences in Sleep-Waking Habits of Students and Workers Samples
L. Mecacci, A. Zani (Italy)
- Human Reliability in Process Control with Shift Work
F G.D. Terssac, Y. Queinnec (France) F

August 24

13:00 ~ 15:20

Room Hall D

Session 5: Anthropometry & Clothing

- Problems in Determining Anthropometric Standards for Persons
D. Gloss (U.S.A.)
- Measurement of Human Body Form Using Pattern Processing Techniques
N. Ito (Japan)
- A Longitudinal Study on Physical Growth at Adolescence
Y. Furumatsu, H. Muto, S. Saito, E. Furumatsu (Japan)
- Two Dimensional Fourier Analysis of Human Torso Surface
T. Furukawa, N. Yamanol, H. Tanaka, K. Yajima, T. Aoki, K. Aoki, S. Kinoshita, K. Hirayanagi (Japan)
- A Three-Dimensional Measurement of the Torso Shape and an Application to Early Detection of Spinal Deformities
Y. Yamashita (Japan)
- A Study of the Anthropometric Differences of the Lordotic Curvature in Adult Men and Women
N.E. O'Neill (U.S.A.)
- Head Dimension Measurement for Telephone Handset Design
H. Matsui (Japan)
- On Morphological Theorization for the Garment Modeling
S. Nakazawa (Japan)
- Physiological Evaluation of Clothing Heat Transfer
H. Ingvar (Sweden)
- Body Temperature Measurement for Appropriate Clothing by Means of Internal Temperature Measurement Device
S. Nagashio (Japan)
- The Protective Characteristics of Clothings for Protection against Heat and Fire
Y. Kawashima (Japan)
- Thermal Effects and Finger Strength Changes in Cold Water Immersion with a Survival Suit
K. Kimotsuki (Japan)
- Evaluation of Shoe-Fitting
N. Yamazaki (Japan)
- On Mannequins Especially Made for 19th Century Costumes Considering Kinesiology of Human Bodies
C. Tamagawa (Japan)

August 24

15:20 ~ 17:30

Room Hall D

Session 6: Motion & Gait

- On the Central Control of Voluntary Arm Movements
T. Kurokawa (Japan)
- Effect of Two Handed Asymmetrical Simultaneous Motions and Task Difficulty on Performance Time and Heart Rate Variability
A. Raouf, K. Tsuchiya (Canada)
- A Study on a Manner of Holding Ball-point Pen to Write Legible Characters
Y. Ishida (Japan)
- Analysis of the Human Rhythmic Movement by a Markov Process
H. Nagasaki (Japan)
- Mechanism of Microvibration and the Application to Fatigue in Works of Lifting of Weight and Typewriting
T. Usui, K. Sakamoto, K. Seki, A. Iwasaki (Japan)
- The Application of the Three Dimensional Measurement to the Motion Analysis
Y. Suzuki (Japan)
- Kinematic Analysis of Three-Dimensional Motion in Loading Operations
K. Iwata, T. Moriwaki, T. Kawano (Japan)
- Force Sensor Using Carbon Fiber and Its Application to Foot-Force Measuring System for the Gait Analysis
K. Katahira (Japan)
- Anthropometry in Relation to Ergonomics of Walking for Work Study Application in Indian Agricultural Workers
Dr. Rabindra Nath Sen (India)
- Characteristics of Spectral Analysis of Strides on Treadmill Walking
M. Yamasaki (Japan)
- Desktop Computer-Aided Analysis of Dynamics in Human Standing and Walking
T. Yamashita, T. Taniguchi, M. Ando (Japan)
- Finite State Measurement System of the Human Gait
A. Kato, K. Ito, K. Tsuchiya (Japan)
- A Study on Walking Width, Time and Speed in Manual Carrying Loads
Y. Oguro (Japan)

August 24

13:00 ~ 14:00

Room Hall E

Session 7: Quality of Working Life

- Factors in Quality of Working Life: Two Case-Studies
S. Bagnara, R. Misiti, D. Mazzonis, M. Rollier (Italy)
- Brief Description of a Complex Work Organization Change in a Big Steel Company in Italy Involving Ergonomics and Socio-Technical Approach to Improve the Quality of Working Life
S. Micheli (Italy)
- Women and Work in a Finnish Manufacturing Plant
M-L. Honkasalo, M. Lich (Finland)
- A Study on the Motivation of a Manager by Canonical Correlation Analysis
Korea S.Y. Lee (Korea)

August 24

14:00 ~ 16:00

Room Hall E

Session 8: Environment: Noise & Vibration

- Noise Immissions from Industrial Plants and Annoyance in the Neighbourhood
G. Stefan, E. Grandjean (Switzerland)
- Tentative Evaluations of Oscillating Sounds Based on Loudness Measures
P. Schaefer (F.R.G.)
- Individual Protection against Noise
J. Ducrocq (France)
- The Influence of Environmental Noises on Performance of Repetitive Task
K. Takata (Japan)
- Studies on the Influence of Infrasound to the Human Body — Physiological Effects of Long Term Exposure to Infrasound by Case of the Rabbits —
N. Machida, Y. Yoshida, H. Ito (Japan)
- Human Response to Infrasound below Hearing Threshold
O. Okai (Japan)
- Studies on the Influence of Low Frequency Vibration to the Human Body — Vertical Vibration —
Y. Yoshida, N. Machida M. Ryota (Japan)
- A Study of Vibration Effect on Muscle Fatigue in Man
K. Ohkoshi, Y. Kikuchi (Japan)

- Effects of Psychic Load on the Growth of Temporary Thresholds of Hearing during Exposure to Combination of Stable Noise and Sinusoidal vs Stochastic Low-Frequency Vibration at a Dry-Bulb Temperature of 20°C
M. Olavi (Finland)
- TTS of Vibratory Sensation Induced by Exposure to Intermittent Vibration
Y. Fukuchi, S. Watanabe (Japan)
- The Use of Resilient Handgrips to Reduce Hand Vibration from Power Tools
C.W. Suggs (U.S.A.)

