reçu documents le 29/05/97.

भारतीय खेल प्राधिकरण

SPORTS AUTHORITY OF INDIA

पश्चिमी क्षेत्र

WESTERN REGION

नेताजी सुभाष पश्चिमी केन्द्र, सेक्टर-१५, गांधीनगर-३८२ ०१६ (गुजरात)
Netaji Subhas Western Centre, Sector-15, Gandhinagar-382 016 (Gujarat)

12/05

Prof. Alain Wisner
Ergonomie et Neurosciences Du Travail
Conservatoire National Des Arts et Metiers
41 RUE GAY-LUSSAC
75005 PARIS
FRANCE.

Ref:SAI/Acad/Sports(Phy)/NSWC/96-97-761
Dated: April 11, 1997.

Respected Sir,

Please find enclosed reprints of nine articles, as promised by me, published by me in last ten years. I wish to read the articles published by you, specially relating to the developing countries. Kindly send me the reprints of your articles or book (if possible).

With regards,

Yours faithfully,

(Asis Goswami) Ph.D.
Scientific Officer.

Encl: as above

Telephone - 02712-23182 Gram "SAIWEST" Telex No. 1203-233 SAIW IN

BY AIR MAIL

PROF. ALAIN WISNER
ERGONOMIE ET NEUROSCIENCES DU TRAVAIL
CONSERVATOIRE NATIONAL DES ARTS ET
41 RUE GAY-LUSSAC
75005 PARIS
FRANCE.

From : DR. A. GOSWAMI
SPORTS AUTHORITY OF INDIA
NETAJI SUBHAS WESTERN CENTRE,
SPORTS COMPLEX, SECTOR-15,
GANDHINAGAR-382 016. (GUJ.)
Fax - 02712 - 22441

भारतीय खेल प्राधिकरण

SPORTS AUTHORITY OF INDIA

पश्चिमी क्षेत्र
WESTERN REGION

नेताजी सुभाष पश्चिमी केन्द्र, सेक्टर-१५, गांधीनगर-३८२ ०१६ (गुजरात)
Netaji Subhas Western Centre, Sector-15, Gandhinagar-382 016 (Gujarat)

Prof. Alain Wisner
Ergonomie et Neurosciences Du Travail
Conservatoire National Des Arts et Metiers
41 RUE GAY-LUSSAC
75005 PARIS
FRANCE.

Dated: January 13, 1997.

Respected Sir,

It was my misfortune that I could not attend your lecture at Delhi. I wrote a letter to my teacher Prof. Sen and also to Dr. Selvamurthy regarding my position. I was in the executive committee meeting which decided to hold Prof. Hamley memorial lecture. We could not think of another person expect you to deliver this lecture. We know about your love and affection for our nation. I really regret for not being with you at Delhi.

I was working at one of the centre of Sports Authority of India (SAI)(NSNIS at Patiala, Punjab). SAI controls all kind of sports training and education in India. SAI have five centres and we are transferable to any of these. I stayed at Patiala Centre for nine years. I was transferred to the centre at Gandhinagar (near Ahmedabad) in May 1996. So I could not prepare a paper for ISE symposium. I had to shift my family here in July. Changes in schooling of my children was very difficult. In the mean time SAI faced unusual financial crunch. I could not get even railway fare from SAI. In all respect I was in a mess.

Finally I thought to visit Delhi, without participation in symposium, on my own cost to meet you and Prof. Kumar. In this also, I failed because of the visit of Minister and our Director General. Unfortunately, I work in an organisation where scientific development is not the priorety. I have spent last ten years to convince people about the importance of science in sports performance. The name of "Ergonomics" is unheard in this circle. I hope, sir, you will understand the situation I face often, and forgive me.

contd....

Telephone - 02712-23182 Gram "SAIWEST" Telex No. 1203-233 SAIW IN

I have read your lecture script, that you had sent, many times. It is interesting to know that the thesis of Dr. Samit Mitra was also examined by you. Dr. Mitra was my teacher at the Graduate level and we share the same city as birth place. Last year I had a long discussion with him regarding his work. Our works have received recognition by your efforts and I am grateful to you for this gesture. I still believe that I will be able to meet you in near future.

In the past ten years I could publish only a few articles, although I have completed variety of research work in the field of sports physiology. I do not get much time to pursue academic work because of the nature of job. But now, with the present place of work I hope to snatch a few months for writing. I am enclosing a few articles I have published, after my thesis work. I have contributed a chapter in the forthcoming book "Perspectives in Rehabilitation Ergonomics" to be published by Francis & Taylor (Ed. S. Kumar). In this chapter "Anthropometry of people with disability" I have tried to review the available anthropometric data on disabled people.

Also, I have embarked on a review work of the works done by the Indian scientists in the field of work physiology, ergonomics and sports physiology, starting from the year 1913. I did start this work during January 1996, but the progress is slow. I find it interesting that most of the Indian studies are not published, at the best they were presented in the local seminars or conferences. Many studies had been repeated and these data or concepts remained un-utilised. This had a detrimental effect on general progress of the subject. In Jan. 1996, Prof. Astrand came at Bangalore (South India) to attend a Sports Science conference. I remember his comments when I asked a question "Why there are so little citation of Indian studies in your book ?" His answer was "Either you do not publish or your works does not add to the existing knowledge." I feel his view hold good to a large extent. I will need your help in this compilation, since you have been associated with our earlier generation Indian Physiologists.

I have made effort to express the views which I had in mind for a discussion with you, in person. I shall be grateful if you can write me about your view on the above review. I believe that you have already given thought in this matter, which is reflected in your lecture. It will be a great help if you can send me a copy/ or copies of your articles on Indian studies.

Once again I express deep regret for not attending your lecture.

I was on tour for two months. So the delay.

With regards to you,

Yours faithfully,

The reprints are sent through office in a separate pack.

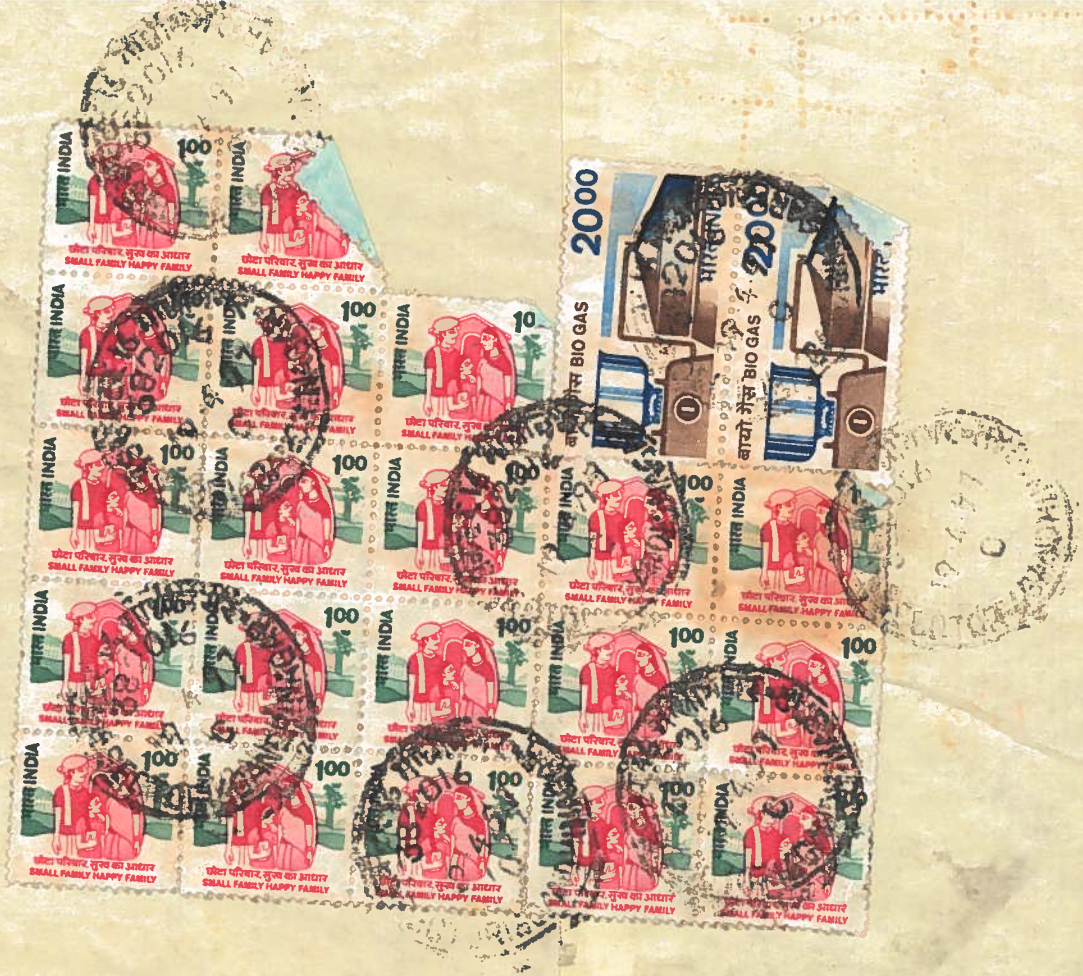
(A. Goswami)

BY: AIR MAIL

To
Prof. Alain Wisner
Ergonomics Neurosciences ou
41, RUE GAY-LUSSAC Metiess.
75005- PARIS
FRANCE

From

Dr. Asis Goswami
Scientific Officer,
SPORTS AUTHORITY OF INDIA
NETAJI SUBHASH WESTERN CENTRE
GANDHINAGAR
INDIA - GUJARAT


INDIA
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छोटा परिवार, सुख का आधार
SMALL FAMILY HAPPY FAMILY
2000
BIO GAS

TRANSMISSION

Date 16 Décembre 1996	Nombre de page (s) : 2 (y compris celle-ci)

DESTINATAIRE : Professor Rabindra Nath Sen

Fax : 00.91.33.241.32.22

Laboratoire d'Ergonomie
Cnam Professeur A. Wisner
41 rue Gay-Lussac
75005 PARIS (France)

Téléphone **01 44 10 78.12**
ou (33) 1 43 54 18 27

Télécopie **01 43 25 36 14**

Message

Cnam
CONSERVATOIRE NATIONAL
DES ARTS ET MÉTIERS
LABORATOIRE D'ERGONOMIE
41, RUE GAY-LUSSAC - 75005 PARIS
TÉL. 01 43 54 18 27 - FAX 01 45 25 35 14

Paris, 13th December 1996

Professor Rabindra Nath Sen
Indian Society of Ergonomics
H.B. 260 Sector 3
Salt Lake City
Calcutta 700.091 Inde
Fax 00.91.33.241.32.22

Dear Robin,

I would like to congratulate you for the beautiful Congress you have organized in Delhi and for successful and friendly group of tutorials that took place before the Congress. I thank you wholeheartdly to have invited me to this festival which is a sort of coronation of the fantastic work you have realised in extremly difficult conditions. I was also very impressed by the help you received from Dipas which members I would like you to congratulate and thank for me.

Though I am an old man and have retired, I cannot fully give up my former commitment in promoting ergonomics and anthropotechnology in industrially developing countries and specially in India. I thought that the Delhi congress would have been a good occasion to meet again some younger indian colleagues of which I admire the production like Nag or Goswami. I was very sorry to realize that they did not receive the money necessary to travel to Delhi I would be very happy to get again in touch with them. Can you confirm that Nag is always working at the National Institute of Occupational Health Meghaninagar. Ahmedabad 380.016, and Goswami at the National Institute of Sports Moti Bagh-Patiala 147.001. Can you also confirm that C.N. Daftuar is always at the Department of Psychology M.S. University Baroda 390.002.

Coming back to the Delhi meeting, I am very happy that you will publish the papers presented to this congress and specially mine though it is rather a long one. I will make some alteration in the title and the text as you kindly advise me to do.

You understand that I am more than either ready to help indian ergonomics and specially you and your school as far as my decaying forces allow me to do.

With my best regards.

Truly yours.

Happy New Year!

A. Wisner

Paris, 19th December 1996

Doctor Asis Goswami
Faculty of Sport Sciences
Netaji Subbash National Institute of Sports
Moti Bagh
Patiala 147.001 Punjab Inde

Dear Dr Goswami,

I have attended with great interest, the tutorials and Congress itself of the Indian Ergonomics Society held in Delhi last November.

But I was extremly deceived to see that many very distinguished indian researchers, well known in the world were not in Delhi. I hoped to have with you a long conversation. Some people told me that your Institute was not in a position to pay the air ticket. I dont know how far it is true.

Anyway, I need to get in touch with you to tell you how I continue to admire your works. You shall receive later, the paper I have presented at the beginning of the Congress, paper in which you are mentioned. This paper will be published in the Congress'book under another title "Contribution of India to anthropotechnology" and with some few alterations. But the book will be published in two years more or less. I send it to you in homage to your works. I know, that this paper is perhaps not very good but I am so convinced of the greatness of indian civilization and of the importance of the contribution that indian ergonomists, physiologists and psychologists have produced.

Happy New Year.

With my best regards.

Truly yours.

A. Wisner

Paris, 19th December 1996

Professor C.N. Daftuar
Department of Psychology
M.S. University
Baroda 390.002 Inde

Dear Dr Daftuar,

I have attended with great interest, the tutorials and Congress itself of the Indian Ergonomics Society held in Delhi last November.

But I was extremly deceived to see that many very distinguished indian researchers, well known in the world were not in Delhi. I hoped to have with you a long conversation. Some people told me that your Institute was not in a position to pay the air ticket. I dont know how far it is true.

Anyway, I need to get in touch with you to tell you that I remember well our meeting in Gosterbeck and that I continue to admire your works. You shall receive later, the paper I have presented at the beginning of the Congress, paper in which you are the author whose works are the most developed. This paper will be published in the Congress'book under another title "Contribution of India to anthropotechnology" and with some few alterations. But the book will be published in two years more or less. I send it to you in homage to your works. I know, that this paper is perhaps not very good but I am so convinced of the greatness of indian civilization and of the importance of the contribution that indian ergonomists, physiologists and psychologists have produced.

Happy New Year.

With my best regards.

Truly yours.

A. Wisner

MINISTERE DE L'EDUCATION NATIONALE
CONSERVATOIRE NATIONAL DES ARTS ET METIERS
ERGONOMIE ET NEUROSCIENCES DU TRAVAIL

Paris, 26th May 1994

Dr. A. GOSWANI
Sports Authority of India
Neetaji Subhas
National Institute of Sports
Moti Bagh
Patiala-147001 (Punjab)
India

Dear Dr. Goswani,

I received with much pleasure your letter of 18th April 1994 and I am glad to see that your activity I have admired for a long time is always important both in quality and volume.

I would be extremely happy to see you in Toronto and thank you for your congratulations on my lecture. I am not sure that the originality of my position will be so well accepted as you may think.

I am really sorry not to be able to give you good news about funds that could contribute to your travel expenses.

As I am 70, I retired six months ago. I continue to be active for three years as "Emeritus" to help students to achieve their thesis but my social power has been quite normally reduced.

The main difficulty is that in France we have university holidays from July 15th to August 31st and nobody will organise a seminar or a conference during this period. I shall be myself out of the country from August 10th until August 26th to attend the congress and visit colleagues in Montreal. Before I shall be in my country house from July 7th to August 7th.

I am really sorry and hope that you may find other sources of funds for your travel.

I shall be very happy to receive some of your papers as I continue to travel for scientific purposes and I sometime think of visiting a few laboratories in India.

With my best regards,

Yours sincerely,

Alain Wisner

CNAM - LENET, 41 rue Gay Lussac, 75005 Paris. Tél.: (1) 43 54 18 27 - (1) 43 54 18 24 - Fax: (1) 45 35 26 14

SPORTS AUTHORITY OF INDIA
Netaji Subhas
National Institute of Sports
Moti Bagh, Patiala-147001 (India)

EXECUTIVE DIRECTOR (Academics)

No NIS/RC/AG/94/10
Date: 18.4.1994

कार्यकारी निदेशक (शैक्षणिक)

Prof. Alain Wisner
Deptt. des Sciences de I'Homme au Travail
Conservatoine National des arts et Metiers
PARIS, FRANCE

Respected Sir,

I hope you had received my letter dated January 6, 1994. My submission "Application of anthropometry in mobility aid design - a developing country perspective" has been accepted for oral presentation in "Rehabilitation Ergonomics" symposia. Also I had requested Dr. Ian Nay for a Travel Grant and subsequently I have received communication from Dr. Grant that they will be able to provide partial assistance.

A few days back I have received the preliminary program of IEA' 94 and came to knnow that you will be delivering the "Grandjean Memorial Lecture" on the opening day. I wish to extend my congratulations to you. This news is also encouraging to me and I am trying my best to collect funds for attending this conference. However, considering the Indian situation it becomes a different task and I have hesitation to inform you that I have never travelled out of this country.

This tour will materialize if I can earn during the same. Is it possible to get a few lecture sessions, with financial assistance, at your institute or any sports institute at Paris ? In such case I can take a break of journey before or after the Congress. I hope you will understand the situation and kindly help ~~be~~ me. I am enclosing my bio-data for your kind perusal. I shall be waiting for your reply. I beg your pardon for bothering you too much.

With warm personal regards to you.

Yours sincerely,

A. Goswami

(A. GOSWAMI)
SO (PHYSIOLOGY)

दूरभाष : 70336
तार : नेटिनस्पोर्टस
टेलेक्स : 0394-204

भारतीय खेल प्राधिकरण
नेताजी सुभाष राष्ट्रीय क्रीडा संस्थान

Phone : 70336
Grams : NATINSPORTS

CURRICULUM VITAE

NAME : ASIS GOSWAMI M.Sc. Ph.D.

I. Personal data :

Birth date	: March 24 1956
Birth place	: Midnapore town. West Bengal. India.
Citizenship	: Indian
Marital status	: Married.
Number of Children	: one daughter, one son.

Home address : Parmanent
: C/O.-Shri Kalipada Goswami
: 32 Khudiram Nagar
: Midnapore 721 101
: West Bengal. India.

Office Address : Faculty of Sports Sciences
Netaji Subhash National Institute of Sports
Sports Authority of India
Moti Bagh. Patiala 147 001.
INDIA.

II. Education :

Year	Degree	School/College	Board/University
1971	H.S	Vidyasagar Vidyapith School. Midnapore. W.B.	W.B. Board of Secondary Education. W.B.
1974	B.Sc.	Midnapore College Midnapore.	Calcutta University.
1976	M.Sc.	University College of Science. Technology & Agriculture. Calcutta.	Calcutta University.
1987	Ph.D.	Bioengineering Unit University College of Medicine. Calcutta.	Calcutta University

Ph.D. Thesis Details :

Submitted on March 27 1984
Awarded in Nov., 1987.

Title: Bioengineering/Ergonomic Evaluation of different Types of Mobility Aids for Lower Extremity Handicapped.

Guide : Dr. S. Ganguli Hony. Bioengineer, UCM (GH), C.U.

contd....2/-

I am sorry for the poor print quality.

III. ACADEMIC POSITIONS HELD :

From	To	Position	Institution
March 16 1978	July 31 1979	Lecturer in Physiology	Vidyasagar College Calcutta.

IV. RESEARCH POSITIONS HELD :

From	To	Position	Institution
January 1978	February 1979	Honorary Research Scientist	Under Dr.R.N. Sen Department of Physiology University College of Sc. Tech. Calcutta University.
November 1979	March 1983	Research Assistant	Bioengineering Unit University College of Medicine Calcutta University.
May 1983	September 1986	Research Assistant	Occupational Physiology Div. National Institute of Occupational Health (ICMR) Ahmedabad. India.

Present Attachment :

September 1986 (involves teaching in Post-graduate level also)	Onwards	SCIENTIFIC OFFICER and In-Charge, Dept. of Exercise Physiology (was responsible for setting up Neurophysiology Laboratory under the Dept. of physiology).	Faculty of Sports Sciences Netaji Subhash National Institute of Sports Patiala, India.

V. PROFESSIONAL TRAINING :

Year	Period	Indstitution/Field	Sponsorer
1977	14-19th March	Regional Labour Institute Calcutta, on "Industrial Safety and Hygiene".	Calcutta University.
1984	5-7th March	Central Labour Institute Bombay, on "Development of Anthropometric Standards for Indian Workers", conducted by Prof. K.H.E. Kroemer, ILO Expert, Virginia Polytechnique, USA.	National Institute of Occupational Health, ICMR, Ahmedabad 380 016.
1987	23-27th November	Blue Star Ltd., New Delhi (agent of Hewlett-Packard USA), in "Workshop on Measurement Automation Through HP-IB".	Netaji Subhash National Instutute of Sports, Patiala, 147 001, India.

contd....3/-

VII. AREAS OF RESEARCH :

1. Ergonomics/Human Factor Engineering
2. Work physiology/sports physiology
3. Evaluation and development of mobility aids for lower extremity handicapped
4. Evaluation of heat stress and heat acclimatization in man
5. Electromyographic studies on man at rest and work.
6. Blood lactate, heart rate and other physiological parameters of sportsmen/women during game and laboratory conditions

VIII. CURRENT PROJECTS :

1. Studies on muscle involvement in various sports
2. Lactate removal pattern, fatigue and recovery in man
3. Time motion analysis of badminton and hockey.
4. Development of computer programme for physiological measurements and clinical diagnostics.
5. Correlation between electrophysiological responses and muscle fibre composition.

IX. SPECIAL TEACHING ACTIVITY :

1. Participated in the workshop on Physical education as a visiting faculty during oct.15 1984 to oct. 30 1984 at Dept. of Physical Education, University of Kalyani, West Bengal.
2. Acting as visiting lecturer at Dept. of Physiology, Vidyasagar University, Midnapore, since 1991. Has been one of the member to prepare the syllabus for M.Sc. in "Physiology with community health" of Vidyasagar University, Midnapore, West Bengal.

X. STUDENT COUNSELLING :

1979-82 Two students per year on informal basis to help planning and executing M.Sc. dessertation at Calcutta University.

1983-86 Cooperated in the preparation of Ph.D. thesis of Dr. A.K. Banerjee, Professor, Department of Physical Education University of Kalyani, Kalyani, West Bengal and Dr. C.K. Pradhan, Research Officer, National Institute of Occupational Health, ICMR, Ahmedabad, specially in statistical analysis, presentation and interpretation of data.

XI. THESIS GUIDENCE :

Master level thesis (completed) :

1. Development of suitable methodology to evaluate skill and match play in hockey by using time motion analysis and physiological variables - Submitted by Vasu Thapliwal, 1991.

2. Relationship between selected motor abilities and performance in 800 meters run of 16 to 19 years Indian male runners - Submitted by P.J.S. Bajwa, 1992.