August 24

16:00 ~ 17:20

Room Hall E

Session 9: Environment: Under Water & Space

- The Influence of Hyperbaric Environment (11-31ATA, He-O₂) on Disturbed Human Sleep
K. Seki (Japan)
- The Influence of Hyperbaric Environment to Fatigue in Human Deep Dives
Y. Taya, N. Kuwabara (Japan)
- Convective Heat Transfer Coefficient of Human Body in Hyperbaric Helium-Oxygen Mixed Gas Environment
H. Nakayama (Japan)
- Neutral Buoyancy Manned Maneuvering Unit—An Underwater Simulator of the Shuttle MMU
C.N. Van Valkenburgh, T.E. Loughhead (U.S.A.)
- Manned Zero-Gravity Simulations: Case Histories of Extravehicular Activity (EVA) Simulations and Techniques
E.C. Preutt (U.S.A.)
- Dynamic of Physical Fitness and Orthostatic Tolerability during Hypodynamics Exposure
H. Saiki, M. Nakaya, M. Sudo, M. Abe, K. Shioda (Japan)
- Quantitative Behaviour of Intraocular Ascorbic Acid upon Hypermetropic Amplitude in Overstraining of Fictitious High Altitude
M. Carapancea (Rumania)

August 25

9:00 ~ 10:45

Room Hall B

Session 10: Work Load: Muscle Activity

- Assessment of Physiological Cost in Dynamic Muscular Work by Oxygen Cost and Cardiac Cost
H. Sato (Japan)
- Several Aspects of the Prediction Method of Local Muscle Energy Metabolic Rate
S. Yokoyama, K. Yoshida (Japan)
- The Effect of Arm Elevation on Muscle Circulation
H. Yata, T. Fukunaga, A. Matsuo (Japan)
- Evaluation of Local Muscle Fatigue in Dynamic Muscular Work by Isometric Test Contraction
S. Kira, K. Yamasaki, H. Sato (Japan)
- Critical Power as a Measure of Muscular Fatigue and Anaerobic Threshold
A. Nagata, M. Muro (Japan)
- What Do We Neglect when Evaluating Muscle Fatigue?
G.N. Gantchev (Bulgaria)
- Trunk Muscle Activity during Dynamic forward Bending and Straightening Up
K. Tanii (Japan)
- Occupational Muscular Strain Indicated by Serum Creatine Kinase
M.T.L.J. Hagberg (Sweden)
- Creatinine Excretion under Physical Exercise and Hypokinesia
Y. Zorbas, V. Petrovskiy, Y. Koichi (Greece)
- Pulling and Pushing Forces as a Function of Elbow Flexion
Y. Ikeda (Japan)

August 25

10:45 ~ 12:30

Room Hall B

Session 11: Work Load: Physical

- Psychophysiological Studies of Physical Performance
G. Borg (Sweden)
- A Study on Seasonal Variations of Circulatory and Metabolic Responses during Prolonged Exercise
A. Okada (Japan)
- Effects of Specific Dynamic Action on the Metabolism at Rest
K. Yamasaki, S. Watanuki, S. Kira (Japan)

—22—

- The Effect of Body Postural Change on Anaerobic Threshold
T. Fukunaga, H. Yata, S. Ikegawa (Japan)
- Relation between Exercise Diuresis and Running Load
T. Inomoto (Japan)
- The Effect of Additional Weight on External Mechanical Energy in Running
A. Matsuo, T. Hirata, N. Tsunoda, T. Fukunaga (Japan)
- Mechanical Efficiency in Relation to Pedaling Rate During Cycle Ergometer Work
Y. Fukuba, Y. Koya, S. Watanuki, K. Fujile (Japan)
- Optimum Speed of Up-Hill Cycling with Special Reference to Slope Gradients and the Gear Ratio
A. Kimura, M. Morioka, S. Horino, K. Kishida, K. Uchida (Japan)

August 25

9:00 ~ 10:15

Room Hall C

Session 12: System Evaluation Methodology

- An Application of Decision Data Tables Method in Ergonomic Research
L. Pacholski, B. Mateja (Poland)
- An Ergonomic Method Diagnosing Complex Production Systems
L. Pacholski (Poland)
- Combined Use of an Ergonomic Checklist and Complaint Rating as a Means of Identifying Problems
K. Sakai, K. Kogi (Japan) *ROG*
- Pluralistic Treatment in the System Research of Ergonomics
T. Marek, R. Michałek, N. Czeław (Poland)
- The Use of Operator Workload Measures in the Evaluation of Different Telemanipulators
J. Richardson, N.F.-Savery, D. Xirau, D.A.-Lescoat (France) *F*
- The Evaluation on the Repairmen of Motorcar Using the RS-Method
S. Nakayama (Japan)

—23—

August 25

10:15 ~ 12:15

Room Hall C

Session 13: System Design Methodology

- Ergonomical Correction of Working Conditions at the Stage of Working Station
S. Marek (Poland)
- A Systematic Ergonomics Design Procedure
J.-H. Kirchner (F.R.G.)
- The Computer Technique Usage in Design and Ergonomic Attestation Function of Controlling Devices Distribution
L. Pacholski, S. Stanisław (Poland)
- The Interaction between Ergonomic Criteria and Industrial Design
V. Popovic (Australia)
- Back-to-Front Systems Design: A Guns and Butter Approach
R.S. Didner (U.S.A.)
- The Third Dimension — Computer Modelling for Ergonomics
E. Kingsley (U.K.)
- VAD — A Video Aided Ergonomics Design System
F. Peter (Sweden)
- Use of Modular Simulators in Selection, Training and Workpost Design
J.-C. Rouhet (France)

August 25

9:00 ~ 10:10

Room Hall D

Session 14: Eye Movement

- Maximum Velocity in Smooth Pursuit Eye Movement
K. Horii, K. Tanaka, Y. Tomoda (Japan)
- Frequency Responses of the Pursuit Eye Movement System
K. Matsuoka (Japan)
- Lambda Responses and Evaluation of Visual Task Load
A. Yagi (Japan)
- Individual Differences Observed from Relationship between Percent Correct Counts and Eye Movements
H. Togami (Japan)
- A Study of the Constitution of Visual Judgment Process on the Composite Images
T. Kurabayashi (Japan)

—24—

- Modelling of Visual Scanning Sequence to Multiple Targets
M. Makikawa, H. Tamura, M. Makikawa (Japan)

- An Evaluation of the NAC Eye Mark Recorder
E.D. Megaw, J. Richardson (U.K.)

X

August 25

10:10 ~ 12:20

Room Hall D

Session 15: Education & Training

- A Comparison of Exponential and Hyperbolic Functions Describing Learning Curves in the Literatures of Psychology and Industrial Engineering
L. Stanley (U.S.A.)
- Time Pressure, Training and Decision Optimality
Z. Dan (Israel)
- Cost-Effectiveness of Ergonomics: Elusive Data and an Exchange Heuristic
A.B. Russell (U.S.A.)
- Cognitive Psychology of Manual Control: Expert and Novice Differences in Cognition and Performance
Y. Anzai, Y. Ishii, Y. Hayashi (Japan)
- Ergonomics Training for Computer Users
T. Houghton (France)
- The Influence of Job Knowledge in Product Quality Judgments on a Continuous Process Production Line
J. Richardson, X. Cuny (France)
- Human Factors in Instructions
N.M. Simonelli (U.S.A.)
- Introduction of Ergonomics in the Development of Educational Systems
S. Kozuki (Japan)
- An Instructional System which Permits the Students to Critically Discuss Their Own Test Answers
I. Kitagaki, Y. Shimizu, K. Suetake (Japan)
- A Trial of Introducing Game Factor into the Rehabilitation Training
M. Ohnishi, K. Tsuchiya, F. Ito, S. Nagai (Japan)
- Development of General Purpose Biofeedback System
M. Ohsuga (Japan)

F

F

—25—

August 25

9:00 ~ 11:00

Room Hall E

Session 16: Environment: Temperature & Physiological Responses

- Effects of Repeated Cold Exposures on Thermal Responses of Men
Y. Tochihara (Japan)
- Effects of Body Build and Sweat Rate on Rectal Temperature during Acute Heat Exposure in Man
K. Iwanaga, K. Yamasaki, . Yasukouchi, H. Sato, M. Sato (Japan)
- Cardiovascular and Metabolic Reactions to Work in Different Ambient Temperatures
T. Nariai, Y. Fukuba, J. Ohashi, Y. Izumitani (Japan)
- Relationships between Physique and Increase in Body Temperature during Exercise at Different Ambient Temperatures
T. Katsuura (Japan)
- Effect of Hot Dry and Hot Humid Environment in Continuous Work Performance in Man
J.S. Gupta (India)
- Effect of Ambient Temperature on Physical Work Capacity
T.L. Mathew, J.S. Gupta (India)
- The Effects of Work Rates and Ambient Temperature on Transient Physiological Responses
Y. Takasaki (Japan)
- The Effects of Exercise, Ambient Temperature and Season on Estimation of Maximal Oxygen Intake
S. Watanuki, K. Yamasaki, Y. Koya (Japan)
- Influence of Age on Circulatory Responses to Exercise at Different Air Temperature Conditions
Y. Kikuchi, T. Katsuura, A. Okada (Japan)
- Evaluation of Cardiac Output by Electrical Impedance Method under Different Ambient Temperatures
T. Azuma, T. Katsura, A. Okada, Y. Kikuchi (Japan)
- Change in Pulmonary Diffusing Capacity for CO under Various Conditions of Temperature Combined with Hypobaric Hypoxia
A. Yasukouchi, K. Iwanaga, Y. Koya, M. Sato (Japan)
- Physical Work Capacity of Young Competitive Swimmers in Water at Three Different Temperatures
T. Nomura (Japan)

August 25

11:00 ~ 12:10

Room Hall E

Session 17: Environment: Heat Stress Evaluation

- The Effects of Outside Conditions and Cab Temperature on Tractor Driver Heat Stress
D.H. O'Neill (U.K.)
- Sensitivity Analysis Supports Simplified Heat Stress Rules
J.D. Ramsey, C.P. Chai (U.S.A.)
- A Statistical Analysis of Values of WBGT Factor in Complex Production Systems
L. Pacholski (Poland)
- Analytical Determination of Heat Stresses
J.J. Vogt, V. Candas (France)
- Experimental Thermoesthesiometer
H. Mito, J.P. Libert (Japan)

August 26

9:00 ~ 10:45

Room Hall B

Session 18: Architecture

- Shaping (Size and Form) of Workrooms from the Viewpoint of Pleasant Working. Environments and Humanization of the Work System
H.F. Mulder (The Netherlands)
- The Relation between Physical Elements and Visual Effects in Living Rooms — Part 1 On the Wall Colour —
T. Yanase (Japan)
- The Relation between Physical Elements and Visual Effects in Living Rooms — Part 2 On the Wall and Light —
M. Kunishima (Japan)
- Required Clearance for Passages in Dwelling House
Y. Koh, K. Kamada (Japan)
- A Study on Walking up and down Stairs in Elderly People
K. Aoki (Japan)
- Accident Research for Safety on Stairs
H. Nagata (Japan)
- Safety Requirements of Stairs
S. Kose, H. Uno (Japan)
- Ergonomic Values of Traditional Housing in Bali
A. Manuaba (Indonesia)
- A Systems Approach to the Aetiology of Human Injury in Livestock Building Design
G.A. Bramall (U.K.)

- Experimental Study on the Cognitive Process of Street-scapes
Y. Kubota (Japan)

August 26

10:45 ~ 12:20

Room Hall B

Session 19: Work Load: Methodology

- On the Validity of Japanese Fatigue Feeling Scale
Y. Saito (Japan)
- Factorial Analysis of Fatigue
S. Kondo, M. Oshima (Japan)
- Work Load Studied by Multi-point Critical Fusion Frequency (MCFF)
H. Osaki, S. Kikuchi, M. Ogata (Japan)
- Measurement of Critical Fusion Frequency by Liquid Crystal
R. Hosaka (Japan)
- A Consideration on the Classification of Two-Dimensional Displayed Patterns of EEG
H. Takeda, Y. Takashima, Y. Ikeda, S. Hata (Japan)
- Mental Effects of Risky Behaviour Seen by Means of a Portable Heart Rate Analyzer
H. Muroya, M. Ikeda (Japan)
- A Three-Level Computer-Assisted System for the Evaluation of Physiological Changes during Work, before and After Ergonomical Intervention
F. Jaroslav (C.S.S.R.)
- Disturbances in Curve Progress Smoothness of Pupillary Reflex Induced by Mental Workload in the Long Period of Time
M. Tadeusz, N. Czesław (Poland)
- Measurement on Brain Arousal Rate
S. Inaba (Japan)

August 26

9:00 ~ 10:00

Room Hall C

Session 20: Evaluation of Human Activities

- The Evaluation of Each Daily Human Activity by the Instrumentation of a Continuous Heart Rate Measurement
S. Adachi (Japan)
- Measurement of the Effect of Central Acting Drugs on Performance and Reaction Time
H. Krueger (F.R.G.)