3. Study on the physiological stress of Weightlifting exercises. Submitted by Swaran Singh Mokha, 1993.

Master level thesis (on going) :

1. A study on the upper body muscle involvement during submaximal Olympic lifts - To be submitted by Mr. H.C. Mohan, 1994.

contd..4/-

Papers Published in National and International Journal :

1. Tibarewala, D.N., A.K. Ghosh, A. Goswami, S. Ganguli and K.S. Bose : Biomechanical and bioenergetic studies on human gait - a new approach. Medical and Life Science Engineering (India), Vol.5, No.2, 81-92, 1979.

2. Ghosh, A.K., D.N. Tibarewala, S.R. Dasgupta, A. Goswami and S. Ganguli : Metabolic cost of walking at different speeds with axillary crutches. Ergonomics(UK), 23, 6, 521-527, 1980.

3. Goswami, A., A.K. Ghosh and S. Ganguli : Assessment of a handicapped mobility aid by means of heart rate. Journal of the Institution of Engineers(India), 62, pt IDCE-3, June, 55-57, 1982.

4. Banerjee, A.K., A. Goswami and S. Ganguli : Performance Index - A systematic approach in athletic evaluation. Proc. "All India Seminar on New Dimensions in Physical Education and Sports", Department of Physical Education, University of Kalyani, 70-73, 1983.

5. Goswami, A., A.K. Ghosh, S. Ganguli and A.K. Banerjee : Aerobic work capacity of the disabled Indians. Ergonomics(UK), 27, 12, 1267-1269, 1984.

6. Nag, P.K., C.K. Pradhan and A. Goswami : Ergonomics in railway track maintenance. Special Report, National Institute of Occupational Health, ICMR (India), Ahmedabad, 1985.

7. Pradhan, C.K., A. Goswami, S.N. Ghosh and P.K. Nag : Ergodesign and physiological valuation of different types of Spades work. In: 'Ergonomics in Developing Countries - An international symposium', Occupational Safety and Health Series(I.L.O.), No. 58, 436-444, 1985.

8. Goswami, A., S. Ganguli, K.S. Bose and B.B. Chatterjee : Anthropometric analysis of tricycle designs. Applied Ergonomics(UK), 17, 1, 25-29, 1986.

9. Goswami, A., S. Ganguli and B.B. Chatterjee : Ergonomics analysis of Wheelchair designs. Clinical Biomechanics(UK), 1, 3, 135-139, 1986.

10. Pradhan, C.K., A. Goswami, S.N. Ghosh and P.K. Nag : Evaluation of working with spades on agriculture. Ind. J. Med. Res., 84, 10, 424-429, 1986.

11. Nag, P.K., C.K. Pradhan and A. Goswami : Cardiorespiratory and muscle responses in static, dynamic and combined work. J. Human Ergology (Japan), 15, 73-77, 1986.

contd.....6/-

12. Nag, P.K., A. Goswami, C.K. Pradhan and S. Ashtekar : Convergence of surface and deep body temperature in combined stress of metabolic and environmental warmths. Ind. J. Med. Res., 84, 10, 413-423, 1986.

13. Goswami, A., S. Ganguli and B.B. Chatterjee :Anthropometric characteristics of disabled Indians. Ergonomics(UK), 30, 5, 817-823, 1987.

14. Nag, P.K., A. Goswami, S.P. Ashtekar and C.K. Pradhan : Ergonomics in in Sickle operation. Applied Ergonomics(UK), 19, 3, 233-239, 1988.

15. Ghosh, A.K., P. Mazumdar, A. Goswami and G.L. Khanna : Aerobic-anaerobic transition level of Indian middle and long distance runners. Ind. J. Med. Res., 88, 10, 371-375, 1988.

16. Pradhan, C.K., A. Goswami, S. Ashtekar and P.K. Nag : Use of wire claw in railway track maintenance work. J. Human Ergology (Japan), 17, 1, 37-42, 1988.

17. Pradhan, C.K., A. Goswami, S.P. Ashtekar and P.K. Nag : Postural stress and discomfort in railway gangmen. Ind. J. Occupational Health, 32, 1&2, 6-12, 1989.

18. Ghosh, A.K., P. Mazumdar, A. Goswami, A. Ahuja and T.P.S. Puri : Heart rate and blood lactate response in competitive badminton. Annals of Sports Medicine (USA), 5: 85-88, 1990.

19. Ghosh, A.K., A. Ahuja and A. Goswami : Physical and Physiological profile of Indian National Women Hockey players. NIS Scientific Journal, 14, 4, 1-9, 1991.

20. Ghosh, A.K., A. Goswami, P. Mazumdar and D.N. Mathur : Heart rate and blood lactate response in Field Hockey. Ind. J. Med. Res., 94[B], October, 351-356, 1991.

21. Ahuja, A., A. Goswami, A. Adhikari and A.K. Ghosh : Evaluation of effects of Revital on Physical Performance in Sportsmen. The Indian Practitioner, August, vol.XLV, no. 8, 685-688, 1992.

22. A.K. Ghosh, A. Goswami and A. Ahuja : Evaluation of a sports specific training programme in badminton players. Ind. J. Med. Res., 98[B], 10, 232-236, 1993.

23. Ahuja, A. and A. Goswami : Injury Index : an indicator of epidemiology in sports trauma. NIS Scientific J., 16, 4, 3-8, 1993.

24. Ahuja, A., A. Goswami and R. Ahuja : Cardiac volume of elite Indian weight lifters. NIS Scientific J., 17, 1, 3-10, 1994.

25. Sadhukhan, A.K., A. Goswami, A. Kumar, and S. Gupta : Effect of sampling frequency on EMG power spectral characteristics. Electromyography and clinical neurophysiology (Belgium), 34, 1, 1-5, 1994.

26. Ahuja, A., A.K. Ghosh and A. Goswami : Heart rate and blood lactic acid changes in ameteur boxing. Ind. J. Med. Res. (communicated).

contd...7/-

Abstracts in National and International Symposia (contd) :

12. Goswami, A., A.K. Ghosh and D.N. Mathur : Lactate removal pattern in Indian sportsmen - A pilot study. XVI Annual Conference of Indian Association of Sports Medicine, New Delhi, July 28-29, 1990.

13. Goswami, A., A.K. Ghosh, A. Ahuja and D.N. Mathur : Movement and posture analysis in competitive sports. International Symposium on Ergonomics, Occupational Health, Safety and Environment. IIT, Bombay, Jan 2-6, 1991.

14. Ahuja, A. and A. Goswami : Sports injury - an occupational hazard. International Symposium on Ergonomics, Occupational Health, Safety and Environment. IIT, Bombay, Jan 2-6, 1991.

15. Ghosh, A.K., A.Ahuja, A. Goswami : Physiological demand of ameture boxing. International Symposium on Ergonomics, Occupational Health, safety and Environment. IIT, Bombay, Jan 2-6, 1991.

16. Bali, P.L. and A. Goswami : Study of the cobbler's work from Ergonomic point of view. International Symposium on Ergonomics, Occupational Health, Safety and Environment. IIT, Bombay, Jan 2-6, 1991.

17. Sadhukhan, A.K., A. Goswami, D.N. Mathur, A. Kumar, and S. Gupta Effect of sampling rate on surface EMG. Presented in 3rd Annual Conference of Physiological Society of India, Nov. 29-30, 1991, Bangalore, India.

18. S. Gupta, A. Goswami, A. Ahuja, D.N. Mathur, A. Adhikari and A.K. Sadhukhan : Removal pattern of lactic acid from blood after Supramaximal exercise. Presented in 3rd Annual Conference of Physiological Society of India, Nov. 29-30, 1991, Bangalore, India.

19. Goswami, A., A.K. Ghosh, A.Ahuja and T.P.S. Puri : Ergonomics aspects of tactics development in badminton. Abstract in 1st World Congress of Science and Racket Sports, July 10-13, 1992, Liverpool, England.

20. Goswami, A., S. Gupta, S. Mukhopadhyay and D.N. Mathur : An analysis of upper body muscle involvement in overhead forehand clear and smash in badminton. Abstract in 1st World Congress of Science and Racket Sports, July 10-13, 1992, Liverpool, England.

21. Goswami, A. : Application of anthropometry in mobility aid design - a developing country perspective. Accepted for Presentation in the session of Specialized Conference on Rehabilitation Ergonomics, Anthropometry of the Disabled, at 12th Congress of the International Ergonomics Association, to be held at Toronto, Canada, during August 15-19, 1994.

22. Mathur, D.N. and Goswami, A. : Blood lactate removal pattern after submaximal and supramaximal exercise. Communicated for Presentation at Commonwealth Sports Science Congress, to be held at Victoria, Canada 1994.

23. Mokha, S.S. and Goswami, A. : Heart rate variations of Indian weightlifters during Olympic lifts at different loads. Accepted for Oral presentation at International congress on Applied Research in Sports, to be held at Helsinki, Finland during August 1994.

2940567
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2937275
2523413 Res
Fax : 91-11-2932869
E Mail : MPS @ dipas. ernet. in

M. P. SINHA
SR. SCIENTIST-
SO to Director

Defence Institute of Physiology And allied Sciences (DIPAS)
Lucknow Road, Timarpur, Delhi - 110 054

भारत सरकार सेवाय

AIR MAIL

P/07/F/DIPAS

Dr. A. Wisner
Laboratoire
D'Ergonomie
4-1 RUE GAY-LUSSAC
75005, PARIS
FRANCE

30/12

सत्यमेव जयते
डा० डब्लू सेल्वामुर्ति
निदेशक
DR. W. SELVAMURTHY
Director

अ.स.प.स./D.O. No. P/0/4/F/DIPAS
भारत सरकार, रक्षा मंत्रालय
Govt. of India, Ministry of Defence
रक्षा अनुसंधान तथा विकास संगठन
Defence Research and Development Organisation
रक्षा शरीर क्रिया एवं सम्बद्ध विज्ञान संस्थान
Defence Institute of Physiology and Allied Sciences
लखनऊ रोड़, दिल्ली-110054/Lucknow Road, Delhi-110054.
दूरभाष/Telephone : 2512035, 2937275
तार/Telegram : DIPAS फैक्स/Fax : 91-11-2932869
इ मेल/E. Mail : wsm @ dipas. ernet. in.

दिनांक/DATED : 27 Dec' 96

Dear Dr. Wisner,

I am delighted to receive your letter of 19th Dec. 1996 and to know that you enjoyed your recent visit to India as well as your participation in the International conference on Ergonomics organised by us. Your presence in the conference was a source of inspiration for young ergonomics specialists and participants of the conference. I deeply appreciate your love for our country and our people. Your presentation covered the socio cultural perspectives of ergonomics with special focus on the problems of India.

I have conveyed your appreciation to Mr. Harinath who looked after you during your stay at Delhi. We like to nurture our friendship in the years to come.

Wishing you a VERY HAPPY AND PROSPEROUS NEW YEAR.

Yours Sincerely,

W. Selvam

SHILPA AKS-13

Prof. Wisner,

This greeting
brings a loving wish
for New Year
happiness with all
the very best of health
And a future of success.

SAMIT MITRA
CALCUTTA.

BY:
AIR MAIL
PAR AVION

Prof. A. Wisner,
Dept. of Work Physiology and Ergonomics
at C.N.A.M.

11 - RUE GAY. LUSSAC.

75005 PARIS.

FRANCE

from

Dr S.K. mitra.
Dept. of Physiology
University College of Science
92. A.P.C Road.
Cal - 700009.
India.

Date: 27th December, 1996.
Calcutta.

Prof A. Wisner,

Dear Sir,

Wish you a happy new year. I have the pleasure to inform you that I have been awarded Ph.D by the University of Calcutta. I could have contacted you earlier, but being a man with family, with various engagements, it is late for me. Hope you will feel it. Recently I have lost my father.

I shall ever remember you for your valuable criticism and suggestions for my research work "Physiological Study of workers engaged in Brick-field," that I completed inspite of many limitations. If any day I get chance, I will meet you.

Pray to God for your long life and prosperity.

with regards.

yours affectionately.
Samit Kumar Mitra.
Dept. of Physiology.
92. A.P.C Road.
Calcutta-700 009.

Address for communication
Dr. S. K. Mitra.
35, Chirimarshal.
P.O - Midnapore
Dt - Midnapore.
West Bengal.

Under Certificate of Posting.

BY AIR MAIL
PAR AVION

Prof. Dr. R. N. Sen
HB-260, Sector-3, Salt Lake City
Calcutta-700 091, INDIA

PROF. DR. ALAIN WISNER
EMERITUS PROFESSOR
LABORATOIRE D' ERGONOMIC
CONSERVATOIRE NATIONAL DES ARTS
41, RUE GAY LUSSAC
F - 75005 PARIS
FRANCE.

ISE-OH-SE
ISE-OH-SE

Second International Symposium on Ergonomics, Occupational Health, Safety and Environment (ISE-OH-SE)

November 25-28, 1996, New Delhi

ISE-OH-SE Secretariat :

- H.P. Chattopadhyay
  Chairman
- R. N. Sen
  Hony. Secretary General
- S. Das
  Treasurer

Indian Society of Ergonomics
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Salt Lake City
Calcutta-700 091, INDIA
Fax : 091-33-241-3222
Phone : 091-33-3341 90-3
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rnsen @cubmb. ernet. in

Local Organizing Committee

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  Chairman
- S. K. Mangal
  Co-Chairman
- D. Majumdar
  Secretary

Ref : ERG/RNS/ISE-OH-SE/96 Date 15th Dec.'96

Dear Prof. Dr. Wisner

We wish to express our heartiest thanks for your active participation, excellent and highly appreciated Keynote Address/Plenary Lecture/ Workshop deliberations/ Oral presentations at the 2nd ISE-OH-SE.

The interactive discussions were very much thought provoking on the questions after different presentations as well as during the breaks. We also appreciate your patience in sitting through the long sessions.

We would earnestly request you kindly to send me, if you have not yet done so, the camera ready copy of the full text of your Keynote Address/Workshop Deliberations /Plenary Lecture/Oral presentations for publication of the full Proceedings, after incorporating in your manuscript the portions you have discussed with the learned delegates regarding the approach to the subject of your presentation. Kindly send two or three important recommendations of your session for inclusion in the document to be send to the appropriate Ministries of the Govt. of India.

Despite the financial and other constraints and the inconveniences,all the participants, specially you,have so kindly helped us and contributed to the tremendous success of the deliberations at the Pre-Symposium Workshop and the Symposium for which I convey my sincere gratitude to you on behalf of the Indian Society of Ergonomics (ISE) and the Local Organisers (DIPAS).

With kindest personal regards,Season's Greetings,and Best Wishes for a Very Happy and Prosperous New Year,

Yours sincerely,

(Prof. Dr. R.N. Sen)
Hony. Secretary General,ISE-OH-SE.

Prof.Dr. Alain Wisner
Emeritus Professor
Laboratorie D' Ergonomie
Conservatoire National des Atrs
CNAM
41, Rue Gay Lussac
F - 75005 PARIS
FRANCE

Grams : NIOHEALTH
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Telex : (91) 121-6471 NIOH IN
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राष्ट्रीय व्यावसायिक स्वास्थ्य संस्थान
(Rashtriya Vyawasayik Swasthya Sansthan)

Meghani Nagar,
Ahmedabad-380 016.

NATIONAL INSTITUTE OF OCCUPATIONAL HEALTH
(INDIAN COUNCIL OF MEDICAL RESEARCH)

Our Ref No. ERG/3/3463 Date :

dated 13 January 1997

To

Prof Alan Wisner
Laboratoire D'Ergonomie
C.N.A.M.
41 Rue Gay-Lussac
75005 Paris
France

Respected Prof Wisner,

I was extremely delighted to receive your letter and the article - **Ergonomics and Economic Development.** For obvious reasons, as anticipated, I could not attend the Delhi meeting and missed the opportunity to see you. Your boundless admiration is my constant inspiration in continuing work in the field of Ergonomics towards greater social objectives. I have a strong belief that ergonomics is the problem solver in a developing economy. Your views on *anthropotechnology* have a great importance to modulate ergonomics strategies for social planning in the industrially emerging countries.

For the new ILO Encyclopaedia on Occupational Health and Safety, I have come out with an amended ergonomics work analysis checklist. When the new volume is available to you, kindly make it convenient to let me know your reactions on the approaches adopted in the work analsyis technique.

Looking forward to an opportunity to see you and share your vast experiences.

With warm personal regards,

Yours sincerely,

P.K. Nag

P.K. Nag

Enclos: an article

Greetings 1997

Pranab

N I O H Ahmedabad 380 016 India

24.01.97.

Dear Prof. Wisner,

First of all I wish you and your family a Happy New Year.

I am that "Bengali Young Man" whom you met at the Second International Symposium on Ergonomics, Occupational Health, Safety and Env. (2nd ISE-OH-SE) held in New Delhi.

Probably you might remember that I attended the Pre Symposium Workshop, and was in the same group with you on the day of Dr. Kogi's Workshop.

I am grateful to you for all your valuable advices during the 2nd ISE-OH-SE.

As you returned back to your Country before the Symposium ended, I think you'll be glad to know that my paper on Anti Mosquitoe Dress, was awarded the "Best Paper Award" of the Symposium.

Anyway how are you and your family? We are all keeping fine here at Calcutta.

I shall be extremely grateful if you could let me know about career opportunity in Ergonomics in diffrent foreign countries for Indian Ergonomists like us.

Well, its time to stop now, looking forward to hear from you soon.

With Regards

Yours Sincerely

Prabir. Mukhopadhyay

(PRABIR- MUKHOPADHYAY)

P.T.O. for my address!—

हवाई पत्र
Aerogramme

UNDER CERTIFICATE OF POSTING

6.50

To:—

PROF. A. WISNER,
LABORATOIRE D'ERGONOMIE
DU CONSERVATORIE NATIONAL DES
ARTS ET METIERS,
41, RUE-GAY LUSSAC 75005, PARIS
FRANCE

दूसरा मोड़
SECOND FOLD

भेजने वाले का नाम और पता:-
Sender's Name and Address:-

PRABIR MUKHOPADHYAY, M. SC. (CAL)
C/O. Mr. D. N. Mukherji
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P.O. Kamarhati, Calcutta-700058
Telephone- 553-4194

इस पत्र के अन्दर कुछ न रखिये
No Enclosures Allowed

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HB-260, Sector-3, Salt Lake City
Calcutta-700 091, INDIA

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(+91 - 33) ~~250 - 8896 / 8386~~
223-2084

ERGONOMICS LABORATORY
DEPARTMENT OF PHYSIOLOGY
UNIVERSITY OF CALCUTTA

From :
Prof. Dr. R. N. Sen, D.Sc. (Cal)
Hon. Professor ~~and Head~~, Ergonomics Laboratory
Please Reply to : HB - 260, Sector - 3, Salt Lake City,
Calcutta - 700 091, INDIA

Medicine
University College of [illegible]
INDIA

Ref. No. PHY/ERG/RNS/ CNAM/97

Dated 5th January 1997.

Dear Prof. Dr.Wisner,

Thank you very much indeed for your very kind and affectionate Fax letter dated 13th December 1996 received by me on 19th December, 1996. I was out of Calcutta for a Field Study and returned on 28th December 1996.

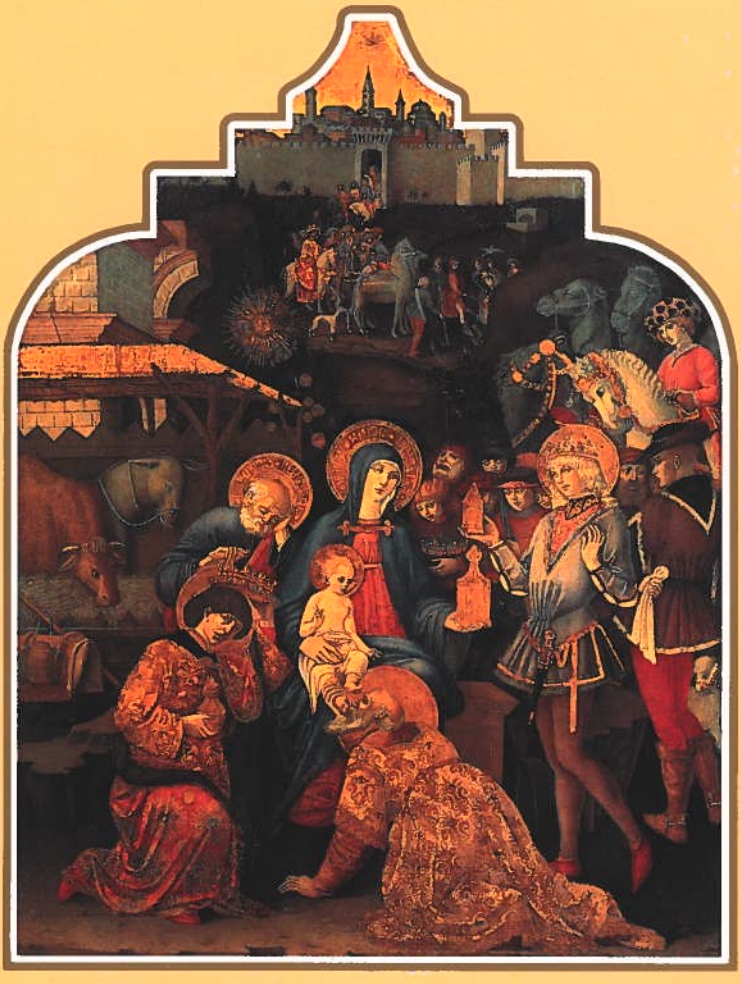
The whole of Second ISE-OH-SE with the Pre-Symposium Workshop was a grand success because of your august presence and your constant guidance and help with your valuable scientific contributions continuously all along the different sessions which encouraged us all. You gave "life" to the Congress and also for the cause of the development of Ergonomics in India and Industrially Developing Countries. We are all extremely grateful , beyond words.

I confirm that Dr. Pranab Kumar Nag is still working at the National Institute of Occupational Health, Meghaninagar, Ahmedabad 380 016 but Dr. Ashis Kumar Goswami has recently been transferred from Patiala to Gandhinagar (Gujarat). I would send you the detailed address of ~~Dr. Goswami and~~ Mr. C N Daftuar immediately on receipt of the same.

* I am also enclosing herewith a few photographs that I had taken at the Second ISE-OH-SE ~~and~~ as Memento.

With kindest personal regards,

Sincerely yours,



My present address is

A. GOSWAMI
SPORTS AUTHORITY OF INDIA
NETAJI SUBHAS WESTERN CENTRE
SECTOR-15
GANDHINAGAR - 382016
GUJARAT, INDIA

To
Prof. Wisner and family,

恭 Season's Greetings
賀 Meilleurs Voeux
新 Felices Fiestas
禧 Поздравляю

A. Goswami & family
Гоями.

Benvenuto di Giovanni (1436-1518) * Sienese School • Ecole Siennoise • Escuela sienesa * The Adoration of the Magi • L'adoration des Mages • Adoración de los Reyes Magos * Courtesy of National Gallery of Art, Washington DC, U.S.A.