—28—

- Effect of Sleep Deprivation on the CNV and Dual Task Performance

M. Miyao, T. Ohga, H. Sakakibara, T. Nagasawa, F. Kobayashi, S. Kanada, K. Takihi, S. Yamada, M. Terashima, T. Endoh (Japan)

- A Biotechnological Study of Relationship between Sleep and Beds — A Polygraphic Study with Sounds
K. Fukuda (Japan)

- Responses of Sympathetic Nervous System to Hand Induced Vibration
T. Sakurai (Japan)

- On the High-Order Dynamic Activity and Its Component Activities
K. Sato (Japan)

August 26

10:00 ~ 12:10

Room Hall C

Session 21: Systems Design II — Vehicle, Sign & Others

- Safe and Easy Coupling of Tractor Implements
Sjøflot Lars (Norway)
- Improvement of Visibility for Large Truck Drivers to Prevent Unsafe Turning to the Left
S. Horino (Japan)
- Ergonomic Aspects of Operator Cabs on Earth Moving Machines
P. v.d. M. Grinten (The Netherlands)
- Design of a Vehicle for Mail Delivery. An Ergonomic Study
M. Björkstén, D. Caple, S. Carlsöö, P. Friedrich, J.E. Hansson, (Sweden)
- Ergonomic Changes of Our Automatic Welding Machine, Our Track-Pin Press Machine and Our Fellies Assembling Machine in Our Repair-Shop
Haugan, Astrid Else (Norway)
- The Use of Routing Information in a Public Environment
H.J. Zwega (The Netherlands)
- Evaluation of a Set of Graphic Symbols
H.J. Zwega (The Netherlands)
- Standardization of Public Information Symbols
H.J. Zwega (The Netherlands)
- Standardization of Geometric Radar Symbolology
R.J. Carter (U.S.A.)
- A Study of Human Cosmetic Behavioral Factors
K. Morooka, S. Morikawa (Japan)

—29—

August 26

9:00 ~ 10:25

Room Hall D

Session 22: Introduction of Ergonomics to Industry

- Ergonomic Aspects of New Technologies
Dr. K.J. Zink (F.R.G.)
- An Investigation on the Actual Condition Pertaining to Introduction of Ergonomics into Japanese Industries
S. Nishikawa (Japan)
- A Problem in Applications: An Investigation into Methods and Materials for Upgrading Nuclear Power Control Boards
D. Smith (U.S.A.)
- Ergonomics in Agriculture and Forestry — the Present and Future State
Ir. J. Zander (The Netherlands)
- Ergonomics in Agricultural Engineering in India
B.G. Yadav, L.P. Gite (India)
- Intergration of Ergonomics in Transportation in Bali
A. Manuaba (Indonesia)

August 26

10:25 ~ 12:20

Room Hall D

Session 23: Ergonomics of Computer Systems

- The Use of Ergonomics Computer Equipment
T. Houghton (France)
- The Development of User Hostility Towards Computer Systems
T. Houghton (France)
- The Influence of System Response Time and Memory Load on Problem Solving Behavior
H. Bergmand, A. Brinkman, H.S. Koelega (The Netherlands)
- Response Time Discrimination
R.M. WU, C.R. Brown, P.D. Pagerey (U.S.A.)
- Language and Computer Systems "Work Analysis and Cognitive Load"
A. Wisner (France)
- Ergonomics of Computer Commands in Restricted Natural Language
D.-L. Scapin (France)

•Reading Grade Level as a Factor in Computer Dialogue Design

J.M. Roemer (U.S.A.)

•Ergonomics of Hybrid Japanese Text Entry Method
M. Kurosu, T. Nakayama (Japan)

•"Heimen-Dentaku" — Table Generator with Personal Computer —
Y. Mori (Japan)

August 26

9:00 ~ 10:35

Room Hall E

Session 24: Work Load: Visual

- Eyestrain of Industrial Visual Workers
M. Saito, K. Kishida, T. Hasegawa (Japan)
- Subsidiary Behaviors of Bottle Inspection Workers in Three Shift System
K. Kishida, M. Saito, T. Hasegawa (Japan)
- Accommodation Responses in CRT Display Task
M. Takahashi (Japan)
- A Study on Visual Function of VDU Operators
M. Ohashi, K. Aoki (Japan)
- Visual Loads at VDT Workplace
T. Läubli, G. Etienne, H. Wilhelm (Switzerland)
- Lighting Characteristics of Visual Display Terminals of Different Makes
U. Brauninger, E. Grandjean, R. Gierer, T. Fellmann (Switzerland)
- Physiological Effects of Oscillating Luminances in Reversed Display of VDTs
K. Nishiyama, U. Bräuninger, H. DE Boer, R. Gierer, E. Grandjean (Switzerland)
- Visual Ergonomics and Existing Person-Display Design Guidelines
R. Benel, D. Benel (U.S.A.)

August 26

10:35 ~ 12:35

Room Hall E

Session 25: Visual Inspection & Vigilance

- The Method of Evaluating the Aptitude of the Visual Inspectors at Line of the Steel Product
T. Kurabayashi (Japan)

- The Distribution of Visual Inspection Times
T.J. Gallwey (Ireland)
- E •Conveyor Paced Visual Inspection Efficiency over Short and Extended Work Periods
M.H. Elwany (Egypt)
- Methodologies for Visual Inspection Research and Development of Inspection Robot
K. Noro (Japan)
- Personal Error of Visual Judgement in Precision Measurement
K. Tanaka (Japan)
- A Study on the Distribution of Sensory Evaluation and Angular Transformation
T. Takahashi (Japan)
- Psychophysiological Criteria in the Analysis of Hypovigilance in Control Rooms
F **R.J. Claude (France)**
- Signal Vigilance Errors by Railway Drivers
S. Haga (Japan)
- Signal Detection Theory in Ergonomics
M.H. Christoph (F.R.G.)