For the well-being of the world's children * Pour le bien-être des enfants du monde * Por el bienestar de los niños del mundo * На благо всех детей мира * 造福世界儿童。

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United Nations Children's Fund

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PROF. ALAIN WISNER
LABORATOIRE D'ERGONOMIE
41, RUE GAY-LUSSAC
(CONSERVATOIRE NATIONAL DES
ARTS ET METIERS)
~~Paris~~ 75005 PARIS
FRANCE.

FROM:
A. GOSWAMI
SAI, NSWC
GANDHINAGAR
GUJARAT
INDIA.

AIR-MAIL

Prof. A. Wisner
Ergonomie Et Neurosciences Du Travail
Laboratoire D Ergonomie
41, Rue Gay - Lussac - 75005
PARIS FRANCE

C/O DAFTUAR

If undelivered please return to :
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3-Adhyapak Niwas, Pratap Gunj, Baroda-390 002.

Dr. C.N. Daftuar, D. Litt.
Head, Department of Psychology,
M.S. University, Baroda-390 002, INDIA.
Phone : (0265) 327409

Res. : 3, Adhyapak Niwas, Pratapgunj, Baroda-390002, INDIA.
Phone : (0265) 330713

Prof. A. Wisner
Ergonomic Et Neurosciences Du Travail
Laboratoire D Ergonomic
41, Rue Gay - Lussac - 75005
Paris
FRANCE

Dear Prof. Wisner,

My new years greetings.

Received your heart warming letter. It has given me excellent memory of our meeting at Oosterbeek. Your letter has infact given me extremely pleasant surprise of a person who met at such a long time back still remembers me with respect and warmth. Thank you very much. I deeply appreciate it.

The mention of Air fare is irrelevant. In fact, I have no idea of any organization called Indian Ergonomics Society. I had attended a meeting at N.I.D., Ahmedabad, a few years back where it was decided to organize such a society. I had suggested for such a formation as early as in 1970s to Prof. Sen, but at that time he was not enthusiastic about the idea.

The situation is, the Indian psychologists have not taken much interest in Ergonomics. Physiologists led by Dr. Sen, could build an excellent tradition. As a result, there are just a few ergonomic centers in India and they are managed by Physiologists. Psychologists are not involved. I tried to put a few of my students at NID but that did not work partly because of lack of career prospect for a psychologist in NID (these people left within a year or so) and partly because of different orientations followed by psychologists on the one hand and designers on the other in India. This is not to blame psychologists but it is a statement of history. Failure of Indian psychologists in the Ergonomics field is regretable but a fact. On retrospect, I may shoulder some of the blame. I did took a lead but could not sustain it beyond 1980 since I left Gaya and shifted to Baroda. My small team at Gaya broke because all three of us left for different places. Later, my interest shifted to OB and HRD fields. I became actively involved in these areas for teaching, research and consultancy. Since, then I have worked only occasionally in the field of Ergonomics.

Your letter has done a very unexpected thing. It has jolted me from inside out. I had perhaps never realized the importance of my works. Now, I am awakening and realizing why I remained restless for the last 15 years and always had a feeling that I have lost my base (ground). Yes, I am realizing, it was because of my getting away from Ergonomics. OB and HRD could never give me the same sense of accomplishment and achievement of anything new, original.

Contd... 2/-

Since, I received your letter, I am wondering - can I go back ? At the fag end of my job career (I am retiring from service in October 2000 A.D.) I am not very sure. Can you guide me ? May, helps me ?.

I have received your paper also. I can say that I have been able to glance through only. I shall write my detailed comments after a few weeks. But, on the cursory look, I can only say, please do not be guided on Indian psychology by Prof. Sinha's book. According to one South Indian (Madras) commentator, the book does not reflect Indian Psychology but only psychological works of Allahabad team where he lives and his friends (better word 'his group'). He is perhaps least qualified to talk about Ergonomics as of now. Adhisheshia's works are the classical works in India of course.

Any way, actually if I sit down to write about all these, even my own story, it will emerge into a paper itself. I don't want to tire you with that stuff.

It seems you have been visiting India quite often. Would you mind sharing your experiences. Do you think we can join hands on some project(s) ?

Once again, please accept my thanks, warm regards and greetings !

Please remain in touch.

Yours affectionately,

(C.N. DAFTUAR)

P. K. NAG

DOSSIER

ARTICLE

NAG

Dr. Pranab Kumar Nag
Ph.D., D.Sc.

Res:
1 Ashmita Apartments
6, Damobhai Colony
Vasna
Ahmedabad 380 007

To

dated 20 January 1992

Prof A. Wisner,
Laboratoire d'Ergonomie
Conservatoire National des Arts et Metiers
41 Rue Gay Lussac-F
75005 Paris
FRANCE

Respected Prof Wisner,

I am writing this letter to remind you for your book chapter. About 60% of our text matters have already been given to the publisher for final scrutiny. Because your views on technology development will be very useful reading for all concerned in organization design and development, I requested you to write a chapter on the technology transfer issues related to work design perspectives in an organization.

Please indicate in a telex note the approximate time for you to send the chapter. While I am fully aware that I am pressing too much on your time, personally I feel proud to get you as a contributor.

I request that you may send your write up in duplicate and if possible, a IBM PC compatible 5.25 inch floppy, preferably in Word Perfect (5.0).

Looking forward to the pleasure of hearing from you soon.

With warm personal regards and Greetings of the Season.

Yours sincerely,

P.K. Nag

(Pranab)

Office : National Institute of Occupational Health, Meghaninagar, Ahmedabad-380 016, India
Gram : NIOHEALTH Phone : 67351-2, Telex : 121-6471 NIOH IN

D. WISNER
41 rue Gay-Lussac
75.005 PARIS

12 Février 1992

Cher Henri,

Je vous fais parvenir ci joint un texte qui m'est demandé en version anglaise pour livre à paraître prochainement en Inde. Les corrections du texte français sont manuscrites. Sont-elles lisibles? Je compte vous faire parvenir les pages 21 bis, ter et quater ~~dactylographiées~~ dactylographiées dans un bref délai.

J'ai joint également une lettre de l'éditeur du livre le DINAG qui comme vous le verrez sollicite une version en cassette avec un certain nombre de spécifications. Vous est-il possible de les accepter?

Le texte est évidemment celui dont Madame REBIFFE vous a parlé au téléphone et qui est d'une relative urgence

Veuillez agréer avec mes remerciements l'expression de mes sentiments les meilleurs

MINISTERE DE L'EDUCATION NATIONALE
CONSERVATOIRE NATIONAL DES ARTS ET METIERS
ERGONOMIE ET NEUROSCIENCES DU TRAVAIL

Paris 27th February 1992

Dear Dr NAG,

Would you find under the same cover the typed text of the chapter you kindley asked me to write and 2 disketts each of them containing the chapter. I hope that both content and form will be acceptable for you.

I would be very happy to know if this parcel has reached you and what are the title and publisher of the book and, if possible the expected publication date. If there is any defect in the disketts, please write me for I have kept a copy of each

With my best regards

Truly yours

A. Wisner

A. WISNER

CNAM - LENET, 41 rue Gay-Lussac, 75005 Paris - Téls: (1) 43 54 18 27, (1) 43 54 18 34 - Fax : (1) 43 25 36 14

MINISTERE DE L'EDUCATION NATIONALE
CONSERVATOIRE NATIONAL DES ARTS ET METIERS
ERGONOMIE ET NEUROSCIENCES DU TRAVAIL

Paris 27th February 1.99.

Dear Dr NAG,

Would you find under the same cover the typed text of the chapter you kindley asked me to write and 2 disketts each of them containing the chapter. I hope that both content and form will be acceptable for you.

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MINISTERE DE L'EDUCATION NATIONALE
CONSERVATOIRE NATIONAL DES ARTS ET METIERS
ERGONOMIE ET NEUROSCIENCES DU TRAVAIL

Paris 27th February 1992

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With my best regards

Truly yours

A. Wisner

A. WISNER

CNAM - LENET, 41 rue Gay-Lussac, 75005 Paris - Téls: (1) 43 54 18 27, (1) 43 54 18 34 - Fax : (1) 43 25 36 14

THE NEW FACTORY IN INDUSTRIALLY DEVELOPING COUNTRIES

TRANSFER OR NEW DESIGN

INTRODUCTION: DILAPIDATED OPERATING MODE

The significant difficulties encountered by technology transfers to industrially developing countries (IDCs) now constitute a major ergonomic question. The negative effects noted are located in both the field of health and that of the economy.

Health is affected in various ways (Wisner, 1976a, 1977):

- the high rate of work accidents
- the sharp rise in work illnesses
- the appearance of considerable ailments linked to the disorders of industrial and urban development.

The economic success of the transfer is threatened by several major technical causes (Wisner, 1981, 1984a):

- the low operating rate of machines and, due to this, the insufficient production volume,
- the mediocre quality of the products which means they cannot be exported or even used in the country itself,
- the rapid deterioration of equipment leading to dilapidated operation.

It is obvious that these sinister triads are not encountered everywhere: Brazil is now the world's 10th industrial power and is a formidable rival in matters of engineering and the sale of arms to the Middle East. India is also one of the world's major industrial powers and produces small nuclear power stations since it is also a great intellectual country, including in the technological field. South-East Asia produces one third of the shoes sold in France. But it is noticeable that these are newly industrialized countries (NICs). There is a limited number of NICs and the favourable characteristics which have just been mentioned are far from being spread over these countries in a homogenous way, as shown by J. Abrahao's study of Brazilian distilleries (1986). In effect, in each country, for example in France (Negroni, 1986) and in Italy (Dell'Oro B. Pellegrini V., Roveda C., 1978) there are industrially developing regions (IDRs) which raise questions similar to those of IDCs.

The negative effects on health and the economy most often originate from the so-called dilapidated operating mode. In this situation, in particular it is the automated action and control systems which are altered or put out of action. The machines are used under circumstances that are very different from those envisaged by the manufacturer, maintenance is neglected and staff are often insufficient in number, qualification and experience.

In 1984, N. Sahbi showed the serious deterioration of the timbering and walling system in the Gafsa phosphate mines in Tunisia. Thousands of obsolete hydraulic pit props were littered around the maintenance workshop. N. Sahbi also described the main causes of this situation:

- the equipment was not suitable for phosphate mines since it was designed for coal mines,

- the lack of communication between departments and inside departments,

- the absolute predominance of concerns relative to the production volume compared to the cost of deterioration of the equipment,

- very poor development of the maintenance and repair activity.

He also noted the value and the insufficiency of the strategies used by workers to ensure production in the dilapidated operating mode.

Since 1984, research has been done in various companies to find the origin of the dilapidated operating mode (A. Kerbal, in Algeria, in 1987), the strategies used by workers to compensate for mediocre operation or non-use of automated action or control systems (M. Sagar, in Tunisia, 1987), the importance of the skills developed as such by the operators, the fact that managers were frequently unaware of this (A. Aw, in Senegal, 1987), and the increased workload which is not very well accepted (S. Khoulali, in Algeria, 1987).

This research showed that the dilapidated operating mode often led to an acceptable production volume but that the operator cannot replace automated action and measuring systems in order to ensure a good, stable level of quality. It is obvious that this situation of dilapidated operation also exists in industrialized countries, but the extension of dilapidated operation is a lot lower in these countries due to the strict social and economic constraints and the easier means of prevention (V. De Keyser, 1987).

THE ORIGIN OF THE DILAPIDATED MODE

In fact, there are many ways in which a complex system can operate in a dilapidated mode (Aw, A., 1987). There are also many origins. Two main explanations, which are very debatable, are usually put forward to explain the dilapidated operation of systems imported into IDCs: the mediocrity of staff and the dishonesty of transactions. First of all, we shall mention the multiple geographical type difficulties linked to the transfer.

Transfer problems linked to geography

More particularly, we shall consider four geographical factors: the poor quality of transport, installation in an underprivileged region, the effects of a hot climate and the instability of electricity supplies.

Poor quality transport

The studies carried out already are very explicit about a lot of important points. As such, J. Abrahao (1986) shows that a distillery installed in the industrial region of Ribeiro Preto (State of Sao Paulo in Brazil) near the factory which makes the distilling equipment for a lot of the distilleries in Brazil, can almost immediately obtain the spare parts necessary to cover any breakdown. But, on the other hand, a distillery located far from the factory, in the State of Goias, linked by poor quality roads, would have to wait several days for spare parts necessary to repair a breakdown or incorrect operation and this would be at a high price in view of the deterioration of trucks on the road.

This diversity of supply determines the different distilling strategies. Some manoeuvres, which are very efficient at reducing distilling incidents, are liable to damage parts which are cheap in Ribeiro Preto and expensive in Goias. Due to this, these manoeuvres are routine in the former case and prohibited in the latter case.

Installation in an underprivileged region

It is not always possible to choose the installation location. N. Sahbi (1984) studied the Gafsa phosphate mines in Tunisia, which are actually located at Metlaoui, 35 km from Gafsa, in a desert region which is polluted by the mine. Priority for water supplies, which are very rare, is given to production. Due to this, there are no gardens, swimming pools or even running water for part of the day.

Although the miners who originate from the region remain loyal to the mine - which is the only employer - the technicians, and especially the managers and their families, find this situation difficult to bear, all the more so since most of Tunisia's industry is located in coastal regions which are so attractive that they have become famous tourist areas. The average working period of a senior manager at Gafsa-Metlaoui is between one and two years. This is the same as in the paper mill studied by M. Sagar in Kasserine, an austere town located in the desert, but also in the middle of alfa-grass fields whose production supplies the factory.

The origin of the instability of senior managers is not due exclusively to the unpleasant character of the location, since similar conditions are found in the paper mill studied by A. Kerbal near Algiers or in the phosphate treatment company whose factories are located closed to Dakar.

If anything, perhaps mention could be made of the general dissatisfaction in these four companies as regards the abnormal operation of production systems, accompanied by sudden decisions made by a general management which is often located a considerable distance from the production location. All these types of behaviour are mainly due to the lack of knowledge of the serious difficulties encountered by managers and workers when they try to operate a system that is not properly suited to the installation location. It is these difficulties which are the subject of the anthropotechnological analysis. A description of the real situation should lead to technical and social solutions and, in particular, should reduce the turnover of senior managers.

The effects of the work situation, bad design and a hot climate

It is obvious that workers are also affected by the unfavourable effects of an incorrect installation. But these effects are more obvious for ergonomists and are described more often. However, an example which could be given is that of workers who load and unload crates of beer in the Bangui brewery described by K. Meckassoua (1985) in the Central African Republic.

For fully justifiable reasons of employment and technological simplification, the automated systems which are used in Europe for handling bottles were replaced by workers. But these men were not given the space necessary to work. This means that the production line is sometimes blocked and the work of the drawer is made more difficult. In addition, these men are tired when they arrive at the factory since they have walked around 5 km in the heat of an equatorial night. They have also slept badly due to their type of housing and the night life in a hot climate.

If the village of the workers was close to the factory and if the quality of housing was better, it would be easier to raise the quality of inspection of impurities in the bottles. In effect, this work is done by the same handling workers in order to alternate between a job that is physically hard and a sedentary job.

Unfortunately, due to fatigue and lack of sleep, they cannot maintain their concentration in a satisfactory way. They doze during the inspection phases and let impurities past.

Instability of electricity supplies

It is important to insist on the difficulties linked to the weakness of the country's infrastructure. Mention has already been made of the poor quality of the roads, the lack of water resources and their poor quality and the absence and poor quality of housing and public transport. A description could be given of the effects of the saturation of ports and the irregularity of waterways. But only an essential point will be underlined here: the instability of electricity supplies.

The investments necessary for electricity production are considerable as shown by the controversy over the EDF's debt in financing French nuclear power stations. In addition, the substantial variations in the price of energy, in particular that of oil, make it difficult and sometimes prevent the necessary purchases of fuel. Due to this, in many IDCs there is insufficient electricity production which often provokes load-shedding of electrical power in companies: sudden power cuts, which can sometimes take place several times a week, or sharp drops in voltage.

The sudden stoppage of electricity supplies can have a dramatic effect. In the port of Dakar, there is a large gantry crane whose load - which can be considerable - moves along a rail. If the electrical power is suddenly cut off when the load is being moved from the ship to the quayside and is in the last third of its travel, the inertia would crush the driver's cab through its weight. The driver knows this and confides his anxiety (A. Aw, 1987).

Other than the serious aspect of safety, voltage cut-offs and variations clearly upset automated systems in such a way that the manoeuvres necessary to return to normal operation are not always carried out.

Here again, the ergonomist who is used to limiting himself to the design of the technical system according to the man-machine system concept, is confused since spare parts are not available, the managers are incompetent, the workers are not very efficient and there is a threat of danger for reasons which are remote from the workstation or even the company. What is in question is the more extensive relation between design of the technical system and the new problems raised by the location of the installation in circumstances which are very different from those which the designer had in mind when he designed the technical system. In effect, the designer refers, in a relatively specific way, to his own historical and geographical conditions, unless his attention has been specifically drawn to the different characteristics of the future installation. In general, it can be considered that all machines are cultural, like any object produced by man.

Lots of examples could be given to show the importance of the geographical factors to be taken into consideration at the time of technology transfers: physical geography (earthquakes, typhoons, climatic variations, water regimes), geography of energy and transport, geography of health (endemic diseases) and industrial geography. Of course, the last point is essential. The concept of the industrial fabric (Boucher, 1983) is worth extending in such a way that, before a company is set up, it is possible to assess the advantages and disadvantages of the region and the location, to plan the reinforcements which are necessary - but expensive - and to make technological choices which are compatible with local realities. C. Rubio (1988) showed the joint importance of the social fabric and the industrial fabric in the Philippines.

The cognitive qualities of production staff

The mediocrity of staff turned out to be a poor explanation. The most blatant proof of the universal industrial capacity of the world's populations is perhaps given by the "anthropotechnological islands" (Wisner, 1977): factories, airports, banks or hotels which operate everywhere thanks to autochtonous staff with a remarkably uniform result in all countries.

However, more often this is the result of a deliberate and rather expensive policy of multinational companies. This policy is only justified economically in a limited number of specific cases. In addition, these companies, which operate according to an organization that is totally foreign to the country, contribute little or nothing to general industrial development.

Neri Dos Santos (1985) gave a very striking demonstration of the accurate reproduction of behaviour which can be obtained at the time of a transfer. In a normal working situation for workers in a metro control room, what differentiates the series of movements of the eyes (change of direction of the glance) is not the place of work, Paris or Rio de Janeiro, but the previous experience of the operator as a metro train driver. N. Dos Santos also points out that the differences in behaviour between Paris and Rio become considerable in the case of incidents due to the poor quality of the organization transfer, as will be seen further on.

The central question, that of the cognitive capacities of diverse peoples, was dealt with extensively by K. Meckassoua (1985). In particular, he showed the very remarkable control capacities of the central operator in a brewery in Bangui. This illiterate operator, raised in a village where farming on burn-baited land, pottery, hunting and fishing were practiced, was capable of constructing an operational representation that was more vast and more complex than the corresponding operator in France. The extent and the complexity of the representation were necessary in Bangui due to several flaws in the technical system: bottles of unequal dimensions imported from a neighbouring country, quality of the glue of labels which did not correspond to room temperature, manual emptying and filling of crates done in poor conditions and an imperfect visual check of impurities. This study underlined the fact that <u>more</u> cognitive capacities were needed for the proper operation of a system which had been rendered imperfect by the transfer conditions.

Furthermore, mention could be made of the work of Feuerstein (1980) who, in the space of two years, managed to turn miserable emigrants from the desert into efficient tractor drivers and repairers. As this author writes: "Apart from their specific content, different cultures provide an entire (mental) structure inside which the direct contact and the experience of objects and events can be organized, interpreted and understood. Recognition of the past and anticipation

of the future constitute cultural demands which enable the human system to adapt while evoking representative processes, making it possible to project oneself beyond the immediate universe of observation and direct action ... The language of instruction and the level of technological sophistication of a given culture are not determining for the efficiency of mediatized learning. Whether a child learns to build a canoe or a transistor radio, he should simultaneously learn to plan and use the appropriate strategies, to understand how the parts are linked to the assembly and to draw logical conclusions. In addition to the specific contents of each task or specialty, whether writing a computer program or tracking an animal, the information has to be organized, operations have to be performed and a whole set of complex activities has to be integrated with a system of rational and significant actions."

However, we shall see that the existence of these "universals" of human operational thought should be revealed to the person who possess them so that they can be applied to situations other than those where they were acquired. As we see it, this is the essential task when it comes to training adults.

The high level of abstraction and the operability of "Pensée Sauvage" (to use the expression of Levi-Strauss, 1962) has been the subject of impassioned debates for the last 100 years about Micronesiasn navigation (Hutchins, 1983). However, in the vast majority of cases, industrial staff come from a culture which produces ancient and refined techniques (Wisner, 1984c, 1985b).

These considerations may appear useless to those who are already convinced of the universality of human cognitive capacities. However, it should be underlined that only ethnological approaches (Goodnow, 1976), and now the cognitive psychology used in ergonomic work analysis, can highlight the intellectual capacities which are expressed in activities that are specific to a people. The old approach using tests applied to samples from two different populations is often disappointing since it appears that the "culture-free" test is a myth. The very situation of the test is the school type and, due to this, is found linked to the academic form of intelligence (Neisser, 1976) and not the "natural" form of intelligence which is used in daily professional life (Charlesworth, 1976).

In order to get an idea of the value of the test methods, one could read the interesting report by Lehlin, Lindzey and Spuhler in their book "Race difference in Intelligence" (1975). In fact, studies of this type often concern black and white populations in the United States where the existence of different cultures is combined and where there is natural deprivation of many blacks. This expression by Feurstein designates the result of an insufficient relation between the individual and the culture of his own ethnic group due to illness and misery as well as family and ethnic dislocation.

Thus, we don't consider that cognitive capacities differ considerably from one people to another. But, of course, this is not the same as regards abilities. The great effort made in the last 40 years to improve the quality of technology transfers is situated in the field of training (for example: Maguerez, 1966). Later on, we shall see what ergonomic work analysis can contribute in this field.

Dishonesty of transactions or cultural misunderstandings

The dishonesty of transactions appears obvious to certain analysts of the situation of the "Third World". Without denying a deliberate effort to deceive, which should be denounced, we would like to insist on the wrong representations of technology transfer possibilities. The errors are made by the seller as much as the buyer in terms of their cultural belonging. That is why we can speak of anthropotechnology for the field which concerns us.

As such, in a French paper mill, the automatic device used is monitored by a team of four workmen who are well trained through school and experience (Sagar, 1987). They can consult the supervisors or the engineers who are also stable and competent. In the Kasserine paper mill, there are only half the number of workmen while they have the serious task of replacing defective automated systems with non-verbal communications, in addition to the fact that there is a high turnover of supervisory staff, meaning that they are unable to acquire the necessary skills. Perhaps, in this mill, they have not understood the importance of the cognitive activity of workers and maybe they considered that the physical activity did not justify a higher number of staff. Whatever the reason, in this case the number of staff planned in the transferred organization was reduced to a dangerous level in Tunisia. This is probably the origin of certain operating defects in the system transferred.