August 27

9:00 ~ 11:30

Room Hall B

Session 26: Vehicle Driving

- Analysis on the Driving Operations of Drivers
S. Ueno, K. Haneishi, M. Nishikawa (Japan)
- Evaluation of the Arousal Level of Automobile Drivers Based on Their EEG etc.
T. Yanagishima (Japan)
- Evaluation of Vehicle Steering Control Characteristics by Skin Resistance Level and Heart Rate
T. Sawada (Japan)
- The On-Line Use of Driving Performance Measures to Detect Abnormal Driving Behaviour
Y.I. Noy, D.A. Attwood (Canada)
- Effects of Fatigue and Drugs on Driving Performance
K. Yajima, K. Aoki, T. Aoki, H. Tanaka, N. Yamanoi, S. Kinoshita, T. Furukawa (Japan)
- Autoregressive Analysis of Highway Driving Performance by a Simulator
S. Kinoshita, K. Yajima, K. Aoki, H. Tanaka, T. Aoki, N. Yamanoi, T. Furukawa (Japan)
- Driver and Pedestrian Speed Estimation
M.H. Bergman (U.S.A.)

—32—

- Rural Road Delineation at Night
T.J. Triggs (Australia)
- Fatigue of Bullet Train Drivers Operating on Multi-Tunnelled Sections
A. Watanabe, K. Kogi, N. Onishi, H. Shindo, K. Sakai (Japan)
- Measurement of Pilot Workload during Take Off and Landing by C-1 Jet Carrier
Y. Nagasawa, S. Aramaki, (Japan)
- A Study on the Changes of Physiological Functions on Motorcycle Riding
T. Matsumoto (Japan)
- Subjective Symptoms and Physio-Psychological Effects by Motorcycle Driving
A. Hisashige, H. Ohara, Y. Kume, M. Yamamoto, T. Ogawa, H. Aoyama (Japan)
- Performance, Physiological Stress and Mood State Changes Resulting from Vessel Motions at Sea
R.L. Pepper, S.F. Wiker, M.E. McCauley (U.S.A.)
- A Biotechnological Study of Hang Glider Crewmen
N. Ando (Japan)

August 27

9:00 ~ 11:20

Room Hall C

Session 27: Introduction of Ergonomics to Social Systems

- The Functioning of Occupational Health Service in Scandinavia — on the Basis of Empirical Research in Norway and Sweden and Experience from a Field Research Project in Denmark
O. Rieper, A.S. Johansen (Denmark)
- Applied Ergonomics in the Danish Labour Inspectorate
Lundstedt, Dorte (Denmark)
- The Tasks of an Industrial Physician
J.-I. Kamoy (Norway)
- Is Selective Traffic Code Enforcement Practical? A survey of Canadian Traffic Police
G.F. Rabideau, M.L. You (Canada)
- Human Factors in Organizational Design and Management
H.W. Hendrick (U.S.A.)
- Cognitive Complexity, Conceptual Systems and Organizational Design: Implications for Ergonomics
H.W. Hendrick (U.S.A.)
- Assessment Center Ratings as an Interim Criterion Measure in Leadership Research
H.W. Hendrick (U.S.A.)

—33—

- Accuracy of Leaders' Perceptions of Self and Others, and Actual Group Status as Functions of Cognitive Complexity
H.W. Hendrick (U.S.A.)

- The Ergonomics, Has It Its Specific Laws?
P. Burloiu (Rumania)

August 27

9:00 ~ 10:20

Room Hall D

Session 28: Posture

- Dynamic Analysis of Human Upright Posture Control Activity
K. Sato, M. Chikami, N. Tajima (Japan)
- On the Analysis of Erect Posture by the Foot-Pressure
H. Itoh, T. Sakamoto (Japan)
- An Ergonomic Evaluation of Foot-Complaints among Waiters
Jörgen Winkel (Sweden)
- The Postural and Health Problems of Workers in Pear and Apple Orchard
H. Sakakibara, M. Miyao, T. Nakagawa, F. Kobayashi, S. Kanada, K. Takihi, S. Yamada, K. Masuda (Japan)
- Localized Fatigue Complaints Related to Output and Body Posture of Dentists
K. Maeda (Japan)
- A Study of Space Allotment Procedure for Dental Treatment Area in Measurement of Human Posture
M. Ohashi (Japan)
- A Study of "Driving Position" in Passenger Vehicles
S. Takaji (Japan)
- Holding Performance of Automobile Seats
M. Sano (Japan)

August 27

10:20 ~ 11:30

Room Hall D

Session 29: Work Load: Lifting

- Energy Cost of Lifting in Sagittal and Lateral Planes by Different Techniques
S. Kumar, D. Magee (Canada)

- An Ergonomic Evaluation of Working Postures in Manual Weight Lifting

M. Morioka, A. Kimura, K. Kishida, S. Horino, M. Saito (Japan)

- An Ergonomic Approach To Reduce Hazards of Lifting Tasks

M.M. Ayoub (U.S.A.)

- Recommended Work Rates and Container Configuration for Manual Lifting and Lowering Activities

A. Mital, S.S. Asfour, M.M. Ayoub (U.S.A.)

- Guidelines for Permissible Limits for One-Handed Lifts by Women

A. Garg (U.S.A.)

August 27

9:00 ~ 11:30

Room Hall E

Session 30: Perception & Recognition

- Color Contrast and Visual Task Performance
H.L. Snyder (U.S.A.)
- The Influence of Colour Saturation on the Chromatic Error of Accommodation of the Human Eye
H. Krueger (F.R.G.)
- Effects of Television Noise Interference on Character Reading Time
A. Watanabe, M. Saito (Japan)
- Signal Detection in the Noisy Background Figure through Limited Area of Visual Field
S. Saito (Japan)
- A Discriminability Metric for VDU Characters
M. Schneider (U.S.A.)
- Interitem and Intraitem Symmetries in Same Responses to Pairs of Letters
S. Bagnara, D.B. Boles, F. Simion, C. Umilta (Italy)
- How Many Letters Can We Recognize at a Glance?
T. Fukuda (Japan)
- An Analysis of the Interaction Effects between Successively Exposed Two Figures
T. Yoshida (Japan)
- A Multidimensional Scaling Analysis on Perceptual Structures of Japanese Syllables
K. Mizuki (Japan)
- Tactile Letter Display for a Reading Aid
Y. Shimizu (Japan)