In other cases, an important part of the system was not transferred. Most often, this concerned maintenance and repair. For example, although the operating documents of the Paris Metro were translated and transferred to the Rio de Janeiro Metro, this was not the case for maintenance and repair. It seems that the latter were not covered by a contract. It is true that in this field the seller does not always have knowledge that can be organized and encoded and the buyer is not always convinced of the need to follow recommendations whose cost might appear huge. Unfortunately, deterioration of complex systems is the price of the negligence of such an important part of operation.

However, the ergonomic analysis of cases where the factory only operates properly on the day it is inaugurated under test run conditions highlights some of the unfair aspects of transfers. In most cases where a factory or a production system is delivered on a "turnkey" basis, the contract actually states that this shall not be considered as performed until a demonstration has been given of the operating capacity of the system: this is the test run.

A team from the seller country is sent to the buyer country for the inauguration. It consists not only of staff who are experienced in operation and maintenance of the system but may also include staff from the design office who had the opportunity to make a few changes in the initial system. This team, which is of an exceptional quality, is capable of operating the system. But the day after they leave, nothing works any more because the local staff who replaced them is far from having the same theoretical and practical knowledge, even if they have been given serious training, which is not always the case. For the seller, the contract has been respected and for the buyer it hasn't. The origin of this serious misunderstanding is linked to an underestimation of the cognitive activities of monitoring and maintenance of the system, but also to the insufficient awareness of operating difficulties linked to the installation which was mentioned previously.

These facts explain why it is necessary to redesign the systems rather than transfer them to industrially developing countries.

A REDESIGN METHOD

The error common to both parties is that they fail to understand to what extent the technical system, the organization of work and the training programmes are marked by the representation which their initial designers have of the general situation of the future factory and the characteristics of the workers. This implicit representation often turns out to be very different from reality itself when designers and users come from the same country, or even the same company.

Daniellou (1986) rightfully consecrates a third of his new course on the ergonomics of automated production to a prior analysis of the situation. In the case of a technology transfer, this analysis is all the more necessary and should be extended. It should be a study basis for both parties, the buyer and the seller, a situation which is rarely the case nowadays.

A study of the "anthropotechnological islands" shows that a system which operates in the same way as in the country of origin can be built in a country which is very different from the designer country, although it would be very expensive. Most of the time, the massive investments and high operating costs which are necessary for construction of the isolate are impossible for financial reasons. Very often, they are not even envisaged through ignorance of or contempt for local difficulties. Some people consider that these difficulties, which will be studied later on, are redhibitory and blame industrialization, therefore the necessary industrial development. Yet, there are nations throughout the world which want to carry out this industriazation by managing to get the system they buy to work properly and by making profits so that they can invest again.

Naturally, the ideal situation would be to monitor, from the start, a complete industrial design process, like the one described by Daniellou. But the price of design and production of the equipment makes such a process impossible. This is all the more true in industrialized countries where every effort is made to incorporate elements from the old system in the new system. This is why a transfer of equipment can only be accepted on condition that it is redesigned. This is "Ergonomics in the project planning of a factory for export" (Wisner, 1976b), the main difficulty of which lies in the transfer of Organization (Wisner, 1984b, 1985a).

Among the stages of redesigning a factory for export, the following should be distinguished: an in-depth analysis of the situation of the buyer country, the characteristics of the importing company and the planned installation location, the study of similar existing situations, the projected reconstitution of probable future activities, the consequences which these prior stages have on the choice of technology and the modification proposals, the design of buildings, the supply of fluids and transport networks, the organization of work, training programmes, and the contractual conditions of the final inspection of delivery. Each of these themes is very important and deserves detailed explanations which cannot be given here.

The important questions relative to the choice of technologies, in particular those concerning the degree of complexity of checks and automated systems, raise a difficult problem in which an objective analysis is associated with political or even ideological considerations not to mention commercial and financial considerations. This combination is not easy to analyze but deserves to be. But, in any event, in the case of redesign of a technical system, which we prefer to a simple transfer, financial resources are most often limited, not only for construction of the original technical systems, but also for the studies necessary to make substantial changes in the arrangement. At the very most, perhaps the physical differences of the worker populations (body measurements, cardio-respiratory capacity, muscular strength, Wisner, 1987) should be taken into account sometimes.

Here, we shall limit ourselves to mentioning a few aspects of work analysis, training and the organization of work.

Analysis of work and extension of ergonomics

To come back to the very action of the ergonomist, of the anthropotechnologist, the objects on which it is possible to act must be specified.

For this reason, it is interesting to adopt the viewpoint recently developed by Pavard (1985) and by Pinsky and Theureau (1988).

According to Pavard, the main question for the ergonomist is that of the definition of pragmatic constraints. How can the technical system and work organization be designed so that the representation of the activity to be accomplished is clear enough to allow for efficient strategies at a reasonable cost for the operator. For Pinsky and Theureau, the insistence on the operator's activity is all the greater since only the course of action should be considered. This course of action, which includes both the action on commands and the intake of information and communications, should consider all the work activities in an exhaustive way. Thus, the multiplicity of activities linked to the prevention and correction of incidents, the replacement of defective technical checks, and the search for information or events which he didn't know, constitute the work of the operator just as much as the activity which is formally described and considered as essential.

Such a conception of ergonomics, and more particular that of work analysis, is precious when one studies systems that work in <u>dilapidated mode</u>, a situation that is very frequent in companies in IDCs. as we saw previously. This is why the anticipated reconstitution of probable future activities (Daniellou, 1986) should consider both the analysis of work on the system to be transferred, operating in a seller country, and the analysis of work on a similar system operating in the buyer country (Wisner, 1976b).

Training

For some time now, training programmes have been associated with technology transfers. Although some of them have been successful, many have failed and their authors have challenged the learning capacities of the future operators who were entrusted to them. We saw previously that these capacities cannot seriously be challenged. On the other hand, a training programme cannot be carried out without good knowledge of the cognitive tools produced by operator in their previous activities, in their own initial culture or in industrial-type activities. There is no operational "tabula rasa" in the mind of an adult.

So it is necessary to know not only the starting point but also the arrival point and the knowledge to be acquired. Yet this knowledge is often described in an incorrect way due to an arbitrary representation of the activities.

As we have just seen, the necessary skills can only be defined through an ergonomic analysis of the work in a company in the seller country using the transferred technology, and in a company in the buyer country using similar technology, as well as an analysis of work in the context of projected reconstitutions of the probable future activity.

However, an important question remains unanswered concerning the activities themselves: how far should realism be pushed in the preparation for management of difficulties and incidents linked to the probable deterioration of the system due to the local situation (electrical power cuts, lack of spare parts, poor quality raw materials). If dilapidated operation is considered as accidental, we shall continue to train operators how to control a fictitious system: work of adaptation that is difficult, long and dangerous has to be accomplished almost secretly by learner operators when they come out of a training centre and have to control the real technical system (Aw, 1987). If, on the other hand, we consider the dilapidated mode as inevitable, we should develop the training programme in relation to this situation. This is a brutal demonstration of the errors made at the time of technological choices. This contradiction cannot be tolerated by those who made the choices.

On the other hand, at the time of a change, it is sometimes possible to analyse the causes of deterioration, to drop certain automated systems, to restore others to full operation and to develop a realistic training programme in terms of the new situation.

In fact, this is a very abstract approach; the types of deterioration are various and variable although some are more frequent and stable than others. The solution to these contradictions is probably found in the considerable importance given to the treatment of situations of the partial defectiveness of various elements of the system along with training in the non-dilapidated situation.

We also think that the training methods intended to upgrade the operators from their initial knowledge to the necessary skills still suffer from excessive empiricism. Considerable theoretical work still remains to be done in the field of cognitive transformation in the adult.

For example, Feuerstein considers that the role of the teacher is essential in order to make the trainee pass from the stage of manipulating objects and to that of obtaining imaginary manipulations. He insists on the importance of the development of technical vocabulary: tools, parts and operations should be properly named. Inversely, Sinaïko (1979) shows that, in certain cultures, the fact of knowing the vocabulary and the name of objects and operations appears sufficient for trainees who neglect execution and the actual work.

However, there is a field where empirical findings and theoretical explanations are very coherent, that of linguistic difficulties. Sinaïko (1975) shows it is possible to achieve excellent performance on highly complex systems anywhere in the world if the oral instruction and technical documentation are fully understood by the operators. But this obvious condition has a very high cost: at least one year's training in the seller's language or very high-quality translation. Mediocre quality translations and insufficient linguistic teaching leave confusion or errors which can be formidable when it comes to controlling or maintaining technical systems. Replacement of the text by images is not always better since the switch from a two-dimension to a three-dimension representation takes place under conditions which vary from one culture to another.

Particular attention should be paid to the training of senior managers from the buyer country whose turnover, as we have seen previously, is much higher for multiple reasons. Many of these senior managers are engineers and specialists with an excellent international level, trained in the best foreign or national schools, but who have never had the chance to consider and acquire practices that are pertinent to the local situation. The only training documents they have are provided by the foreign company which sold the technical system. Most often, these documents are unsuitable, since they concern theoretical operation which is far removed from the real situation in the seller country.

The most serious point is that this theoretical training, like practical training acquired in their functions, is very volatile in view of the high turnover of managers. The expression of permanent training then takes on its full meaning. How can the essential technical documentation, often considered by the manager as his personal property, be conserved when the manager leaves? How can the content of his experience in the field be described? How can this knowledge be transmitted to successive waves of senior managers who will replace those who leave?

It could be surprising to see an ergonomist insisting on the role and training of senior managers while our analysis is often more concerned with the activities of operators. However, the study done by P. LANGA, in an oil mixing factory in Zaire, shows the extensive knowledge of the engineer who starts production and runs the factory (1992). The phenomenon of the turnover of senior managers in many companies in IDCs is part of the main difficulties encountered in the industrialization of these countries. Furthermore, this phenomenon is present in certain companies in industrialized countries and, here again, requires policies for the prevention and treatment of this real company disorder.

Redesign of work organization - The contingency theory

Recent progress has been achieved in two main fields in the redesign of technology which accompanies the transfer of equipment: one is that of the rebuilding-transformation of the equipment (Lund, 1986), comparable to the ergonomics of arrangement which we shall not study here; the other is that of the organization of work due to work in the field, but also thanks to the adoption by anthropotechnology of a theory of organization which is very close to its conceptions and requirements. In 1983, Robbins gave an excellent report on the contingency theory. This type of conception is also reported in a clear way by Hendrick (1987a and b).

Other authors have shown that the negative effects of repetitive work were just as formidable in an IDC as in industrialized countries. For example, Aktouf (1986a and b) compares the packing department of two breweries, one in Canada and one in Algeria, and, in both cases, notes the same suffering by workers. This suffering is also described by Meckassoua in packers in the Bangui brewery. Meckassoua also shows the great cognitive qualities of the drawer. These cognitive qualities, which are crushed by the so-called Taylorian organization, can be improved and also achieve the same excellent results in IDCs as in industrial countries if sociotechnical resources are used (Corlett, 1980; De (1984), and Khaleque (1984). However, sociotechnics itself should be used in a precise way if reliability is to be maintained and improved (Quintanilla, 1987).

However, we know that, on the one hand, these discussions concern mass production in particular and, on the other hand, the various organizational solutions are only effective in terms of concrete situations: this is the very basis of the contingency theory.

Contingency theory

J. Woodward (1986) was the first to show that the same organization was not equally suited to three types of industrial technology: unit, mass and process production. The three main dimensions of the organization structure are complexity, formalization and centralization. For J. Woodward, unit production needs a low level of complexity, formalization and centralization: this is the small-scale production workshop. This model operates very well in the sector of maintenance and servicing in both industrialized countries and in certain companies in IDCs. On the contrary, mass production requires a lot of complexity, formalization and centralization of the organization: this is the Taylorian formula which is upset by its unbearable character for workers and its economic and technical rigidity. Most of the work sociology debates over the last 20 years have concerned this production method. On the other hand, process industries only need a low level of complexity, formalization and centralization. For example, it is noticeable that in the case of the Brazilian distilleries mentioned by J. Abrahao (1985), the company which operates badly has a formalized and centralized organization, while, in companies which operate well, it is the opposite.

In the same direction as Woodward, Perrow (1967), who extended his field of observation to service activities, proposed other criteria for classifying technologies:

- task variability measured by the number of exceptions to usual operation,

- problem analysability depending on whether or not exceptions could be diagnosed by formal logic or by experience.

We consider that this classification by Perrow is a demonstration of the necessary character of a change of organization when the system operates in dilapidated mode in an IDC. In this case, the exception becomes the rule and the difficulty of the questions raised can only be solved by experience.

Unfortunately, in the most difficult periods in the life of a company, there is often a tendency to encourage the departure of the most competent operators. This was one of the remote causes of the Bhopal disaster. It is also a solution adopted where there are difficulties in the operation of chemical plants in Algeria and Senegal, with disastrous results.

Although the influence of technology on organization is essential, the role of the environment is just as considerable. If the term environment is taken as referring to the forces and institutions which can act on organization and on which organization has little influence, it is easier to understand why an organization designed in a country where the market is large and stable, where the government's industrial policy is consistent and where social relations only develop progressively, cannot be transferred to the profoundly different situation which often prevails in IDCs.

For Burns and Stalker (1961), rigid (mechanical) structures are suitable for stable situations due to their high degree of complexity, formalization and centralization. But when a switch is made to an unstable environment, flexible (organic) structures are better suited. In this case, horizontal communications are suitable. The role of experience and knowledge is then more important than the hierarchical authority. Information is exchanged more than directives. Responsibilities are defined more than tasks.

Perhaps these considerations give a better understanding of why the work organization of the Paris metro, transferred to the Rio metro in a remarkable way, was unable to maintain the rapid turn-round of trains for long because, although the operators had a comparable quality level, the same could not be said for many aspects of the company's environment. Along the same lines, M. Vidal (1985) shows that the same type of construction cannot be done as successfully in certain villages in Brazil as in France because, for example, the cement suppliers sometimes advance cement deliveries to suit themselves without worrying about any water-free storage facilities on the site.

For Lawrence and Lorch (1967), variations in the environment or, even more, their unexpected character, constitute critical elements. These authors classify company environments in terms of:

- the frequency of their changes
- the clarity of information about these changes
- the speed of information feedback about the response to changes.

They also underline the fact that each company activity has a different environment: for example, the environment of the commercial department is the market, that of production is the technical/economical development, and that of the research and development department is the scientific situation. There are many examples of companies in IDCs where the difficulties come from confusions between two levels. For example, what purpose is served by the gigantic gantry cranes in the ports of Dakar and Casablanca? Certainly, they are admirably suited to the scientific and technical situation. But, from the economic and commercial viewpoints, their capacities are obviously excessive.

Many automated systems are satisfactory from the scientific viewpoint and could achieve commercial success linked to quality if they were not unsuitable from the technical/economic viewpoint.

Although we have given some details of the effects of technology and the environment as determinants in the organization, the role of the other two rather obvious factors should not be minimized: the size of the company and its strategy.

In many IDCs, and more particularly in those which have adopted a determined planning policy, the creation of a company often corresponds more to strategic considerations than economic criteria. The aim of political leaders is to improve the technical level of the country by training nationals in new activities, creating a modern centre in an under-developed region and developing a national industry in steel or cement, even if there is a threat of excess worldwide production. Under these circumstances, the economic constraint, which is usually determining in modelling the organization, becomes weak or even absent.

However, the current condition of the debt of IDCs induce other strategies which are more linked to the financial situation, are replacing the previous ones and are affecting organization in a way that is sometimes dangerous. As such, the purchase of supplies, spare parts, documentation and the services of experts can suddenly stop with the risk of accentuating the deterioration of the technical system.

The size, the strategy, the technology and the environment thus appear as determinants of the organization. Yet there is a fifth element which disturbs these logical constructions: the struggle for power or a share of power.

Like Chila (1972) we can also see just one factor in the combination of the strategy and power; the existence of the struggle for power in organizations explains the conflicting character of the official or unacknowledged aims of various power groups in the system, and the inconsistences of the organization which are due to contradictory logics. Most often, those who want to keep power organize the company in a rigid, centralized and formal way, even if the type of technology and the environment suggest an opposed organization. It could be thought that, for example, one of the reasons for the rigid structure which is wrongly adopted in the Goias distillery described by J. Abrahao (1986) corresponds to a anxious concern by the management to keep control of the system, despite its poor level of skill. It uses the power control strategies described by Crozier and Fridberg (1977) concerning knowledge, control of rules, control of communications and information and relations between the system and its environment.

National contingencies

It maybe considered surprising that an aspect of the environment which is considered essential by lots of authors is not mentioned here: the buyer country and its culture. There are a lot of texts which tend to class countries according to their major characteristics, as done, for example, by Hofstede (1980). This author uses four criteria: hierarchical distance, control of uncertainty, individualism and masculinity-femininity, thanks to which he can place in the same category countries that are actually very different. But this factorial point of view cannot indicate the complexity of each country. Each national culture can be considered from a point of view that is more respectful and more correct scientifically, by adopting a structuralist approach. This approach is presently showing its strength in Europe where the former features of nations are reappearing after the fall of regimes which tried to wipe out cultural identities.

The structuralist point of view of cultural identity is expressed in particular by monographs, like that of Morishima (1982), entitled in English "Why has Japan succeeded" and in French "Capitalism and confucianism, Japanese ethics and Western technology." The great interest of this book is perhaps the comparative evolution of Confucianism in China, Korea and Japan. From the same viewpoint, it is interesting to read the work of Mathieu (1987) on Indian industrial culture. This text is entitled "Taylor et Peters au pays d'Arjuna". A lot of texts on national identity are far from having the value of those of Morishima and Mathieu and only leading to reinforcement of prejudices.

Some authors take opposite stances, denying any national influence on the organization of companies, or at least think that other contingent elements are sufficient to describe the environment. This is the position of Hickson et coll. (1974) in a text entitled "The culture free context of organization structure."

Authors, who are just as convinced as Mansfield and Poole (1981) of the importance of national characteristics, do not reach empirical results which confirm their hypothesis. There is perhaps a two-fold reason for this. First of all, national theories implicitly assume that a country has a homogenous culture. This is not likely to be the case with the major industrial powers whose vast territory, complex history and economic diversity do not lead to such homogeneity. To be convinced of this, just think of Brazil, China, India and the United States. Another vital element which rules out simple classification is the distance between formal and informal organization. For example, the study by Mansfield and Zeffane (1983) which compared the organization of companies in Africa, France and Great Britain, only takes into account the characteristics declared in the companies' answers to questionnaires and takes these answers as the description of real situations. Yet in countries with a Latin culture where there are usually a lot of hierarchical levels, decisions are often made at a very low level subject to approval which is given automatically at a higher level due to the very widespread practice of delegation of power. Inversely, the apparent decentralization of power in Anglo-American organizations does not necessarily lead to greater freedom at the lower levels of the hierarchy which are subject to the powerful unwritten constraint of the standard practices of the company and society as a whole.

The relation between organizations and the countries where new technical systems are installed is a very difficult subject whose stage of progress is still not enough to establish any rules. The wisest approach is probably to analyze each case with the confirmed tools of the contingency theory.

CONCLUSION

Our hope is that a better ergonomic analysis of work, combined with better knowledge of the factors determining technical choices and organization, will enable company directors to see more clearly, to dominate their fears and to choose production, training and organization methods that are more in line with the demands of reality in IDCs. There is no successful passive transfer. Only a review of the design of the technical system will make the most of the immense latent cognitive capacities of company workers and give them a job that is worthy of them. This is the price that has to be paid for the economic success of IDCs and the safety, health and living standard of the workers in these countries.

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LA NOUVELLE USINE
EN PAYS EN DEVELOPPEMENT INDUSTRIEL

TRANSFERT OU NOUVELLE CONCEPTION

INTRODUCTION : LE MODE DEGRADE DE FONCTIONNEMENT

Les difficultés majeures que rencontre le transfert de technologie vers les pays en développement industriel constituent maintenant une grande question de l'ergonomie. Les effets négatifs que l'on constate se situent à la fois dans le domaine de la santé et dans celui de l'économie.

La santé est atteinte de diverses façons (Wisner, 1976a, 1977)

- fréquence élevée des accidents du travail
- extension importante des maladies du travail
- apparition de troubles considérables liés aux maladies du développement industriel et urbain.

Le succès économique du transfert est menacé par plusieurs grandes causes techniques (Wisner, 1981, 1984a)

- faible taux d'engagement des machines, et de ce fait, volume insuffisant de production
- qualité médiocre des produits qui les rend inexportables, voire inutilisables dans le pays même
- détérioration rapide du matériel qui conduit à un fonctionnement en mode dégradé.

Il est bien évident que cette sinistre triade ne se rencontre pas partout : le Brésil est maintenant la 8e puissance industrielle du monde, et est un rival redouté en matière d'ingéniérie et de vente d'armes au Moyen Orient, l'Inde est la 10e puissance industrielle mondiale et va vendre de petites centrales nucléaires, l'Asie du Sud-Est fabrique le 1/3 des chaussures vendues en France. Mais on remarquera qu'il s'agit, dans ces cas, de N.P.I. (Nouveaux Pays Industriels). Les N.P.I. existent en nombre limité et les caractéristiques favorables que l'on vient d'évoquer sont loin d'être générales dans ces pays, comme le montre l'étude de J.Abrahao dans les distilleries brésiliennes (1986). En fait, dans chaque pays, par exemple en France (Negroni, 1986) et en Italie (Dell'Oro B., Pellegrini V., Roveda C., 1978), il existe des R.D.I. (Régions en Développement Industriel) qui posent des questions analogues à celles des P.V.D.I.

Les effets négatifs sur la santé et l'économie ont le plus souvent pour origine la situation de fonctionnement dite en mode dégradé. Dans cette situation, ce sont surtout les systèmes d'automatisme et de régulation qui sont altérés, voire hors circuits, les machines sont employées dans des conditions assez différentes de celles qui avaient été prévues par le constructeur, la maintenance est négligée, le personnel est souvent insuffisant en nombre, en qualification, en expérience.

Dès 1984, N. Sahbi montrait la grande dégradation du système de soutènement dans les mines de phosphates de Gafsa. Des milliers d'étançons hydrauliques hors d'usage jonchaient les environs de l'atelier de maintenance. N. Sahbi décrivait également les causes principales de cet état de fait :

- matériel inadapté aux mines de phosphate car destiné aux mines de charbon
- absence de communications entre services et à l'intérieur des services
- prédominance absolue des préoccupations relatives au volume de production par rapport au coût de la dégradation du matériel
- très faible développement de l'activité de maintenance et de réparation.

Il notait également la valeur, mais aussi l'insuffisance des stratégies employées par les travailleurs pour assurer la production au sein du mode dégradé.

Depuis 1984, des recherches ont été réalisées dans des entreprises diverses sur la genèse du mode dégradé (A. Kerbal, 1987), les stratégies des travailleurs pour assurer le fonctionnement médiocre ou nul des systèmes de contrôle et des automatismes (M. Sagar, 1987), l'importance des compétences ainsi développées par les opérateurs et leur méconnaissance fréquente par l'encadrement (A. Aw, 1987), la charge de travail accrue et plus ou moins bien acceptée (S. Khoulali, 1987).

Bien qu'aucune de ces recherches ne soit achevée, on peut déjà estimer que le mode dégradé permet souvent un volume acceptable de production, mais que l'opérateur ne peut suppléer les systèmes de mesure et les automatismes pour assurer un bon niveau stable de qualité. Il est bien évident que cette situation de dégradation existe aussi dans les pays industriels, mais l'extension du mode dégradé y est beaucoup plus faible du fait des contraintes sociales et économiques rigoureuses et des moyens plus aisés de prévention (V. De Keyser, 1987).

LES ORIGINES DU MODE DEGRADE DE FONCTIONNEMENT

Les dégradations possibles du fonctionnement d'un dispositif complexe sont en réalité multiples (Aw A., 1987). Les origines sont également nombreuses. Deux explications principales sont habituellement mises en avant pour expliquer le fonctionnement en mode dégradé des systèmes importés en P.V.D.I. : la médiocrité du personnel et la malhonneteté des transactions. Nous évoquerons en outre les difficultés multiples d'ordre géographique liées au transfert.

Problèmes de transfert liés à la géographie

On considérera plus particulièrement quatre facteurs géographiques : la mauvaise qualité des transports, l'implantation dans une région défavorisée, les effets du climat chaud, l'instabilité de la distribution d'électricité.

Mauvaise qualité des transports

Les études déjà réalisées sont très explicites sur beaucoup de points importants. Ainsi, J. Abrahao (1986) montre qu'une distillerie installée dans la région industrielle de Ribeiro Preto (Etat de Sao Paulo au Brésil) au voisinage de l'usine fabriquant le matériel de la distillation pour une partie importante des distilleries brésiliennes, dispose des pièces détachées nécessaires en cas de panne de façon quasi immédiate. Au contraire, une distillerie installée loin de l'usine, dans l'Etat de Goïas, et reliée à elle par de mauvaises routes, ne dispose des pièces détachées nécessaires en cas de panne ou de mauvais fonctionnement que dans un délai de plusieurs jours et à un prix élevé du fait de la détérioration des camions sur la route.

Cette diversité d'approvisionnement détermine des stratégies de distillation différentes. Certaines manoeuvres très efficaces pour réduire les incidents de distillation risques de détériorer des pièces peu coûteuses à Ribeiro Preto et chères dans le Goïas. Ces manoeuvres sont, de ce fait, courantes dans le premier cas, et interdites dans le second.

Implantation dans une région défavorisée

Il n'est pas toujours possible de choisir l'implantation. N. Sahbi (1984) a étudié les mines de phosphates tunisiennes de Gafsa situées en réalité à Metlaoui à 35 km de Gafsa, dans une région désertique et polluée par la mine. L'eau, très rare, est utilisée en priorité pour la production. Il n'y a, de ce fait, ni jardins, ni piscines, ni même d'eau courante pendant une partie de la journée.

Si les mineurs originaires de la région restent fidèles à la mine, seul employeur, les techniciens et surtout les cadres et leurs familles supportent mal cette situation pénible, d'autant plus que l'essentiel de la Tunisie industrielle est située dans les régions côtières, si agréables qu'elles sont devenues de célèbres lieux touristiques. La durée moyenne de travail des cadres supérieurs à Gafsa-Metlaoui se situe entre 1 et 2 ans. Il en est de même dans la papeterie qu'étudie M. Sagar à Kasserine, agglomération austère située dans le désert, mais aussi au milieu des champs d'alfa dont la production alimente l'usine.

L'origine de l'instabilité des cadres supérieurs ne se situe pas exclusivement dans le caractère déplaisant du lieu de séjour, puisqu'on trouve des faits analogues dans la papeterie qu'étudie A. Kerbal près d'Alger ou à la compagnie de traitement des phosphates dont les usines se situent au voisinage de Dakar.

Peut-être pourrait-on, d'ailleurs, évoquer plutôt l'insatisfaction générale dans ces 4 entreprises à propos des dysfonctionnements de la production qui s'accompagnent de décisions brutales des directions générales situées souvent assez loin du lieu de production. L'ensemble de ces comportements s'explique principalement par la méconnaissance des graves difficultés que rencontrent cadres et ouvriers pour faire fonctionner un dispositif qui ne convient pas bien au lieu d'implantation. Ces difficultés font précisément l'objet de l'analyse anthropotechnologique. La description du réel devrait permettre de trouver des solutions techniques et sociales, et en particulier, de réduire la rotation des cadres supérieurs.

Les effets du climat chaud

Il est bien évident que les travailleurs sont également atteints par les effets défavorables de mauvaises implantations, mais ces effets sont à la fois plus évidents pour les ergonomistes, et plus souvent décrits. On peut toutefois donner comme exemple celui des décaisseurs et encaisseurs de bouteilles de bière dans la brasserie de Bangui décrite par K. Meckassoua (1985).

Pour des raisons tout à fait légitimes d'emploi et de simplification technologique, les systèmes automatiques utilisés en Europe pour la manutention des bouteilles ont été remplacés par des ouvriers. Mais on n'a pas été jusqu'à donner à ces hommes l'espace nécessaire pour travailler, ce qui bloque parfois la chaîne de production et rend plus difficile le travail du soutireur. Par ailleurs, ces hommes arrivent fatigués à l'usine, car ils ont dû parcourir à pied une distance d'environ 5 km dans la chaleur de la nuit équatoriale. Ils ont également mal dormi du fait de leur type de logement et de la vie nocturne en climat chaud.

Si le village des travailleurs et l'usine étaient voisins, et la qualité du logement meilleure, on obtiendrait plus aisément une bonne qualité de l'inspection des

impuretés dans les bouteilles. En effet, ce travail est confié aux mêmes ouvriers manutentionnaires afin d'alterner un travail physique pénible et un travail assis. Malheureusement, la fatigue et le manque de sommeil ne leur permettent pas de maintenir leur attention de façon acceptable.

L'instabilité de la distribution d'électricité

Il est également important d'insister sur les difficultés liées à la faiblesse de l'infrastructure du pays. On a déjà évoqué la mauvaise qualité des routes, l'insuffisance et la mauvaise qualité des ressources en eau, l'absence et la mauvaise qualité des logements et des transports en commun. On pourrait décrire les effets de la saturation des ports, de l'irrégularité des voies navigables. On insistera ici seulement sur un point essentiel : l'instabilité de l'alimentation électrique.

Les investissements nécessaires pour la production électrique sont considérables comme en témoignent les controverses sur les dettes d'E.D.F. pour financer les centrales nucléaires françaises. En outre, les variations considérables du prix de l'énergie, et en particulier du pétrole, rendent difficiles et empêchent parfois les achats nécessaires de combustibles. Dans beaucoup de P.V.D.I., il y a, de ce fait, une production d'électricité insuffisante qui provoque trop souvent des délestages de courant électrique dans les entreprises : arrêts brutaux qui se produisent parfois plusieurs fois par semaine ou baisses plus ou moins fortes de la tension du courant.

L'arrêt brutal de l'alimentation électrique peut avoir un effet dramatique. Dans le port de Dakar, il existe un grand portique dont la charge, qui peut être considérable, se déplace sur un rail. Si l'arrêt instantané de l'alimentation électrique se produit quand la charge se déplace du bateau vers le quai et se trouve au dernier tiers de sa course, l'inertie provoquera l'écrasement de la cabine du conducteur par la charge. Le conducteur le sait et confie son anxiété (A. Aw, 1987).

En dehors du grave aspect de la sécurité, l'arrêt et les variations de tension provoquent le dérèglement des automatismes de façon plus ou moins nette, de telle sorte que les manoeuvres de remise en marche normale ne sont pas toujours réalisées.

Là encore, l'ergonomiste habitué à se limiter ici à la conception du dispositif technique selon le concept du système homme-machine, se trouve dérouté car les pièces détachées ne sont pas disponibles, les cadres ne sont pas compétents, les ouvriers sont peu efficaces, le danger menace pour des raisons situées bien loin du poste de travail et même de l'entreprise. Ce qui est en cause, c'est la relation plus large entre la conception du dispositif technique et les problèmes nouveaux posés par l'implantation de l'installation dans des conditions très éloignées de celles que le concepteur avait en tête quand il dessinait le dispositif technique. En effet, de façon plus ou moins explicite, le concepteur se réfère à des conditions historiques et géographiques qui sont les siennes, à moins que son attention n'ait été fortement attirée vers les caractéristiques différentes de la future implantation.

On pourrait multiplier les exemples qui montrent l'importance des facteurs géographiques à considérer à l'occasion du transfert de technologie : géographie physique (séismes, typhons, variations climatiques, régime des eaux), géographie de l'énergie et des transports, géographie de la santé (endémies), géographie industrielle. Le dernier point est naturellement essentiel. La notion de tissu industriel (Boucher, 1983) mérite d'être approfondie de telle sorte qu'avant l'installation d'une entreprise, il soit possible d'avoir une évaluation des forces et des faiblesses de la région et du lieu, de prévoir les renforcements nécessaires - mais coûteux -, de faire des choix technologiques compatibles avec les réalités locales.

Les qualités cognitives du personnel de production

La médiocrité du personnel s'est révélée une mauvaise explication. La preuve la plus éclatante de la capacité industrielle universelle des populations du monde est peut-être donnée par les "îles anthropotechnologiques" (Wisner, 1977) : usines, aéroports, banques ou hôtels qui fonctionnent partout grâce à un personnel autochtone avec un résultat remarquablement uniforme dans

tous les pays. Toutefois, il s'agit le plus souvent du résultat d'une politique délibérée et assez coûteuse des firmes multinationales. Cette politique ne se justifie économiquement que dans des cas précis, en nombre limité. Par ailleurs, ces entreprises qui fonctionnent selon une organisation totalement étrangère au pays, contribuent peu ou pas au développement industriel général.

Neri Dos Santos (1985) donne une démonstration très frappante de la fidélité de la reproduction du comportement qui peut être obtenue lors du transfert. En situation normale de travail des opérateurs de salle de contrôle de métro, ce qui différencie les séries de mouvements des yeux (changements de direction du regard), ce n'est pas le lieu de travail, Paris ou Rio-de-Janeiro, mais l'expérience antérieure de l'opérateur comme conducteur de rame de métro. N. Dos Santos signale, par ailleurs, que les différences de comportement entre Paris et Rio deviennent importantes en cas d'incidents, du fait de la mauvaise qualité du transfert d'organisation, comme on le verra plus loin.

La question centrale, celle des capacités cognitives des divers peuples, a été traitée de façon approfondie par K. Meckassoua (1985). Il montre, en particulier, les capacités tout à fait remarquables de régulation de l'opérateur central d'une brasserie à Bangui. Cet opérateur analphabète, élevé dans un village où l'on pratique la culture sur brûlis, la poterie, la chasse et la pêche, est capable de construire une représentation opératoire plus vaste et plus complexe que l'opérateur correspondant en France. L'étendue et la complexité de la représentation sont nécessaires à Bangui du fait de plusieurs imperfections du dispositif technique : bouteilles de dimensions inégales importées d'un pays voisin, qualité de colle des étiquettes ne correspondant pas à la température ambiante, encaissage et décaissage manuels réalisés dans de mauvaises conditions, contrôle visuel imparfait des impuretés. Cette étude souligne le fait qu'il faut plus de capacités cognitives pour faire fonctionner correctement un dispositif rendu imparfait par les conditions de transfert.

On peut encore citer les travaux de Feuerstein (1980) qui réussit en 2 ans à transformer les émigrés misérables venant du désert en conducteurs et réparateurs de tracteurs efficaces. Comme l'écrit cet auteur : "Mis à part leurs contenus spécifiques, les cultures différentes fournissent toutes une structure [mentale] à l'intérieur de laquelle le contact direct et l'expérience des objets et des événements peuvent être organisés, interprétés et

compris. La reconnaissance du passé et l'anticipation de l'avenir constituent des exigences culturelles qui permettent à l'organisme humain de s'adapter en évoquant des processus représentatifs, le rendant capable de se projeter au-delà de l'univers immédiat de l'observation et de l'action directe ... Le langage de l'instruction et le niveau de sophistication technologique d'une culture donnée, ne sont pas déterminants pour l'efficacité de l'apprentissage médiatisé. Qu'un enfant apprenne à construire un canoë ou un poste transistor, il devra simultanément apprendre à planifier, à utiliser des stratégies appropriées, à comprendre comment les parties sont reliées à l'ensemble, à tirer des conclusions logiques. En plus des contenus spécifiques de chaque tâche ou spécialité, que ce soit d'écrire un programme d'ordinateur ou de pister un animal, l'information doit être organisée, les opérations exécutées et tout un ensemble d'activités complexes doit être intégré dans un système d'actions rationnelles et significatives".

Nous verrons cependant que l'existence de ces "universaux" de la pensée humaine opératoire doivent être révélés à la personne qui les possèdent, pour qu'ils puissent être appliqués à d'autres situations que celles où ils ont été acquis. C'est, à nos yeux, la tâche essentielle de la formation des adultes.

Le niveau élevé de l'abstraction et de l'opérationnalité de la "Pensée Sauvage" (pour reprendre l'expression de C. Levi-Strauss, 1962) fait l'objet de débats passionnés depuis 100 ans à propos de la navigation des micronésiens (Schück, 1982, Hutchins, 1983). Toutefois, dans l'immense majorité des cas, le personnel industriel est issu d'une culture productrice de techniques anciennes et raffinées (Wisner, 1984c, 1985b).

Ces considérations peuvent paraître inutiles à ceux qui sont déjà convaincus de l'universalité des capacités cognitives humaines. Toutefois, on doit souligner que seules les approches ethnologiques (Goodnow, 1976), et maintenant la psychologie cognitive utilisée dans l'analyse ergonomique du travail, peuvent mettre en évidence des capacités intellectuelles s'exprimant dans des activités spécifiques à un peuple. L'approche ancienne par des tests administrés à des échantillons de deux populations différentes est souvent décevante, car il semble que le test "culture-free" soit un mythe. La situation même de test est de type scolaire, et se trouve de ce fait reliée à l'Intelligence Académique (Neisser, 1976) et non à l'Intelligence Naturelle, qui est mise en jeu dans la vie quotidienne (Charlesworth, 1976).

Pour se faire une opinion sur la valeur de la méthode des tests, on peut lire par exemple le bilan intéressant de Lehlin, Lindzey et Spuhler dans leur livre "Race différence in Intelligence" (1975). En fait, les études de ce type portent souvent sur les populations noires et blanches des Etats-Unis où se combinent l'existence de cultures différentes, et du côté de beaucoup de Noirs la présence d'une déprivation culturelle. Cette expression de Feurstein désigne le résultat d'une relation insuffisante de l'individu à la culture de son propre groupe ethnique du fait de la maladie, de la misère et de l'isolement.

Ainsi, il ne nous semble pas que les capacités cognitives diffèrent sensiblement d'un peuple à l'autre. Il n'en est pas de même naturellement en ce qui concerne les compétences. Le grand effort réalisé depuis 40 ans pour améliorer la qualité du transfert de technologie se situe d'ailleurs dans le domaine de la formation (par exemple : Maguerez, 1966). On verra plus loin ce que l'analyse ergonomique du travail peut apporter dans ce domaine.

Malhonnêteté des transactions ou malentendus culturels ?

La malhonnêteté des transactions paraît évidente à certains analystes de la situation du "Tiers Monde". Sans nier une volonté délibérée de tromper qu'il peut être utile de dénoncer, nous voudrions insister sur les représentations erronées des possibilités du transfert de technologie. Les erreurs se trouvent chez le vendeur comme chez l'acheteur en fonction de leurs appartenances culturelles. C'est pourquoi on peut parler d'anthropotechnologie pour le domaine qui nous occupe.

C'est ainsi que, dans une papeterie française, le dispositif automatique qui est employé est surveillé par une équipe de 4 ouvriers bien formés par l'école et l'expérience (Sagar, 1987). Ils peuvent consulter la maîtrise ou les ingénieurs qui eux aussi sont stables et compétents. Dans la papeterie de Kasserine, il y a 2 fois moins d'ouvriers, alors qu'ils ont la lourde tâche de suppléer les automatismes défaillants par des communications non verbales, et que leur encadrement souffre d'une importante rotation qui ne leur permet pas d'acquérir les compétences nécessaires. Peut-être, dans cette usine, n'a-t-on pas compris l'importance de l'activité cognitive des ouvriers et a-t-on jugé que leur activité physique ne justifiait pas un effectif plus élevé. Quoi qu'il en soit, dans ce cas, les effectifs

prévus dans l'organisation transférée ont été réduits en Tunisie de façon dangereuse, ce qui est probablement à l'origine de certains défauts de fonctionnement du dispositif transféré.

Dans d'autres cas, il n'y a pas eu transfert d'une partie importante du dispositif; il s'agit le plus souvent de la maintenance et de la réparation. Si, par exemple, les documents de fonctionnement du métro de Paris ont été traduits et transférés au métro de Rio-de-Janeiro, il n'en est pas de même pour la maintenance et la réparation. Il semble que ces dernières n'aient en aucune façon fait l'objet d'un marché. Il est vrai que dans ce domaine, le vendeur ne dispose pas toujours de savoirs organisés et codifiés et l'acheteur n'est pas toujours convaincu de la nécessité de suivre des recommandations dont le coût peut lui paraître démesuré. Malheureusement, la dégradation des dispositifs complexes est le prix de la négligence d'une partie si importante de l'exploitation.

Toutefois, l'analyse ergonomique des cas où l'usine ne marche que le jour de son inauguration dans les conditions du test-run permet d'éclairer certains aspects déloyaux du transfert. Dans la plupart des cas où une usine ou un système de production sont livrés "clés en mains", il est, en effet, prévu par contrat que ce dernier ne sera considéré comme exécuté qu'après la démonstration de la capacité de fonctionnement du dispositif : c'est le test-run.

Une équipe du pays vendeur est déplacée dans le pays acheteur pour l'inauguration. Elle comprend du personnel expérimenté aussi bien pour le fonctionnement que pour la maintenance du dispositif ainsi qu'éventuellement les membres du bureau d'études qui ont eu l'occasion de faire quelques modifications du dispositif initial. Cette équipe d'une qualité exceptionnelle, est en état de faire marcher le dispositif, mais le lendemain de son départ rien ne va plus, car le personnel local qui la remplace est loin d'avoir les mêmes savoirs théoriques et pratiques, même si elle a bénéficié d'une formation sérieuse, ce qui n'est pas toujours le cas. Pour le vendeur, le contrat est rempli, pour l'acheteur il ne l'est pas. L'origine de ce grave malentendu est liée à la sous-estimation des activités cognitives de contrôle et de maintenance du dispositif, des compétences des opérateurs, mais aussi à la prise de conscience insuffisante des difficultés de fonctionnement liées à l'implantation que l'on a considérées plus haut.

Ces faits expliquent pourquoi il est nécessaire de reconcevoir les dispositifs plutôt que de les transférer dans les pays en développement industriel.

UNE METHODE DE RECONCEPTION

L'erreur commune des deux parties est de méconnaître à quel point le dispositif technique, l'organisation du travail, les programmes de formation sont marqués par la représentation qu'ont les concepteurs initiaux de la situation générale de la future usine et des caractéristiques des travailleurs. Cette représentation implicite se révèle souvent très différente de la réalité quand concepteurs et utilisateurs sont du même pays, voire de la même entreprise.

Daniellou (1986) consacre à juste titre, le tiers de son nouveau cours d'ergonomie de la productique à l'analyse préalable de la situation. Dans le cas du transfert de technologie, cette analyse est encore plus nécessaire et demande à être approfondie. Elle doit servir de base à la réflexion des deux parties, vendeur et acheteur, ce qui, actuellement, est bien rarement le cas.

L'étude des "îles anthropotechnologiques" montre qu'il est possible de créer, à grands frais, dans un pays très différent du pays concepteur, un système qui fonctionnera comme dans le pays d'origine. La plupart du temps, les investissements massifs et les frais de fonctionnement élevés nécessaires à la construction de l'isolat sont impossibles pour des raisons financières. Ils ne sont souvent même pas envisagés par ignorance ou mépris des difficultés locales. Certains considèrent d'ailleurs que ces difficultés, que l'on étudiera plus loin, sont rédhibitoires et condamnent l'industrialisation, donc le développement économique nécessaire. Or, partout dans le monde, les nations veulent réaliser cette industrialisation en obtenant un bon fonctionnement du dispositif acheté et en faisant des bénéfices pour investir à nouveau.

L'idéal serait naturellement de suivre depuis le début un processus complet de conception comme celui que décrit Daniellou. En fait, les prix de conception et de fabrication du matériel rendent impossible un tel procédé. Cela est d'ailleurs vrai dans les pays industrialisés où l'on cherche à utiliser au maximum les éléments anciens dans le dispositif nouveau. C'est la raison pour laquelle on ne peut qu'admettre le transfert de matériel

à condition, toutefois, qu'il se situe dans un processus de reconception. C'est "L'ergonomie dans l'ingéniérie d'une usine à l'exportation" (Wisner, 1976b) dont la principale difficulté réside dans le transfert d'Organisation (Wisner, 1984b, 1985a).

Parmi les étapes du processus de reconception de l'usine à l'exportation, on peut distinguer l'analyse approfondie de la situation du pays acheteur, des caractéristiques de l'entreprise importatrice et de l'implantation envisagée, l'étude de situations analogues existantes, la reconstitution prévisionnelle des activités futures probables, les conséquences de ces étapes préalables sur le choix de la technologie et les propositions de modifications, la conception des bâtiments, des adductions de fluides et des réseaux de transports, l'organisation du travail, les programmes de formation, les modalités contractuelles du contrôle final de livraison. Chacun de ces thèmes est très important et mériterait des développements qui n'ont pas leur place ici.

Les importantes questions relatives au choix des technologies, et en particulier au degré de complexité des contrôles et des automatismes, soulèvent un problème difficile où l'analyse objective est rejointe par des considérations politiques, voire idéologiques aussi bien que commerciales et financières. Cette conjonction n'est pas aisée à analyser mais mérite de l'être. Mais de toutes façon, à l'occasion de la reconception du dispositif technique que nous suggérons plutôt qu'un simple transfert, les moyens financiers sont le plus souvent limités, non seulement pour faire construire des dispositifs techniques originaux, mais aussi pour faire les études nécessaires pour en changer profondément l'agencement. Tout au plus pourra-t-on parfois tenir compte des différences physiques des populations de travailleurs (dimensions corporelles, capacité cardio-respiratoire, force musculaire, Wisner, 1987).