- Warmth to Touch the Building Materials
I. Matsui, Y. Kasai (Japan)
- Pain Sensation and Skin Deformation
M. Akamatsu (Japan)
- Accuracy of Time Perception in Rhythmic Movement
T. Niihara, K. Kusano (Japan)
- Study of Time-Estimation on a Reactive Simple Action
I. Yoshimura, M. Nakamura (Japan)

August 27

13:00 ~ 14:40

Room Hall C

Session 31: Work Performance

- Dependence of Human Performance on Input Information in Pursuit Manual Control Systems
O. Suenaga, M. Ihara (Japan)
- A Study of Human Operator's Dynamics during Training and Transfer Trials of the Tracking Tasks in Case of a Second-Order Lag System
T. Yamashita, E. Masuyama (Japan)
- Skill Improvement in Manual Control of a Double Integral Controlled Element
A. Tada (Japan)
- A Consideration on the Index of Precognitive Control Behaviors of Human Operator
H. Takeda, Y. Ikeda, S. Hata (Japan)
- Analysis of Precognitive Dynamics in Two Axis Pursuit Tracking Task
T. Aoki, K. Yajima, K. Aoki, H. Tanaka, S. Kinoshita, N. Yamanoi, T. Furukawa (Japan)
- Modeling the Human Operator in a Preview Compensatory Tracking Control System
K. Yoshimoto (Japan)
- On the Self-Paced Preview Manual Tracking Behaviors
K. Ito (Japan)
- Human Operator's Compensation Mechanism for Time-Delay in Manual Control System
M. Yoshizawa (Japan)
- Visual Lead Compensation in Manual Compensatory Tracking
S. Hara, K. Handa (Japan)
- Effects of Exogenic Stimulations upon Monotonous Performance
T. Watanabe (Japan)

August 27

13:00 ~ 14:40

Room Hall D

Session 32: Work Load on the Back

- Dynamic Loading of Static Truck
S. Kumar, P.R. Davis, D.P. Currier (Canada)
- Compressive Load at L₅/S₁ Spine Level as a Biomechanical Factor during Carious Lifting Techniques
T.P.J. Leskinen, H.R. Stalhammar, I. Kuorinka (Finland)
- Posture Optimization through Three-Dimensional Kinetic Biomechanical Modeling
A. Kumer, A. Mital (U.S.A.)
- Physiological Load on the Back of Postmen during Letter Distribution in Urban Districts.
K. Jogensen, H. Christensen, E. Daltorn (Denmark)
- The Musculoskeletal Status in Airport Transport Workers
K. Undeutsch (F.R.G.)
- A Back-Care Program in the Building and Construction Industry in the Netherlands
E.A.P. Oningsveld (The Netherlands)

August 27

13:00 ~ 15:00

Room Hall E

Session 33: Working Environment

- Studies on Subjective Sensations on Air Movement for Creating Comfort Indoor Climate
H. Kubota (Japan)
- Passive Smoking at Work
W. Annetta (Switzerland)
- An Experimental Study on Irritations and Annoyance due to Passive Smoking
T. Muramatsu, S. Muramatsu (Japan) A. Weber, F. Akermann (Switzerland)
- A Survey on the Effects of Involuntary Smoking and Attitudes to Smoking among School Children and Students
S. Muramatsu, T. Muramatsu (Japan) A. Weber (Switzerland)
- Effect of Physical Work on Rate of Dispersal of Bacteria in the Air from Man
K. Terayama, T. Kawarabayashi, H. Ohno, F. Hirata (Japan)

- Hazardous Materials Encountered in Human Factors Design Practice

D. Gloss (U.S.A.)

- Solvent Mixtures Influence Dependent on the Working Process in the Wood Industry

R. Lödersdorf, G. Schäcke, B. Heydenreich-Adloff, A. Fuchs (F.R.G.)

- The Aggregation Method of Heterogeneous Material Environment of Work Factors

L. Pacholski, A. Jasiak (Poland)

TECHNICAL SITE VISITS

The Organizing Committee will provide the participants with the opportunities to visit the following places on 26th (Fri.).

1. Japanese National Railways
(Bullet Train Operation Control Center)
2. Metropolitan Police Headquarters
(Command & Control Center)
3. Tokyo Fire Dept.
(Rescue Control Center)
4. Telecommunication Science Hall of Nippon Telegraph and Telephone Public Corporation
5. The Federation of Bankers Association of Japan
(Data Telecommunication System)
6. Nissan Motor Co., Ltd. — Zama Plant
(Industrial Robot at Assembly Line)

Those who wish to join the Visits are requested to check the column of Form (1) — Registration Form —, and to pay the appropriate fee at the Registration Desk on site. The fee for course 1-5 will be only fare for city transportation. The fare for a motor coach will be charged for course 6. As the number of participants in each course is limited, please apply as early as you can.

SCIENTIFIC EXHIBITION

Along with the Congress, an Exhibition is scheduled to be held and the Exhibition Committee has been making every effort to make the exhibition suitable for the Congress. Currently, the proposed exhibits are being screened for the 20-25 booths.

Participants will be able to enjoy this special Scientific Exhibition.

SOCIAL PROGRAMS

1. WELCOME RECEPTION

A welcome reception is scheduled to be held from 6:30 p.m. on 23rd, Aug. at Banquet Hall of the Congress Site. The Organizing Committee invites all participants and accompanying persons to the reception.

2. FAREWELL PARTY

Time and Date:

19:00-21:30 on 26th August.

Place:

Royal Hall, Akasaka Prince Hotel.

Features:

M.C. of the Party... Mr. Katsuya Kobayashi

Very famous for his job as a disc jockey of several radio and TV programs. He speaks fluent English.

Koto Music... Played by a Koto Music Group consisting of 4 Ladies.

Japanese Popular Song and Dance... Performed



by Miss. Sayaka Ito, Miss Yukiko Yamada, both famous singers and actresses, and Shower, a famous singing and dancing team consisting of 7 pretty girls.

Japanese Folklore Song and Dance... Performed by the Japan Folk Music Association consisting of 13 members, selected performers from the Association members.

Folk songs and dances accompanied by Shamisen, Japanese Drums, etc. will be performed.



String Quartet Music... Performed by the Musica Sacra

String Quartet as background music through the second half of the party.