On se bornera ici à évoquer quelques aspects de l'analyse du travail, de la formation et de l'organisation du travail.

L'analyse du travail et l'extension de l'ergonomie

Pour revenir à l'action proprement dite de l'ergonomiste, de l'anthropotechnologue, il est nécessaire de préciser les objets sur lesquels une action est possible.

A cet effet, il est intéressant d'adopter le point de vue récemment développé par Pavard (1985) et par Pinsky et Theureau (1988).

Selon Pavard, la question essentielle pour l'ergonomiste est celle de la définition des contraintes pragtiques. Comment concevoir le dispositif technique comme l'organisation du travail pour que la représentation de l'activité à accomplir soit assez claire pour permettre des stratégies efficaces à un coût raisonnable pour l'opérateur. Pour Pinsky et Theureau, l'insistance sur l'activité de l'opérateur est encore plus grande puisque c'est le cours d'action qui doit être seul considéré. Ce cours d'action qui comporte aussi bien l'action sur les commandes que les prises d'information et les communications, doit considérer de façon exhaustive la totalité des activités de travail. Ainsi, la multiplicité des activités liées à la prévention et à la correction des incidents, à la suppléance des contrôles techniques défaillants, à la recherche d'informations ou d'événements dont il n'a pas eu connaissance, constituent le travail de l'opérateur tout autant que l'activité formellement décrite et considérée comme essentielle.

Une telle conception de l'ergonomie, et plus particulièrement de l'analyse du travail, est précieuse quand on étudie des systèmes fonctionnant en mode dégradé ce qui est très fréquent dans les entreprises de PVDI comme on l'a vu plus haut. C'est la raison pour laquelle la reconstitution prévisionnelle des activités futures probables (Daniellou, 1986) doit considérer aussi bien l'analyse du travail sur le dispositif à transférer fonctionnant dans le pays vendeur et l'analyse du travail d'un système analogue fonctionnant dans le pays acheteur (Wisner, 1976b).

Formation

Il y a longtemps que les programmes de formation sont adjoints au transfert de technologie. Si certains d'entre eux ont réussi, beaucoup ont échoué et leurs auteurs ont parfois mis en cause les capacités d'apprentissage des futurs opérateurs qui leur étaient confiés. On a vu plus haut que ces capacités ne peuvent être sérieusement contestées. Par contre, un pro- gramme de formation ne peut aboutir sans une bonne connaissance des outils cognitifs produits par les opérateurs dans leurs activités antérieures, dans leur propre culture initiale ou dans des activités de type industriel. Il n'y a pas de "tabula rasa" opératoire dans l'esprit d'un adulte. Il

faut donc connaître le point de départ mais aussi le point d'arrivée, les compétences à acquérir. Or, ces dernières font souvent l'objet d'une description erronée issue d'une représentation arbitraire des activités.

Comme on vient de le voir, seule l'analyse ergonomique du travail dans une entreprise du pays vendeur utilisant la technologie transférée et dans une entreprise du pays acheteur utilisant une technologie voisine, une analyse du travail dans le cadre de reconstitutions prévisionnelles de l'activité future probable, peuvent permettre de cerner les compétences nécessaires.

Toutefois, une grande question reste ouverte en ce qui concerne les activités elles-mêmes : jusqu'où doit-on pousser le réalisme dans la préparation à la gestion des difficultés et des incidents liés à la dégradation probable du dispositif, du fait de la situation locale (pannes d'électricité, manque de pièces détachées, matières premières de mauvaise qualité). Si l'on considère le mode dégradé comme accidentel, on va continuer à former les opérateurs au contrôle d'un système fictif : un travail d'adaptation difficile, long et dangereux devra être accompli presque clandestinement par les opérateurs débutants (Aw, 1987). Si, au contraire, on considère le mode dégradé comme inéluctable, on doit construire le programme de formation en relation avec cette situation. Il s'agit là d'une démonstration brutale des erreurs faites au moment des choix de technologie. Ce démenti peut ne pas être toléré par ceux qui ont fait les choix.

Parfois, au contraire, à l'occasion d'un changement, il est possible d'analyser les causes de la dégradation, de renoncer à certains automatismes, de restituer à d'autres leur plein fonctionnement et de construire un programme de formation réaliste par rapport à la nouvelle situation.

En fait, il s'agit d'une approche bien abstraite; les types de dégradation sont divers et variables quoique certains soient plus fréquents et plus stables que d'autres. La solution de ces contradictions se situe probablement dans l'attribution d'une place importante au traitement des situations de défaillance partielle de divers éléments du système à côté d'une formation à la situation non dégradée.

Il nous semble également que les méthodes pédagogiques destinées à faire passer les opérateurs de leurs savoirs initiaux aux compétences nécessaires souffrent encore actuellement d'un empirisme excessif. Un important

travail théorique reste à faire dans le domaine de la transformation cognitive chez l'adulte. Par exemple, Feuerstein estime que le rôle de l'enseignant est essentiel pour faire dépasser au stagiaire le stade manipulatoire des objets et obtenir des manipulations imaginaire Il insiste sur l'importance du développement du vocabulaire technique : il faut nommer correctement les outils, les pièces et les opérations. A l'opposé, Sinaïko (1979) montre que, dans certaines cultures, le fait de connaître le vocabulaire, le nom des objets et des opérations paraît suffisant aux stagiaires qui négligent la réalisation et le travail effectif.

Il existe toutefois un domaine où les constatations empiriques et les explications théoriques sont très cohérentes, c'est celui des difficultés linguistiques. Sinaïko (1975) montre que l'on peut obtenir partout dans le monde d'excellentes performances sur des dispositifs de haute complexité si l'enseignement oral et la documentation technique sont pleinement compris des opérateurs. Mais cette condition évidente est d'un coût très élevé : au moins un an d'apprentissage de la langue du vendeur ou traduction de très haute qualité. Les traductions de qualité médiocre, les enseignements linguistiques insuffisants laissent subsister des confusions ou des erreurs qui peuvent être redoutables dans la conduite ou la maintenance des dispositifs techniques. Le remplacement du texte par des images n'est pas toujours meilleur car le passage d'une représentation de trois à deux dimensions se fait selon des modalités différentes d'une culture à l'autre.

Une attention particulière devrait être accordée à la formation des cadres supérieurs dont on a vu plus haut la rotation très rapide et ses causes multiples. Beaucoup de ces cadres supérieurs sont des ingénieurs et des spécialistes d'excellent niveau international, formés dans les meilleures écoles étrangères ou nationales, mais auxquels on n'a jamais donné l'occasion de réfléchir et d'acquérir des pratiques pertinentes à la situation locale. Les seuls documents de formation dont ils disposent sont fournis par l'entreprise étrangère qui a vendu le dispositif technique. Ces documents sont le plus souvent inadaptés, car ils sont relatifs à un fonctionnement théorique déjà éloigné du réel dans le pays vendeur.

Le plus grave est que cette formation théorique, comme la formation pratique acquise dans leurs fonctions sont très volatiles, compte tenu de la rotation rapide des cadres. L'expression de formation permanente prend alors tout son sens. Comment conserver la documentation technique essentielle souvent considérée comme propriété personnelle par le cadre qui s'en va ? Comment fixer le

contenu de l'expérience sur le terrain ? Comment transmettre ces savoirs aux vagues successives de cadres supérieurs qui viennent remplacer ceux qui s'en vont ?

On pourrait s'étonner de voir un ergonomiste insister sur le rôle et la formation des cadres supérieurs, alors que notre analyse porte plus volontiers sur les activités des opérateurs. Le phénomène de la rotation des cadres supérieurs dans beaucoup d'entreprises des P.V.D.I. fait partie des difficultés principales que rencontre l'industrialisation de ces pays. Ce phénomène n'est d'ailleurs pas absent dans certaines entreprises des pays industrialisés et appelle, là aussi, des politiques de prévention et de traitement de cette véritable maladie de l'entreprise.

Reconception de l'organisation du travail. La théorie de la contingence

La reconception de la technologie qui accompagne le transfert matériel a progressé récemment dans deux domaines essentiels : l'un est celui de la réfection-transformation du matériel (Lund, 1986) qui se rapproche de l'ergonomie de l'aménagement et que nous n'étudierons pas ici, l'autre est celui de l'organisation du travail du fait de travaux sur le terrain, mais aussi grâce à l'adoption par l'anthropotechnologie d'une théorie de l'organisation très proche de ses conceptions et de ses besoins. Robbins fait en 1983 un excellent exposé de la théorie de la contingence. Ce type de conception est aussi exposé de façon claire par Hendrick (1987a et b).

D'autres auteurs ont montré que les effets négatifs du travail répétitif étaient aussi redoutables dans un P.V.D.I. que dans les pays industrialisés.
Par exemple, Aktouf (1986a et b) compare le département d'encaissage de deux brasseries au Canada et en Algérie et constate dans les deux cas la même souffrance des travailleurs. Cette souffrance est décrite aussi par Meckassoua chez les encaisseurs de la brasserie de Bangui en même temps qu'il montre les hautes qualités cognitives du soutireur. Ces qualités cognitives, écrasées par l'organisation dite taylorienne, peuvent s'épanouir et donner les mêmes excellents résultats en P.V.D.I. qu'ici si l'on utilise les ressources de la sociotechnique (Corlett, 1980; De (1984), Khaleque (1984). Cependant, la sociotechnique elle-même doit être utilisée de façon précise s'il faut maintenir et améliorer la fiabilité (Quintanilla, 1987).

Toutefois, on sait bien que, d'une part, ces discussions portent surtout sur la production de masse et que, d'autre part, les diverses solutions organisationnelles ne sont bonnes qu'en fonction des situations concrètes : c'est la base même de la théorie de la contingence.

J. Woodward (1965) a montré la première que la même organisation ne convenait pas de la même façon à trois types de technologie industrielle : à la pièce, en série, en processus continu. Les trois dimensions principales de la structure d'organisation sont la complexité, la formalisation et la centralisation. Pour J. Woodward, la production à la pièce appelle un niveau faible de complexité, de formalisation et de centralisation : c'est l'atelier artisanal. Ce modèle fonctionne très bien dans le secteur de la maintenance et de l'entretien, aussi bien ici que dans certaines entreprises de P.V.D.I.. La production en série comporte au contraire un fort appel à la complexité, à la formalisation et à la centralisation de l'organisation : c'est la formule taylorienne qui est ébranlée par son caractère insupportable pour les travailleurs, sa rigidité économique et technique. La plupart des débats de sociologie du travail ont porté sur ce mode de production depuis 20 ans. Les industries de processus continu demandent au contraire un bas niveau de complexité, formalisation et de centralisation. On peut observer, par exemple, que dans le cas des distilleries brésiliennes de J. Abrahao (1985), l'entreprise qui marche mal a une organisation formalisée et centralisée alors que c'est le contraire dans l'entreprise qui marche bien.

Dans la même direction que Woodward, Perrow (1967), élargissant son champ d'observation aux activités tertiaires, propose d'autres critères de classement des technologies :

- la variabilité des tâches mesurée par le nombre d'exceptions au fonctionnement habituel

- l'analysabilité des tâches selon que les exceptions peuvent être diagnostiquées par une logique formelle ou par l'expérience.

Cette classification de Perrow nous paraît être la démonstration du caractère nécessaire du changement d'organisation, quand le système fonctionne en mode dégradé dans un P.V.D.I.. Dans ce dernier cas, l'exception devient la règle et la difficulté des questions posées ne peut que faire appel à l'expérience. Malheureusement,

dans les périodes les plus difficiles de la vie d'une entreprise, on a souvent tendance à favoriser le départ des opérateurs les plus compétents. C'est l'une des causes moyennes de la catastrophe de Bhopal. C'est aussi la solution adoptée devant les difficultés de fonctionnement d'ateliers chimiques en Algérie et au Sénégal avec des résultats désastreux.

Si l'influence de la technologie sur l'organisation est essentielle, le rôle de l'environnement n'est pas moins considérable. Si l'on entend par environnement les forces et les institutions qui peuvent agir sur l'organisation et sur lesquelles l'organisation a peu d'influence, on comprendra plus aisément pourquoi une organisation conçue dans un pays où le marché est large et stable, où la politique industrielle du gouvernement est cohérente et où les rapports sociaux ne subissent que des évolutions progressives, ne saurait être transférée dans la situation profondément différente qui prévaut souvent en P.V.D.I.

Pour Burns et Stalker (1961), les structures rigides (mécaniques) conviennent aux situations stables par leur haut degré de complexité, de formalisation et de centralisation. Si l'on passe à un environnement instable, les structures souples (organiques) conviennent mieux. Dans ce dernier cas, ce sont les communications horizontales qui conviennent. Le rôle de l'expérience et du savoir est plus important alors que l'autorité hiérarchique. On échange plus d'informations que de directives. On définit plus les responsabilités que les tâches.

Peut-être ces considérations permettent-elles de comprendre pourquoi l'organisation du travail du métro de Paris, remarquablement transférée au métro de Rio, n'a pas permis de maintenir longtemps à Rio la rotation rapide des trains car, si les opérateurs étaient de qualité comparable, il n'en était pas de même, sous beaucoup d'aspects, pour l'environnement de l'entreprise. Dans le même ordre d'idée, M. Vidal (1985) montre que le même type de construction n'est pas réalisé avec le même succès dans certaines villes du Brésil qu'en France, parce que, par exemple, les fournisseurs de ciment avancent parfois les livraisons de ciment à leur convenance sans se préoccuper des capacités de stockage à l'abri de l'eau que l'on peut trouver sur le chantier.

Pour Lawrence et Lorch (1967), les variations de l'environnement, mais plus encore leur caractère inat-

tendu constituent un élément critique. Ces auteurs classent les environnements d'entreprise en fonction

- de la fréquence de leurs changements
- de la clarté de l'information sur ces changements
- de la rapidité du retour d'information sur la réponse aux changements

Ils soulignent également que chaque activité de l'entreprise a un environnement différent : par exemple, l'environnement du service commercial est le marché, celui de la production est l'évolution technico-économique et celui du service de recherches et développement est la conjoncture scientifique. On peut trouver de très nombreux exemples d'entreprises de P.V.D.I. où les difficultés viennent de confusions entre les deux plans. A quoi servent, par exemple, les gigantesques portiques des ports de Dakar et Casablanca ? Certes, ils correspondent admirablement à la conjoncture scientifique et technique. Mais, sur le plan économique et commercial, leurs capacités sont évidemment excessives.

Beaucoup d'automatismes sont satisfaisants scientifiquement et permettraient d'obtenir un succès commercial lié à la qualité, s'ils n'étaient inadaptés sur le plan technico-économique ?

Si nous avons quelque peu détaillé les effets de la technologie et de l'environnement comme déterminants de l'organisation, il ne faut pas, pour autant, minimiser le rôle de deux autres facteurs assez évidents : la taille de l'entreprise et sa stratégie.

Dans beaucoup de P.V.D.I., et plus particulièrement dans ceux qui ont adopté une politique de planification déterminée, la création d'une entreprise correspond souvent plus à des considérations stratégiques qu'économiques. Il s'agit d'accroître le niveau technique du pays en formant des nationaux à des activités nouvelles, de constituer un centre moderne dans une région arriérée, de créer une industrie nationale dans l'acier ou le ciment, même si la surproduction mondiale menace. Dans ces conditions, la contrainte économique qui est habituellement déterminante pour modeler l'organisation devient faible ou absente.

Toutefois, les conditions actuelles de la dette des P.V.D.I. voient d'autres stratégies, plus liées à l'économie, se substituer aux précédentes et agir sur l'organisation de façon parfois dangereuse. C'est ainsi que l'achat de fournitures, de pièces détachées, de documentation, les services d'experts peuvent subitement cesser au risque d'une accentuation de la dégradation du système technique.

La taille, la stratégie, la technologie et l'environnement apparaissent ainsi comme les déterminants de l'organisation. Pourtant, un cinquième élément vient perturber ces constructions logiques, c'est la lutte pour le pouvoir ou une partie du pouvoir.

On peut aussi, comme le fait Chila (1972) ne voir qu'un seul facteur dans la combinaison de la stratégie et du pouvoir; l'existence de la lutte pour le pouvoir au sein des organisations explique le caractère conflictuel des buts officiels ou inavoués des divers groupes de pouvoir dans le système, et les incohérences de l'organisation qui répondent à des logiques contradictoires. Le plus souvent, ceux qui tiennent à conserver le pouvoir organisent l'entreprise de façon rigide, centralisée, formalisée, même si la nature de la technologie et de l'environnement suggère une organisation opposée. On peut penser par exemple qu'une des raisons de la structure rigide adoptée à tort dans la distillerie du Goïas décrite par J. Abrahao (1986) correspond au souci angoissé de la directrice de garder le contrôle du système, malgré sa faible compétence. Elle utilise les stratégies de contrôle du pouvoir décrites par Crozier et Fridberg (1977) et portant sur le savoir, le contrôle des règles, le contrôle des communications et des informations, et les relations entre le système et son environnement.

Conclusion

Notre espoir est qu'une meilleure analyse ergonomique du travail, jointe à une meilleure connaissance des facteurs déterminants les choix techniques et d'organisation, permettent aux dirigeants d'entreprises de voir plus clair, de dominer leurs craintes et de choisir des modes de production, de formation et d'organisation plus conformes aux exigences de la réalité en P.V.D.I.
Il n'existe pas de transfert passif réussi. Seule la reprise de la conception du dispositif technique permet d'utiliser au mieux les immenses capacités cognitives latentes des travailleurs de l'entreprise, et de leur proposer un travail qui en soit digne. La réussite économique des P.V.D.I., la sécurité, la santé et le niveau de vie des travailleurs de ces pays est à ce prix.

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dated 22.7.77

To

Dr. A. Wisner
Physiologie du Travail Ergomonie
Département des Sciences de l'Homme au travail
41, Rue Gay-Lussac,
Paris 75005.

Dear Dr. Wisner,

I had received your earlier letters and your report on my thesis. I was waitting to write you, for the date when Calcutta University declares my Ph.D.(Sc) award. I got my degree this month.

It is true that every body is craving to be appreciated by others. But the level of appreciation I have received from you and other examineers are beyond my expections. I know that there are lot of inadequacies of evidences and I'll try subsequently to support those hypothesis. I'll expect your suggestions from time to time depending upon your convenience.

You have mentioned about a project in Philipine; is it an international body working for a particular objective? Recently I had been in Calcutta and I've learnt from my teacher that an ILO collaborative project is going to be started in our laboratory in Calcutta for two months. A gentleman, expert in Clothing Physiology (I could not recall that name) is coming to participate on the project.

Nexttime when you are expecting to visit India? I am eagerly waitting to see you in Ahmedabad.

With warm personal regards,

Yours sincerely

(P. K. Nag)

From:

Pranab Kumar Nag
National Institute of Occupational Health
Meghaninagar
Ahmedabad 380 016,
India.

IMP. 28.

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1, STRAND ROAD,

CALCUTTA, 9th August 1977.

Dr. A. Wisner,
Prof. of Physiologie, 4/ Rue Gay-Lussac
75.005 Paris, France.

Dear Sir/Madam,

Under instructions received from University of Calcutta Senate House, Calcutta beig the amt of your remuneration for examining thesis.

I beg to enclose Sola of Exchange of a Draft No. 23/14 for F.Fr. 50.80

Please acknowledge receipt.

Yours faithfully,

Encl: 1 Draft.

for Superintendent.

28 Avril 1977

Monsieur le Docteur P. K. Nag
Occupational Physiology Div.
National Institute of Occupational
Health - Meghaninagar
AHMEDABAD 340 016 (Indes)

Cher ami,

Je vous prie de trouver ci-joint le rapport que j'ai rédigé à l'intention de l'Université de Calcutta, au sujet de votre thèse si remarquable. Je pense tout ce qui est écrit. Il est en effet extrêmement rare de voir une recherche où la sûreté scientifique est jointe à une excellente connaissance de la réalité.

Je suis persuadé que vous allez être déclaré Docteur avec la meilleure mention. J'espère que cela sera pour vous un encouragement pour vos travaux actuels, et que beaucoup d'autres travaux suivront celui-ci.

Je continue à avoir des activités pour le PIACT en Asie du Sud-Est et je ne désespère pas de vous visiter un jour à Ahmedabad.

Veuillez agréer, cher ami, avec mes félicitations, l'expression de mes sentiments très cordiaux.

A. Wisner

5 Janvier 1977

Monsieur le Docteur Pranab Kumar Nag
Occupational Physiology Div.
National Institute of Occupational Health
Meghaninagar
Ahmedabad 340 016 (Indes)

Cher ami,

Je réponds avec un grand retard à votre lettre du mois d'Août, car j'ai eu beaucoup de difficultés personnelles et professionnelles dans la deuxième partie de 1976. La plupart des problèmes sont maintenant résolus.

Je me réjouis très vivement de savoir que vous avez entrepris des recherches en physiologie du travail au sein de l'Institut National de Médecine du Travail de Ahmedabad, et je suis persuadé que votre valeur personnelle et les conseils du Docteur Sen vous permettront de développer un centre de recherche ergonomique bien en relation avec les nécessités de votre pays.

Je serais heureux de recevoir un exemplaire de votre thèse, si cela est possible, et aussi de mieux connaître votre projet d'analyse spectrale des variables physiologiques.

Je note aussi votre projet relatif au salaire minimum des travailleurs, mais je me demande s'il est possible d'établir ce salaire uniquement sur la base de la pénibilité du travail, alors que le travailleur doit pourvoir aux besoins de sa famille et qu'il existe donc des critères sociaux prédominants.

Je serais très heureux d'avoir votre avis sur ce point.

Je continue à avoir une activité au sein du PIACT (programme international d'amélioration des conditions de travail) du B.I.T. et dois me rendre en Février prochain aux Philippines pour essayer de lancer ce programme national dans ce pays. J'espère, comme vous, que mes activités me permettront de visiter votre laboratoire.

Veuillez agréer, cher ami, avec mes bons voeux pour la nouvelle année, l'expression de mes sentiments très cordiaux.

A. Wisner

dated 26th August, 1976

To

Prof. A. Wisner
Département des Sciences de l'Homme au Travail
Physiologie du Travail Ergonomie,
41 Rue Gay-Lussac
75005 Paris, France.

Dear Sir,

After a long back I am writting you again. Now I am appointed as a Research Officer in the Occupational Physiology Div., National Institute of Occupational Health, Ahmedabad.

I have already submitted my Ph.D. in Ergonomics. Immediately after submission I have got this appointment. My teacher, Dr.Sen, has encouraged me like anything to come here and to work for Ergonomics, although I will be deprived of his direct practical guidance and inspiration. I express my most humble and deep appreciation and regards for him.

Now I am planning to start a project on the recognition of patterns of the physiological variables of the industrial workers for identifying the orders of wave form of the variables through different forms of mathematical transformation. Simultaneously, I'll start an another project to fix-up some ergonomic basis for minimum wages of the workers depending on the degrees of heaviness of jobs, perceived efforts, anthropometric status and physiological needs.

Many times, I will be in need of your authentic suggestions and help. I'll expect Dr. Sen's and your active suggestions, guidance and inspiration. I wish to organize another center of Ergonomics Research, here in Ahmedabad.

If you come in India, you'll come to visit our institute too.
Please don't forget to write me only in French.

With kindest personal regards

Yours Sincerely

Nag.

(P. K. Nag)

Pranab Kumar Nag
Research Officer
Occupational Physiology Div.
National Institute of Occupational Health
Meghaninagar
Ahmedabad 340 016, India.

28 Avril 1977

Mr Registrar
UNIVERSITY OF CALCUTTA
Senate House
CALCUTTA 12
(Indes)

Mr Registrar,

You will find with this letter the report I have prepared on the thesis submitted by Mr Pranab Kumar Nag for the Ph. D. (Sc) Degree of the University of Calcutta on "An ergonomic evaluation of different types of manual work in relation to productivity".

As you can see, my opinion is highly favourable to the attribution of this Degree to Mr P.K. Nag.

I would like you to be again my interpreter to the Vice-Chancellor and Syndicate of the University of Calcutta in expressing my thanks for this appointment that gave me a new occasion of cooperation with your University and its outstanding Work Physiology Laboratory.

Truly yours,

A. Wisner

18 Janvier 1977

Mr Registrar
UNIVERSITY OF CALCUTTA
Senate House
CALCUTTA 12 (Indes)

Copie : Pr Sen
Mr P.K. Nag

Mr Registrar,

I thank you very much for your kind letter of December 28 1976, related to the thesis of Mr Pranab Kumar Nag. It is a great honour for me to be a member of the Board of Examiners of this excellent researcher, one of the best of my friend Pr Rabindra Nath Sen, who is an outstanding member of the world community of work physiologists.

I would be delighted if you would accept to be my interpreter to the Vice-Chancellor and Syndicate of the University of Calcutta in expressing my acceptance and thanks for this appointment.

Truly yours,

A. Wisner
M.D., Sc.D., Psych.Dipl.
Professor Physiologie du Travail
et Ergonomie au C.N.A.M.

When replying please quote Number, Date and Subject.

No. 4060 /Ph.D.(Sc).

UNIVERSITY OF CALCUTTA
SENATE HOUSE,
CALCUTTA—12.

Prof. Alain Wisner,
Director,
Work Physiology & Ergonomics Laberatory,
41, Rue Gay Lussac, 75005,
Paris, France.

The Dec. 28, 1976.

Dear Sir,

I have the honour by direction of the Vice-Chancellor and Syndicate to invite you to act as a member of the Board of Examiners to adjudicate upon the undermentioned thesis submitted for the Ph.D. (Sc.) Degree of this University in Physiology.

Each member of the Board of Examiners is paid an honorarium of Rs. 100 (One hundred rupees) only. The thesis covers 227. typed pages.

In case you accept the appointment it will be expected that your report will be made available to the University within three months.

I shall feel obliged if you would kindly let me know, at your earliest convenience, whether you are agreeable to examine the thesis.

A copy of the thesis will be forwarded to you in case you condescend to accept the appointment.

Yours faithfully,

Assistant Registrar.

Name of the candidate: Pranab Kumar Nag, M.Sc.(Cal), Class-I.

Title of the thesis: "An ergonomic evaluation of different types of manual work in relation to productivity.".

md/-

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28 Avril 1977

Monsieur le Professeur R.N. Sen
11 A Mohan Bagan Lane
CALCUTTA 700 004
(Indes)

Dear friend,

I join to this letter a copy of the report I have sent to the registrar of the University of Calcutta. I believe strongly all what I have written on your laboratory and the remarkable thesis of P.K. Nag. I know that he has a new and promising job in Ahmedadab.

I have not forgotten the master of P.K. Nag and Mr de Givry, who has high responsabilities in ILO-Geneva and who you met in Bangkok, is trying hard to help you to have more technical facilities for your brilliant scientific activities. I have also spoken of your laboratory to Mr Jain, a compatriot of yours and Assistant Director General of ILO for all the technical problems.

I think and hope that we shall meet again this year in October, at a PIACT seminar in Manila or in Bangkok. Mr Blanchard, General Director of ILO will attend this seminar.

Truly yours,

A. Wisner

Confidential

11A, Mohan Bagan Lane,
Calcutta 700 004,
India.

Dear Prof.Wisner,

Kindly refer to my letter dated 28th Feb.'77,
* (Copy enclosed for ready reference) written in reply to
your letter dated 1st.Jan.'77.

I have not yet received any reply. I will be extremely greatful if you could kindly let me know by return post at my permanent home address (Dr. R.N.Sen, 11A, Mohan Bagan Lane, Calcutta 700 004, India) whether the adjucation of the thesis of Sri Pranab Kumar Nag has been completed or not. The Indian external along with me (Internal) has completed the adjucation of the Thesis. I will be greatful if you could kindly send me a copy of your report at my permanant home address.

With kindest personal regards,

Yours sincerly,

Dated :- Calcutta,
The 5th. April, 1977.

Dr. R. N. Sen, D.Sc.,
Reader,
Work Physiology & Economics Laboratory
Department of Physiology
Calcutta University

* Enclosed.

No. 4586/ /Ph.D.
(Sc.) /~~D.Sc./D.Litt.~~

UNIVERSITY OF CALCUTTA
SENATE HOUSE,
CALCUTTA—73.

The 1.2/ , 1977 .

Prof. A. Wisner,
Professor Physiologie du
Travail et Ergonomic au C.N.A.S.
Paris, France.

Dear Sir,

Kindly refer to your letter dated... 18.1.77 .

I am sending herewith for favour of your adjudication and report a copy of the thesis submitted by the undernoted candidate for the Ph.D. (Sc) /~~D.Sc./D.Litt.~~ degree of this University.

The thesis may either be examined in consultation with your colleagues and a joint report forwarded to this University or you may forward your individual opinion about the merit of the thesis, stating definitely whether you commend the thesis for the award of the degree or not and your report may kindly be sent to this office together with the copy of the thesis within three months or earlier, if possible. Your kind attention is specially invited to Rule 13 in the enclosed extract from the Regulations.

I am to state in this connection that the University of Calcutta has instituted two Doctorate Degrees of different standards—Ph.D. (Arts/Science/Medical) being the lower degree and the D.Litt. or D.Sc., being the higher, just as they obtain in some British or Foreign Universities.

Yours faithfully,

~~Deputy~~ Assistant Registrar.

Name of the candidate:— Pranabkumar Nag, M.Sc, Class-I.
Title of the thesis:— "An Ergonomic Evaluation of Different Types of Manual Work In Relation to Productivity."
Constitution of the Board of Examiners:—
(1) Prof. A. Wisner,
(2) Dr. S. Banerjee,
(3) Dr. R. N. Sen (Int.).

Enclose:—(1) One copy of the thesis.
(2) An extract from the Regulations.
(3) A remuneration bill.

BMC

SCUP—50R—22-7-76— 5,000.

READER IN PHYSIOLOGY, CALCUTTA UNIVERSITY
92, ACHARYA PRAFULLA CHANDRA ROAD, CALCUTTA-9
Phone : 35-9186 to 89

Dr. Rabindra Nath Sen, D. Sc. (Cal)

Dated :- Calcutta,
28th.Feb.'77.

Dear Prof.Wisner,

Many thanks for kindly enclosing me a copy of your letter dated 18.1.77. to the Registrar, Calcutta University. I hope you have already received a copy of the thesis by now. Though the thesis was submitted on 7.5.76, there was a delay of about 8 months on the part of the University office in loosing the relevent papers submitted by the candidate. May I, therefore, request you to kindly send your report at your earliest.

It is coustomery and very important that if a thesis is recommended by the examiners for the award of the degree, the recomendation must be clearly mentioned by them either at the begining or at the end of their individual report embodying the comments on the work of the candidate. I also look forward for your constructive criticisms for further work.

With kindest personal regards,

Yours sincerly,

Prof. A.Wisner, M.D., Sc.D., Psych. Dipl.
Professor, Physiologie du Travail,
Ergonomie,
Conservatoire National Des Arts Et Metiers,
Departement des Sciences de L Homme au Travail,
41, Rue Gay - Lussac - 75005
Paris.

Dr. R. N. Sen, D.Sc.,
Reader,
Work Physiology & Ergonomics Laboratory
Department of Physiology
Calcutta University

CALCUTTA UNIVERSITY

Extract from the University Regulations

Chapter XXXIII-A

DOCTOR OF PHILOSOPHY IN ARTS AND SCIENCE (Ph.D.)

1. Any Master of Arts and Science or Master of Science (Tech.) of the University of Calcutta, or (subject to the sanction of the Syndicate) any Master of Arts or Science or Master of Science (Tech.) of any other University recognised by this University for this purpose, may apply to the Registrar for registration for the Ph.D. degree in the subject within the purview of the Regulations in which he has obtained the degree of Master of Arts or Science, as the case may be, or in an allied subject.

2. The applicant shall state in the application for registration his qualifications and indicate the subject which he proposes to investigate. The application must be supported by a certificate in a form to be prescribed by the Syndicate from a teacher recognised by the University for this purpose, under whose guidance he intends to carry out the work. The Syndicate may exempt a candidate from production of the certificate in special cases.

3. Every application shall be placed before a Ph.D. Degree Committee consisting of the Vice-Chancellor, the Dean of the Faculty concerned, Head of the Department in the particular subject, and two experts in the subject to be appointed by the Syndicate in consultation with the relevant Executive Committee. The Syndicate will grant the application for registration for the Ph.D. degree after considering the recommendation of the said Ph.D. Degree Committee.

4. On his application being granted by the Syndicate the applicant shall be registered and shall work for two years under a teacher recognised by the University for the purpose and prepare a thesis for the degree. He may, not later than one year after his registration, be permitted to change the subject or scope of his research with the approval of the Ph.D. Degree Committee.

5. The candidate for the Ph.D. degree shall submit three type-written or printed copies of his thesis embodying

the results of research and affording evidence of originality shown by him by the discovery of new facts or by a critical survey of facts or relations between facts discovered by others.

The candidate must produce along with the thesis a certificate from the teacher under whom he has worked, stating that he has fulfilled the requirements of the Regulations relating to the nature and prescribed period of research work.

Notwithstanding anything contained above, the Syndicate may, in special cases, after considering the recommendation of the Ph.D. Degree Committee, permit a candidate for the Ph.D. degree to submit a thesis prepared independently or under the guidance of a person having special knowledge in the subject or under the guidance of one of the University teachers recognised above provided that the candidate concerned has carried on research work for a period of at least two years after he has passed the M.A. or M.Sc. Examination. The candidate shall for this purpose submit an application to the Registrar which shall not be entertained unless two Doctors in any Faculty or two members of the Faculty concerned of this University or unless two members of the relevant Council of Post-graduate Teaching of this University have testified to the satisfaction of the Syndicate that in habits and character the candidate is a fit and proper person for the Ph.D. degree. After the permission to present the thesis for the Ph.D. degree has been granted by the Syndicate the candidate shall be enrolled as a candidate for the Ph.D. degree in a register for such candidates.

6. The candidate may also submit in support of his thesis the contents of any work he may have previously published but he shall not submit as his thesis any work for which a Degree of Distinction has been conferred on him in this or any other University. He will not, however, be precluded from incorporating any such work in a thesis covering a wider field, provided he indicates in a written statement the work so incorporated.

7. Every candidate shall forward with his thesis a fee of Rs. 200. No candidate who fails to pass or present himself for examination shall be entitled to claim a refund of his fee.

8. After considering the recommendation of the Ph.D. Degree Committee, the Syndicate shall refer the thesis to a Board of three Examiners including the teacher, if any, under whom the candidate has worked.

If the thesis is approved by the Board of Examiners, they will furnish the Syndicate with a report indicating in what respects the thesis affords evidence of originality.

9. After the thesis has been approved by the Board of Examiners, the candidate shall be asked to appear at an oral examination, and also in the case of a Science subject at an oral or a practial examination or both, in respect of the subject of his thesis to be held by at least two Examiners of whom the teacher, if any, under whom he worked will ordinarily be one.

The Examiners may also ask questions beyond the subject of the thesis in order to satisfy themselves that the candidate has adequate knowledge of the particular branch of Arts or Science on which he has submitted his thesis.

10. If the Examiners are satisfied with the oral or/and practical examination, they shall submit a report to the Syndicate approving the work of the candidate.

If the candidate fails to satisfy the Examiners at the oral or/and practical examination, the Syndicate may on the recommendation of the Examiners, permit him to appear again at the oral or/and practical examination after six months but within a period not exceeding one year following the date of his failure. The fee on re-entry shall be half the fee originally paid.

11. If the Syndicate, after considering the report of the Examiners, are satisfied that the candidate is worthy of the Degree of Ph.D., they shall cause his name to be published with the title of the subject of his thesis.

12. A diploma under the seal of the University and signed by the Vice-Chancellor will be given to each successful candidate at the next Convocation held for conferring degrees.

13. Notwithstanding anything contained in the above Regulations, if the thesis of a candidate, originally presented for admission to the D.Litt. or D.Sc. degree under the provisions of Chapters XXXIV and XXXIII, respectively, is not recommended by the Board of Examiners concerned, but is on the other hand adjudged by them to be of sufficient merit to justify his admission to the Ph.D. degree, the thesis shall, if the candidate so elects, be deemed to be a thesis presented and approved for the Ph.D. degree for the purpose of Sections 8 and 9 above. Such a candidate shall, unless specially exempted by the Syndicate on the recommendation of the Board of Examiners, be asked to appear at an oral or/and practical examination, as the case

may be, to be conducted by a Board of Examiners to be specially constituted by the Syndicate for the purpose. The Examiners may ask questions beyond the range of the subject of the thesis.

The provisions of Sections 10, 11 and 12 will apply to these candidates.

N.B.—Ph.D. Registration fee—Rs. 50.
Last dates for submission of applications of the thesis—
31st January,
30th April,
31st July,
15th November.

SCUP—11R—12-6-73—5,000.

Confidential

Dated :- 28th.February, 1977.
Calcutta.

Dear Prof. Wisner,

Many thanks for kindly endorsing me a copy of your letter dated 18.1.77 to the Registrar, Calcutta University. I hope you have already received a copy of the Thesis by now. Though the Thesis was submitted on 7th March 1976 there was a delay of about 8 months on the part of the University offiec in loosing the relevent papers submitted by the candidate. May I therefore request you to kindly send your report at your earliest.

It is customery and very important that if a Thesis is recommended by the examiners for the award of the degree, the recommendation must be clearly mentioned by them either at the bigning or at the end of their individual report emboiding the comments on the work of the candidate. I also look forward for your constructive criticism for further work.

With kindest personal regards,

Yours sincerly,

NATIONAL INSTITUTE OF OCCUPATIONAL HEALTH
Meghaninagar, Ahmedabad-380016, India

Fax: (91) 79-866630 NIOH, A'bad, India

Telex: (81) 121-6471 NIOH IN
Gramm: NIOHEALTH Phone: (91) 79-866642

Country	City	Fax Number	Pages:
France	Paris	19-1-43 25 36 14	This +

From	To:
Dr P. K. Nag N.I.O.H., Ahmedabad India	Prof A. W. Dept of E. 41 Rue Cuy [illegible] Paris, France

Our Ref.No. ERG/3 Date: 3 June 1994

Respected Prof Wisner,

I was very much delighted to receive your fax dated 26 May 1994. I look forward for the opportunity to see you at a convenient time and get your advice on some of our on-going programmes. With the present state of socio-technical development, I sincerely believe that it may be appropriate to assimilate various fundamental aspects of inter-cultural variation of ergonomics researches in the developing and the developed world. I would like to get your suggestions on the above issues and works of the competent international authorities.

Visit to IEA'94 could be an important opportunity to meet you. I am not sure whether it will be possible for me to attend the meeting. I have requested Prof Ian Noy, Chairman and also Dr Brian Grant, Treasurer IEA'94 for possible travel grant, however, I am yet to get a favourable response.

I am sending by post some of my recent publications.

With very best personal regards,

Yours sincerely,

P.K. Nag

CONSERVATOIRE
NATIONAL
DES ARTS
ET MÉTIERS

ERGONOMIE ET
NEUROSCIENCES
DU TRAVAIL

Paris, 26th May 1994

Dr. Pranab Kumar Nag
National Institute of Occupational
Health,
Meghaninagar,
Ahmedabad 380 016
India

FAX 91.79.866.630.

Dear Dr. Nag,

I found your letter of April 20th on my return from a scientific exchange visit in Brazil.

I enjoy your achievement : the publication of your book by John Wiley is even more convincing that the first agreement with Sage.

The content of the book is very exciting and I see that you have worked a lot writing yourself four chapters. I am also happy to receive a galley proof from the publisher as this is not always the usual procedure.

You kindly ask me to suggest names for complimentary copies. The first names are those of South East Asia authors who are working in countries which are working along the same line as India :

Professor A. MANUABA, Jalan Serma Gede 18, Denpasar 80114, Bali, Indonesia

Prof. Malinee WONGPHANISH, 39 Moo 16, Nakorn-Kheankhan Road,
Tambol Bangpeung, Amphur Pra-Pradeng
Samutprakarn Province 1030, Thailand

Dr. Kitti INTARANONT, Laboratory for Ergonomic Research, Dpt of Industrial Engineering
Faculty of Engineering, Chulalongkorn University
Bangkok 10330, Thailand

In case these colleagues are already on your list I am also giving you the name of two English-reading Brazilians :

LABORATOIRE
D'ERGONOMIE

41, RUE
GAY-LUSSAC
75005 PARIS

TÉLÉPHONE
(1) 43 54 18 27
TÉLÉCOPIE
(1) 43 25 36 14

Professor N. DOS SANTOS,

Departemento de Engenharia de Produçao
Universidade Federal de Santa Catarina
Campus Universitario - Trinidade
Caixa Postale 476
CEP 88049 FLORIANOPOLIS-SANTA CATARINA,
Brésil

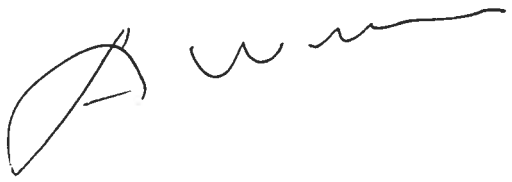
Dr. Laerte SZWELWAR, Rua Batatais n° 253, Apto 141, SAO PAULO SP, Brésil

I am frequently teaching in this country.

I enjoy the idea to see you soon in Toronto and to learn more about your research activities and prospective.

With my best regards,

Yours sincerely,



Alain Wisner

FAX: 91-79-866630
Phone: 91-79-867351

Dr. Pranab Kumar Nag
Ph.D., D.Sc.

20 April 1994

To

Prof A. Wisner
Laboratoire d'Ergonomie
Conservatoire Nationale des Arts et Metiers
41 Rue Gay Lussac
Paris 75005
France

Respected Prof Wisner,

I am glad to inform you that our book 'Ergonomics and Work Design' is ready for publication by the publisher: John Wiley - Eastern. Due to some inconvenience the earlier proposed publisher 'Sage' could not be availed and this resulted in all these delays, beyond my control.

With this letter, I am sending the list of the authors, who contributed in the book. I have taken the liberty to place your article as the concluding chapter of the book. There are minor changes in your article (some references), and you will receive the galley proof within a short period, directly from the publisher. You may have to get some references (titles of Ph.D. thesis) re-checked. The Wiley - Eastern assures that each author will get a copy of the book and the author may suggest two/three names to whom the complimentary copies may be sent by the publihser. Kindly send me your suggested names.

In spite of such an inordinate delay, finally the manuscript has taken a good shape and I express my heartiest thanks and appreciation for your patience, and indulgence.

I am looking forward for the opportunity to meet you during the IEA meeting in Canada.

With very best personal regards,

Yours sincerely,

P.K. Nag

MANUABA
WEN PHANICH
KITTY
[illegible]
SZNELWAR
NERS

Office : National Institute of Occupational Health, Meghaninagar, Ahmedabad-380 016, India
Gram : NIOHEALTH Phone : 67351-2, Telex : 121-6471 NIOH IN

ERGONOMICS AND WORK DESIGN

(Emerging Issues in Organizational Sciences)

P.K. Nag
(editor)

Dr. Pranab Kumar Nag
Ph.D., D.Sc.

Res:
1 Ashmita Apartments
6, Damobhai Colony
Vasna, Ahmedabad 380 007

To

dated 5 March 1992

Prof A. Wisner,
Laboratoire d'Ergonomie
Conservatoire National des Arts et Metiers
41 Rue Gay Lussac-F
75005 Paris
FRANCE

Respected Prof Wisner,

Your parcel arrived here in good condition. Also, I have no difficulty to retrieve the CNAM.DOC and CNAM.ASC files from the floppy. In case I require any rejoinder in the article, I shall write to you.

We have an understanding with the SAGE for publishing the book. You are aware of the publishing house, as you have referred some publications in your article. We proposed the title of the book as 'WORK DESIGN', and accordingly, our original proposal with detailed contents of the book was processed. In course of our progress, we notice that our original contents marginally shifted. The revised proposal is under consideration, with the title 'WORK DESIGN IN ORGANIZATIONS'. I hope to inform you the expected publication date, soon.

With warm personal regards,

Yours sincerely,

P. K. Nag

(Pranab)

Office : National Institute of Occupational Health, Meghaninagar, Ahmedabad-380 016, India
Gram : NIOHEALTH Phone : 67351-2, Telex : 121-6471 NIOH IN

MINISTERE DE L'EDUCATION NATIONALE
CONSERVATOIRE NATIONAL DES ARTS ET METIERS
ERGONOMIE ET NEUROSCIENCES DU TRAVAIL

Paris, 25th February 1993

Dr. Pranab Kumar Nag,
1 Ashmita Apartments
6, Damobhai Colony
Vasna, Ahmedabad 380 007
India

Dear Dr. Pranab Kumar Nag,

Thank you for your kind wishes. I am so sorry to answer late but I continue to accept a quantity of work that is not well related to the reduced possibilities of old age.

I was very happy to learn that your book will be soon published by Sage.

Since I sent you my paper for this book I have continued to work in the same field and I send you under the same cover a copy of the English version of a text that will be published in Spanish in *Sociologia Del Trabajo* (Madrid).

I have still the intention of visiting Ahmedabad but I have not yet found the money to do it. Could you kindly send me your last published works so that, at least, I can follow your so interesting production.