Note: Price of participation in the party: Yen 10,000 per person. Please add the amount to the registration fee of the congress if you wish to participate.

The features of the party are subject to change without notice.

Applications on the Social Programs

Please fill out the attached Form 1 if you will or will not participate in each program. In case you will be participating in the farewell party, please add ¥10,000 to your registration fee of the Congress.

3. LADIES' PROGRAMS

The Organizing Committee proudly announces that all accompanying persons are invited to the ladies' programs, which will provide them with the opportunity to become familiar with the things of Japan. Both programs are available free of charge for up to limited number of seats.

LP-1: "Japanese Traditional Arts"

Full Day program on 25th Aug.

Demonstrations of tea ceremony with one cup trial to the all participants, paper-folding class and class of Kimono fitting including a demonstration of bridal Kimono. Lunch is not included in the program but may be available at Chinzanso Garden Restaurant after paper-folding class on private account basis.

LP-2: "Japanese Garden and Museum"

Morning Tour on 26th Aug.

Rikugien Garden, one of Tokyo's famous Japanese Gardens, and Tokyo National Museum will be visited.

The number of participants are strictly limited up to 35 persons for LP-1 and 40 persons for LP-2 respectively.

All above programs are subject to change without notice.

TRAVEL INFORMATION

OFFICIAL TRAVEL AGENT

The Organizing Committee has designated the Japan Travel Bureau, Inc. (JTB) as official travel agent for the Congress in Japan. JTB will handle all arrangements concerning hotel reservations, tours pre-, post- and during the Congress and other travel arrangements. All inquiries and applications in this regard should be directed to the following address:

**Japan Travel Bureau, Inc. (JTB)
Foreign Tourist Dept.,
Convention and Tours Section
1-13-1, Nihonbashi, Chuo-ku,
Tokyo, 103 Japan
Phone: (03) 271-2346
Cable: TOURIST TOKYO
Telex: J24418 TOURIST (Answer Back)**

PASSPORTS AND VISAS

All foreign visitors desiring to enter Japan must have a valid passport. Visas are not required for tourists who are citizens of the following countries:

Argentina, Austria, Bangladesh, Belgium, Canada, Chile, Colombia, Costa Rica, Cyprus, Denmark, Dominican Republic, Finland, France, Federal Republic of Germany, Greece, Guatemala, Honduras, Iran, Ireland, Iceland, Israel, Italy, Lesotho, Lichtenstein, Malta, Mauritius, Mexico, Netherlands, New Zealand, Norway, Pakistan, Peru, Portugal, El Salvador, San Marino, Singapore, Spain, Suriname, Sweden, Switzerland, Tunisia, Turkey, United Kingdom, Uruguay and Yugoslavia

VACCINATION

No special vaccinations are necessary unless a visitor enters Japan within 14 days of having been in a smallpox-infected area, in which case he must have a valid international certificate of vaccination against smallpox. A cholera certificate is also required for persons coming from an infected area. For further details, participants are advised to consult their local travel Agents or carriers.

WEATHER AND CLOTHING

The weather in Japan during the Congress period is very hot and humid, with an average temperature of about 28°C (82°F). Highest of the temperature will be 35°C in the daytime and the lowest will be 23°C in the night. Congress site and the

hotels are well air conditioned as well as any buildings, underground shopping centers and many of transportations except most of buses and the subways. Please wear light clothes informally.

TRAVEL TO JAPAN

Japan Air Lines has been appointed as the Official Carrier for the Congress. Any of your local JAL office or their travel agents will help you for travel arrangements to/from Japan. Also, the agencies Meon Travel in London, U.K. and Garber Travel in Mass. U.S.A. are the appointed travel agents in the regions respectively. For group or individual flight arrangements, please consult any of the followings:

FOR EUROPEAN COUNTRIES

Japan Air Lines
Congress Coordinator
12 Great Marlborough Street,
London W1V 1DE, England
Phone: 01-629-9244

Meon Travel
32 High Street, Petersfield,
Hampshire, GU32 3JL, England
Phone: 0730-4011
Telex: 86181

FOR CONTINENTAL AMERICA

Japan Air Lines
Convention Coordinator
655 Fifth Avenue, New York,
N.Y., 10022 U.S.A.
Phone: 212-758-8850

Garber Travel
1406 Beacon Street, Brookline,
Mass., 02146 U.S.A.
Phone: 617-734-2100

OPTIONAL TOURS

A variety of optional tours are planned during the Congress for delegates and accompanying persons who wish to see even more of Japan and enjoy their stay to the fullest. These tours can be booked in advance with application Form 2.

(A) During the Congress (OP)

- OP-1: "Tokyo Morning Tour"
Half-day sightseeing, visiting Tokyo Tower, 'Happoen Garden' to see tea ceremony and Imperial East Garden (or Imperial Palace Plaza).
Tour fare: ¥3,500 per person
- OP-2: "Tokyo Afternoon Tour"
Half-day sightseeing, visiting Imperial Palace Plaza, Asakusa Kannon Temple, and boating on the Sumida River.
Tour fare: ¥3,500 per person
- OP-3: "Tokyo Golden Night Tour"
Sukiyaki Dinner and Cabaret Mikado (spectacular revue) and Geisha Party.
Tour fare: ¥11,000 per person
- OP-4: "Nikko Full-day Tour"
The grandeur of 300-year-old shrines; splendor of Japan's scenic Nikko National Park (lunch included).
Tour fare: ¥16,000 per person
- OP-5: "Kamakura-Hakone Full-day Tour"
A delightful excursion into the beauty of nature, with a visit to the great Buddha at Kamakura (lunch included).
Tour fare: ¥16,000 per person

(B) After the Congress (OP-6): "Japan Golden Route"

- Aug. 28, Sat.: Morning drive to Kamakura to visit Great Image of Buddha and sightseeing in Hakone, including a cruise on the lake and the Open Air Museum. (lunch included).
Accommodation in Hakone.
- Aug. 29, Sun.: Take morning bullet train from Odawara to Kyoto (lunch included). Afternoon excursion to Nara, visiting Todaiji Temple, Deer Park and Kasuga Shrine.
Accommodation in Kyoto for 2 nights.
- Aug. 30, Mon.: Morning sightseeing in Kyoto, visiting Nijo Castle, Kinkakuji Temple (Gold Pavilion) and Old Imperial Palace. Afternoon sightseeing in Kyoto, visiting Sanjusangendo Temple, Heian Shrine and Kiyomizu Temple.
- Aug. 31, Tue.: Tour disbands on checking-out at regular check-out time.
- Tour fare: ¥69,000 per person (Dolby occupancy)
¥82,000 per person (Single occupancy)

Tour Condition for "Osaka Symposium Tour" and Optional Tours

Included in the tour fares are hotel accommodations with bath at standard grade hotels; lunch as specified in the itinerary; tourist-class reserved seats on super express trains and best available seats on private railways; sightseeing and transfers by bus on a group basis; transportation of baggages not exceeding two pieces per person; service of an English-speaking escort throughout the tour; and gratuities to hotel maids, porters, chauffeurs etc.

JTB reserves the right to cancel any tour should there be insufficient participation.

CANCELLATION

HOTEL ACCOMMODATIONS

In the event of a hotel reservation having to be cancelled, written notification should be sent to JTB. The following cancellation fees will be deducted before refunding a deposit:

If the notice of cancellation reaches JTB:

Up to 9 days before the first night of stay	¥1,000
2-8 days before	20% of deposit
Less than 2 days before, or not notice given	100% of deposit

TOURS

In the event of tour reservations having to be cancelled, written notification should be sent to JTB. The following cancellation fees will be deducted before refunding the tour fare:

If the notice of cancellation reaches JTB:

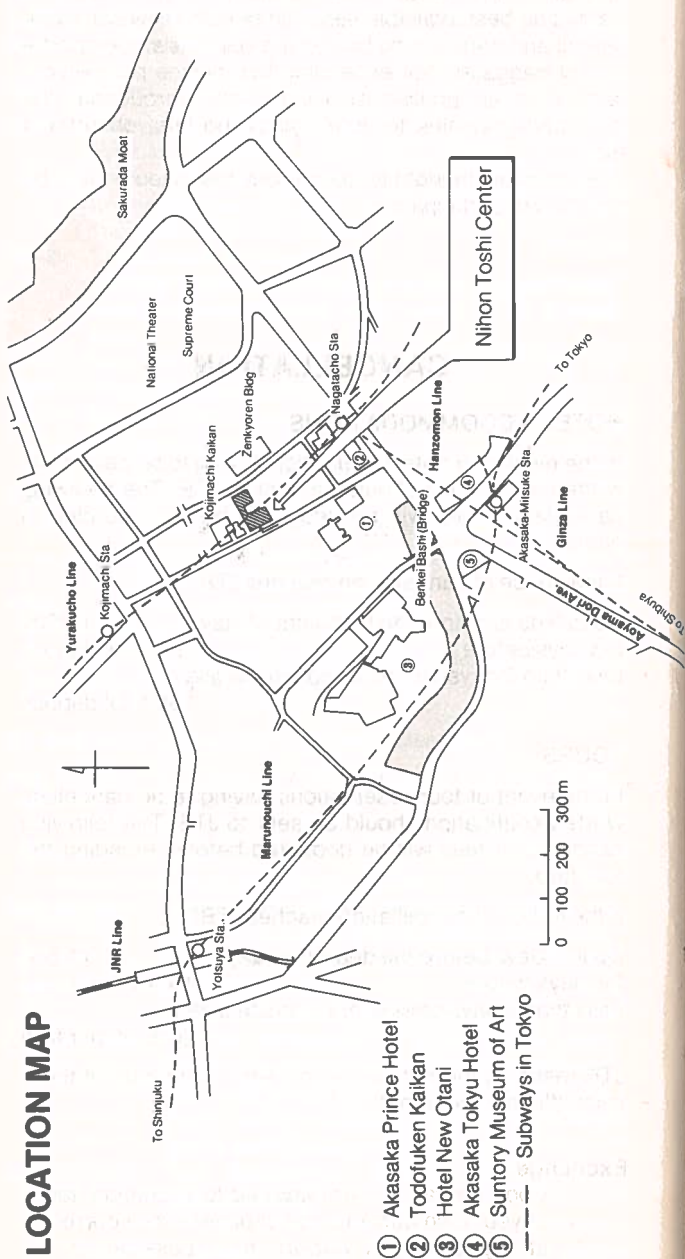
Up to 9 days before the departure day	¥1,000
2-8 days before	10% of tour fare
Less than 2 days before, or no notice given	20% of tour fare

JTB reserves the right to cancel any of the tours if there is insufficient participation.

Exchange

Upon arrival, you are advised to exchange some of your own currency for Japanese Yen currency at the banks at Airport. It is possible to exchange most of the foreign currency into Japanese money at banks or hotels. Personal Cheques can not be accepted for immediate exchange, you are advised not to reply on them.

LOCATION MAP



- ① Akasaka Prince Hotel
- ② Todofuken Kaikan
- ③ Hotel New Otani
- ④ Akasaka Tokyu Hotel
- ⑤ Suntory Museum of Art
- Subways in Tokyo

•Those who take a taxi from Tokyo City Air Terminal to your hotel, or from your hotel to Nihon Toshi Center are requested to show the following and inform a driver of the site to avoid misunderstanding.

● タクシー運転手の方へ (To a Taxi Driver)

この方は、国際人間工学会連合第8回会議に出席される海外の代表者です。下記の示される場所まで安全に御案内下さい。

日本都市センター…………… Nihon Toshi Center
(平河町)

ホテル・ニューオータニ… Hotel New Otani

赤坂東急ホテル…………… Akasaka Tokyu Hotel

銀座キャピタルホテル…… Ginza Capital Hotel
(新富町前)

For further information, Please contact:

Secretariat: IEA '82 Tokyo
c/o Inter Group Corp.
Akasaka Yamakatsu Bldg.
8-5-32, Akasaka, Minato-ku
Tokyo 107, Japan

Phone (03) 479-5318

Cable Address: INTERCONFER TOKYO



Our charming way

You'll be charmed by our service whenever you fly JAL.

To 52 cities in 31 countries across six continents.

And wherever you go, you'll always be helped by a charming stewardess whose upbringing and training go together in perfect harmony.

Our charming way is just one of the many ways that make flying the world with Japan Air Lines so delightfully memorable.

**Serving you
is our way.**



JAPAN AIR LINES
— official carrier —