With my best regards,

Yours sincerely,

Alain Wisner

P.J.

11ème Congrès de l'Association Internationale d'Ergonomie
11 th Congress International Ergonomics Association
PARIS - 15 - 20 JUILLET 1991

Paris 7th May, 1990

Dr. Pranab Kumar Nag
5 AUDA Residential Complex
Vasna,
AHMEDABAD 380 007
India

Dear Dr. Nag,

I received with much pleasure your letter of April 18.

I have been impressed as usual by your research programme always built on very new and efficient considerations.

I am specially interested by SWEAT. I hope that you will describe it fully in Paris. If I can contribute in any way I will be very happy.

I know that the best researchers of countries like India are not in a position to attend congresses in other continents without some financial support. The only offer I can do today is to give you free registration fee. We shall try also and find cheap accommodation in students' home. For Travel expenses, I have not yet any solution but my friend Prof. Horino has decided to provide grants for researchers coming from South and South-East Asia using the interest of Japanese firms of giving a positive image of themselves in Europe.

I hope to see you anyway soon both in Paris and in India.

With my best regards,

Yours sincerely,

A. Wisner

Dr. Pranab Kumar Nag
Ergonomist

Res:

5 AUDA Residential Complex
Vasna, Ahmedabad 380 007

Date : 18 April 1990

Prof. A. Wisner
Laboratoire d'Ergonomie
41 Rue Gay-Lussac
75005 Paris
France

Respected Prof Wisner,

After a long time I am taking the opportunity to write to you. I sincerely hope and pray to God that you are in good health and spirit. I am seriously planning to attend the Paris Congress in 1991. I am always happy to take use of your spare moments for my enlightenment.

I am sending the reply card 'INTENT TO ATTEND', to keep me in the mailing list. I hope that I shall be able to attend and contribute on a topic of importance in our part of world. We are presently working in the unorganized small industry sector, with reference to methods of job analysis. Since the conventional methods are not really applicable in this sector, we are building up a model for application.

In view of the emerging needs of application of ergonomics in village and small industries, we have initiated a 'School of Work Environment & Applied Technology (SWEAT)', to disseminate ergonomics know how. We hope that by the time of Paris Congress we shall be in a position to bring out the activities and contribution of the School. Obviously, I shall be extremely happy to get you as an advisor with honorary capacity. A formal invitation will be communicated to you at a later date.

Through you, I would like to request the Congress Sponsoring Committee to inform me whether there is any provision to extend travel support to participants.

With warm personal regards,

Yours sincerely,
P. K. Nag
Pranab

Office : National Institute of Occupational Health, Meghani Nagar, Ahmedabad 380 016
Gram : NIOHEALTH Phone : 66031-4 Telex : 0121-471
~~Residence : 1/5, Gemini Flats, Deepika Co-op. Housing Society, Paldi, Ahmedabad 380 007~~

24 Mars 1989

Professor Don B. Chaffin
Departement of Industrial
and Operations Engineering
The University of Michigan
IOE Building, 1205 Beal Avenue
Ann Arbor, Michigan 48109-2117
U.S.A.

Dear Professor Chaffin,

I have received yesterday your letter of March 8, stamped by U.S. post March 13. So I try to answer as quickly as possible to your question about Dr Pranab K. Nag.

I know this very distinguished scientist through his works. I have seen him only during a short period very long time ago. So I am not really able to answer about his teaching abilities.

But, I have a very high appreciation about his scientific level. I had 3 occasions to study carefuly his works : first as member of the jury of his Ph.D., second as a member of the jury of his Sc. D., third when preparing a review paper for Industrial Ergonomics about anthropometrics, and work physiology in industrially developing countries. Each time, I admired the precision of the experiments'description, the moderation of comments and, above all, the adequacy of the methods and thinking to the question raised by the situation studied. Dr Nag has allways had coworkers working with him. So I think that he is able to attract and mentor Ph. D. students. I am confident in his general maturity and collegial qualities.

I have no direct evidence of this ability to work with other disciplines, but I remark that he has succeeded in Ahmedabad, where he was a member of an institution where different disciplines are represented.

To summarize my views, I think that Dr Pranab K. Nag is an outstanding scientist, may be the best indian

.../...

work physiologist of his generation, extremely active and creative. I think also, that he is in the leading cohort of the work physiologists in the world. I would certainly be happy to have him as a senior member of my staff if I had an opportunity to develop a programme on work physiology (In fact, we are now involved in work neurosciences and ergonomics).

I hope that this partial answer will be useful and that you shall be able to make the best choice.

With my best regards.

Truly yours.

A. Wisner

Department of Industrial and Operations Engineering

IOE Building, 1205 Beal Avenue
Ann Arbor, Michigan 48109-2117
313/764-6473

College of Engineering
The University of Michigan

March 8, 1989

reçu 13 March

Prof. A.Y. Wisner
Prof. of Work Physiology and Ergonomics
Conservatoire National des Arts et Metiers
41 Rue Gay-Lussac
Paris, 75005 France

Dear Prof. Wisner:

You have been identified by Dr. Pranab K. Nag as a person who could provide us with information about his potential as a faculty member in the Department of Industrial and Operations Engineering. It is desirable to have written recommendations. Could you please find the time to send, as soon as possible, your evaluation of Dr. Nag? It would be extremely helpful to have your assessment of:

His capabilities to provide human factors instruction to graduate and undergraduate engineering students.

His ability to attract and mentor Ph.D. students.

His potential to function as a faculty member, at a research university, including his ability to work with other disciplines in the development and performance of interdisciplinary research.

His general maturity and collegial qualities.

According to University policy, we shall, of course, make every effort to keep your comments confidential. If questions arise, please feel free to contact me. I look forward to hearing from you.

Sincerely,

Don B. Chaffin
Professor
Director, Center for Ergonomics

DBC:jdg

ERGONOMICS : A NEW PERSPECTIVE OF WORK ORGANIZATION

IN TRADITIONAL AGRICULTURE

Thesis submitted by Pranab Kumar NAG M.sc., Ph.D.

for the D.Sc. Degree in the University of Calcutta

Report of Alain WISNER M.D., Sc.D.
(Physiol.), Psychol. Dipl., Professor
of Ergonomics and Work Neurophysiology
Conservatoire National des Arts & Métiers
Paris.

The thesis submitted by Mr Pranab Kumar NAG is highly convincing of the high level of the scientific thinking and works of its author and I fully recommend on this basis the attribution of the title of D. Sc. of the University of Calcutta to Mr P. K. NAG.

When I had the honour, in April 1977, to send a report about the Ph. D. (Sc) of Mr P.K. NAG, I wrote that Mr NAG was "one of the most promising young master of work physiology in the world". We can consider now that these promises have been hold and that Mr P.K. NAG has a good place among the masters of work physiology in the world. In fact, this opinion is not only mine : his papers are now published by the best indian scientific journals and also by the best journals in other great scientific countries (Japan, U.K., U.S.A.). Not less than 23 excellent papers relevant to the subjects discussed in his thesis have been published by Mr P.K. NAG from 1976 to 1982.

The thesis of Mr NAG is remarkable from at least to view points : ergonomics and general work physiology.

It is certainly extremely important for India to have a better knowledge of the physical capacities and behaviour of the hundreds of millions of indian agricultural workers. I think that the results given by Mr NAG in his thesis are highly significant for India though they have been obtained mainly on farmers of the northern part of the country. I am sure that they are also of great interest for other asian countries and even for countries belonging to other parts of the world.

Knowing the caracteristics of indian human resources, Mr NAG is then in a position to appreciate the effects of tropical heat on human productivity. The limitations of indian workers are not only related to their oxygen consumption but also to the cardio-circulatory capacities related both to energy expenditure and to heat. Of course, this is a part of our general knowledge but in this thesis, this relation has been expressed in a very precise way in the indian situation. The recommendations related to the heat load are fully justified and well expressed.

To obtain a better human productivity is of crucial importance in this period of indian history though very fruitful efforts have been done and have obtained excellent results in food production and in other crucial areas of agriculture.

The researches done by Mr P.K. NAG on different types of materials are now classical. His study in agricultural weeders is quoted in all countries as a typical contribution of ergonomists to the progress of basic technology in agricultural development. It is a clear and realistic approach to the difficulties that farmers may find in the use of materials conceived by engineers who have good will but little knowledge about the real physiological capacities of agricultural workers.

The contribution of Mr P.K. NAG to the general physiology of man at work is also outstanding. He shows that though the biological status of the poor agricultural workers is extremely different of the biological status of well trained and well fed olympic sportsmen, the same biological laws are observed. The same quantity of muscle has in every man, the same strength and power. But, as we know, the practical differences are important between workers as whole human beings. The young agriculture workers studied by Mr P.K. NAG have a maximum oxygen consumption of 41 ml/Kg/min which gives for a body weight of 50 Kg approximatively 2 l/minute. The young workers studied by L. BROUHA had a maximum oxygen consumption of 51 ml/Kg/min which gives for a body weight of 75 Kg approximatively 4 l/minute, two times the maximum oxygen consumption of the young indian agriculture workers.

The influence of heat is also remarkably studied by Mr P.K. NAG. His final recommandations very carefully established are, for summer time, at the level of 180 w/m^2 for males aged 20 to 29. For a body surface of 1,35 m^2 (Mr P.K. NAG results) it means 240 w/m^2 that is often taken as the level of light work among young well trained males in western population and cold climate.

The results of Mr P.K. NAG, that he interprets extremely well, show that the universal physiological laws when they are applied among people whose type of life provide only limited muscular strength under hot climate, call for a very careful use of this strength at work. It is a very accurate demonstration of the absolute need of an ergonomic approach of the working conditions and tools in indian villages ... and in so many others.

The works of Mr P.K. NAG are not only excellent and well oriented toward indian problems. They are a part of the scientific light that India is providing on the concrete problems of our world and specially on economical and human development.

As it is written in the beginning of this report, Mr Pranab Kumar NAG is really worthy of being recognized as Sc. D. of the University of Calcutta and one of our most gifted colleagues.

Alain WISNER

CALCUTTA UNIVERSITY

CHAPTER XXXVIII

DOCTOR OF SCIENCE (D.Sc.)

1. Any Master of Science or Master of Science (Tech.) of the University of Calcutta, may offer himself as a candidate for the Degree of Doctor of Science provided three years have elapsed from the time when he passed the examination.

Any Doctor of Medicine or Master of Surgery or Master of Obstetrics or Doctor of Philosophy (Ph.D.) in Science of the University of Calcutta may also offer himself for the Degree of Doctor of Science.

Provided that for the purpose of determining whether a candidate is to be admitted to the Degree of Doctor of Literature or Doctor of Science, it is to be considered whether the subject in which he offers the thesis is attached to the Faculty of Arts on the one hand, or to the Faculties of Science and Medicine on the other.

Provided that the Syndicate may, on the recommendation of the Academic Council, relax the operation of the rule in the case of candidates of other Universities having qualifications considered equivalent to those mentioned above and on fulfilling other requirements that may be laid down by the Syndicate from time to time including residence within the jurisdiction of the University for at least two years.

2. Every candidate shall state in his application the special subject within the purview of the Regulation for the Degree of Master of Science, or a subject allied or ancillary thereto upon a knowledge of which he rests his qualification for the Doctorate, and shall, with the application, transmit three copies, printed or type-written, of a thesis that he has composed treating scientifically some special portion of the subject so stated, embodying the result of research, or showing evidence of his own work, whether based on the discovery of new facts observed by himself or of new relations of facts observed by others or tending

generally to the advancement of science. The candidate shall indicate, generally in a preface to his thesis and specially in notes, the sources from which his information is taken, the extent to which he has availed himself of the work of others, and the portions of the thesis which he claims as original ; he shall further state whether his research has been conducted independently, under advice, or in cooperation with others, and, in what respect his investigations appear to him to tend to the advancement of science.

3. Every candidate may also forward with his application three printed copies of any original contribution or contributions to the advancement of the science professed by him, or any cognate branch of science, which may have been published by him independently or conjointly, and upon which he relies in support of his candidature.

4. No application shall be entertained unless two members of the Faculty of Science or two Doctors in any Faculty of this University or of a University approved by the Syndicate from time to time shall have testified, to the satisfaction of the Syndicate, that in habits and character, the candidate is a fit and proper person for the Degree of Doctor of Science.

Provided that no such certificate will be required in the case of a candidate who has obtained the Degree of Doctor of Philosophy (Ph.D.) in Science.

5. Every candidate shall forward with his application a fee of Rs. 300. No candidate who fails to pass or present himself for examination shall be entitled to claim a refund of the fee.

6. The thesis mentioned in Regulation 2 and the original contributions, if any, mentioned in Regulation 3, shall be referred by the Syndicate to a Board of three Examiners.

7. If the thesis is approved by the Board, and if the candidate has obtained a First Class at the examination for the Degree of Master of Science or has obtained the Degree of Doctor of Medicine or Master of Surgery or Master of Obstetrics or Doctor of Philosophy (Ph.D.) in Science, he shall not be required to submit to any further written examination ; but he may be required by the Board, at their discretion, to appear before them to be tested orally or practically, or by both these methods, with reference to the

the thesis, and the special subject selected by him. The Board shall report to the Syndicate the result of the examination of the thesis, and of the oral and practical examinations, if any, and if the Syndicate, upon the report, consider the candidate worthy of the Degree of Doctor of Science, they shall cause his name to be published, with the subject of his his thesis, and the titles of his published contributions (if any) to the advancement of science.

8. If the candidate is a person who has obtained a Second or Third Class at the examination for the Degree of Master of Science, and if his thesis is approved by the Board he shall be required to submit to a written examination.

Two papers of three hours each shall be set, one upon the special subject mentioned in the application of the candidate, and the other upon the subject of the thesis. The candidate may also be required by the Board, at their discretion, to appear before them to be tested orally or practically or by both these methods, with reference to the thesis and the special subject professed by him. The Board shall report to the Syndicate the result of the examination of the thesis, and of the written examination, and also of the oral and practical examinations, if any, and if the Syndicate upon the report, consider the candidate worthy of the Degree of Doctor of Science, they shall cause his name to be published with the subject, of his thesis, and the title of his published contributions (if any) to the advancement of science.

9. In the case of a candidate obtaining a Second Class at the examination for the Degree of Master of Science and falling under the preceding regulation. If the Board, upon an examination of his thesis and of his original contribution or contributions to the advancement of science, hold the same to be generally or specifically of such special excellence as to justify the exemption of the candidate from the written examination, he may be exempted by the Syndicate, provided that the report of the Board shall set forth the fact and the grounds of such exemption.

10. A diploma under the seal of the University and signed by the Vice-Chancellor shall be delivered at the next Convocation for conferring Degrees to each candidate who has qualified for the degree.

11. Every candidate shall be at liberty to publish his thesis, and the thesis of every successful candidate shall be published by the University, with the inscription : "Thesis approved for the Degree of Doctor of Science in the University of Calcutta."

SCUP—36R—14-12-79—2,000.

No.3542 /~~Ph.D.~~/D.Sc.) (When replying please quote
D.Sc./~~D.Litt~~. Number, Date and Subject)
University of Calcutta

SENATE HOUSE
Calcutta-73
INDIA

The 12 April 1986

Professor Alain Wisner

Dear Sir/Madam,

Kindly refer to your letter, dated **23.10.1985**
I am sending herewith, for favour of your adjudication and report a copy of the thesis submitted by the undernoted candidate for the Ph.D.(**Sc.**)/D.Sc./~~D.Litt~~ degree of this University in **Physiology.**

Either you may examine the thesis in consultation with your colleagues and forward a join report to this University or you may forward your individual opinion about the merit of the thesis, stating definitely whether you commend the thesis for the award of the degree or not. Your report may kindly be sent, through the medium of English language, to this office together with the copy of the thesis within three months or earlier, if possible. Your kind attention is specially invited to Rule 13 / Rule 8 & 9 in the enclosed extract from the Regulations.

I am to state, in this connection, that the University of Calcutta has instituted two Doctorate Degrees of different standards - Ph.D.(Arts/Science/Medical/Agriculture/Engineering/Veterinary Science/Law/Technology) being the lower degree and the D.Litt or D.Sc. being the higher, just as they obtain in some British or Foreign Universities.

Yours faithfully,

Registrar

Name of the Candidate : **Sri Pranab Kumar Nag, M.Sc., Class-I, Ph.D.**

Title of the thesis : **Ergonomics - a new perspective of work organisation in traditional agriculture**

Constitution of the Board of Examiners :

1) **Prof. Alain Wisner**
2) **Consent not yet received**
3) -do-

CALCUTTA UNIVERSITY

Report received
Pay remuneration

Assistant Registrar

Name of the Examiner—Prof. ~~Dr. S. [illegible]~~ Alain Migner

Voucher No.....

Cheque No.....

Rem. Reg. Page.....

Calcutta University.....**Dr.**

To

My remuneration as Examiner in connection with the Ph.D. (.....), D.Sc., ~~D.Litt.~~ thesis Examination of 19~~..~~.

(Candidate—Sri/~~Sm.~~ Pranab Kumar Ray.....)

Rupees (Rs. 300/-) Three Hundred ~~...~~ only

**Signature*.....

Official Designation.....

.....

Present Address (in block letters).....

.....

N.B.—The payee is requested to sign in both the places marked*. PARIS

*Twenty P. Revenue Stamp for payment exceeding Rs. 20

(FOR USE IN THE AUDIT AND FINANCE OFFICE)

Amount of the Bill.....Rs.....

	Amount		Ledger Folio	Balance of Grant		Initial of Checking Assistant
	Rs.	P.		Rs.	P.	
Debit :—						
Budget head—**B. I. No. 19 (d)** Remuneration to Examiners, Ph.D., D.Sc., D.Litt., etc.						
TOTAL						
Credit.....						
.....						
.....						
Net Amount ...						

Checked and passed for payment of Rs.....P.....(Rupees.....

.....Paise) only.

Instructions

1. The bill, which has been prepared in the Registrar's Office, is forwarded to the payee, with the request that he will present it at the Registrar's Office, either personally or through a messenger, after having duly stamped and signed it. After the bill is passed and the cheque is ready for payment an intimation card will be sent to the Examiner, Paper-Setter or Scrutiniser concerned. If there is any objection in signing the receipt in advance, it need not be done, but in such a case, the payee should call at the Registrar's Office on receipt of the intimation card to receive payment and sign the receipt. In no case payment will be made unless a receipt is given at the same time. The bill should always be signed, though it need not necessarily, be receipted, before it is presented.

Note.—Gentlemen not residing in Calcutta should sign the bill and the receipt, and return the same to the Registrar who will remit the amount by money order after deducting the commission as soon as possible after receipt of the bill.

2. Examiners are requested to state their designations below their signatures. Government Officers (excepting Officers of the Education Department of the Government of West Bengal) are requested to note their official designations and to furnish the permission letter from the competent authority, along with the bill.

3. The spaces provided for the purpose, *viz.*, for signature, official designation and address, may please be filled in before the bill is submitted to the University for payment.

4. Under the rules all payments to the persons residing outside Calcutta will be made by Money Order only.

Synd. V. C. dt. 10/8/84
Ph.D. dt.
Synd. dt.

Board of Examiners :—

(1) Prof Alam Visiter

(2)

(3)

SCUP—41R—17-11-83—7,000.

Duplicate for P.D.

CALCUTTA UNIVERSITY

Report received
Pay remuneration

Assistant Registrar.

Name of the Examiner—Prof./~~Dr./Sri~~ Alain Bignier

Voucher No.....

Cheque No.....

Rem. Reg. Page.....

Dr.

Calcutta University.....

To

My remuneration as Examiner in connection with the Ph.D. (.....), D.Sc., ~~D.Litt.~~ thesis Examination of 19.8.[illegible]

(Candidate—Sri/~~Sm~~ Kanak Kumar Nag .....)

Rupees (Rs. 300/-) Three hundred only

*Signature.....

Official Designation.....

.....

Present Address (in block letters).....

.....

Received payment.

*Twenty P. Revenue Stamp for payment exceeding Rs. 20

N.B.—The payee is requested to sign in both the places marked*.

PAYS

(FOR USE IN THE AUDIT AND FINANCE OFFICE)

Amount of the Bill.....Rs.....

	Amount		Ledger Folio	Balance of Grant		Initial of Checking Assistant
	Rs.	P.		Rs.	P.	
Debit :—						
Budget head—B. I. No. 19 (d) Remuneration to Examiners, Ph.D., D.Sc., D.Litt., etc.						
TOTAL						
Credit.....						
.....						
.....						
Net Amount ...						

Checked and passed for payment of Rs.....P.....(Rupees.....

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3. The spaces provided for the purpose, *viz.*, for signature, official designation and address, may please be filled in before the bill is submitted to the University for payment.

4. Under the rules all payments to the persons residing outside Calcutta will be made by Money Order only.

Synd ~~V.C.~~ dt. 16/8/84
~~Ph.D.~~ dt.
~~Synd.~~ dt.

Board of Examiners :—

(1) Prof. Olivier Bigner

(2)

(3)

SCUP—41R—17.11.83—7,000.

plus grand 158 ↓ 166 plus lourd 45 ↓ 50 n 64

fig 1304 B

1283

les jeunes hommes de 50 kg ont une consommation d'O_2 de 2 l/min (41 ml/kg min)

par BROUHA

les hommes de 70 kg ont une consommation d'O_2 de 3 l/min (31 ml/kg/min.)

1,22
3,6
732
366
4,392

~~27 x 70~~

51,3 x 70

3500

3 l/mn.

Jeunes musulmans jeunes hommes paysans = 32 kg

≠ ouvriers américains.

surface corporelle 1m² 35 ∝ 4/3

Travail	180 W/m²	20.29	240	W
	160	30 39	210	
	130	40 49	200	
	140	50.59	190	

WATT unité de puissance 1 J /sec

10^7 ergs / sec

JOULE unité de travail
d'énergie

travail produit par 1 force de 1 NEWTON dont
le point d'application se déplace de 1 m

1 J = 10^7 ergs

1 Kgm = 9,8 J ⟩ (calorie : 4 J)

WATT = 0,1 Kgm /sec

1 WATT = 6 Kgm

Kcal / mn

0,25 /
15 ·

10 Kcal / minute

~~10/6~~ Kcal / sec

4/6 J / sec

2/3 W

162
325

0,65 6,5 65 650 W

April 1977

SECRÉTARIAT D'ÉTAT AUX UNIVERSITÉS
CONSERVATOIRE NATIONAL DES ARTS ET MÉTIERS
Département des Sciences de l'Homme au Travail
PHYSIOLOGIE DU TRAVAIL — ERGONOMIE

Paris, le

AN ERGONOMIC EVALUATION OF DIFFERENT TYPES OF MANUAL WORK IN RELATION TO PRODUCTIVITY

Thesis submitted by Pranab Kumar NAG M.sc.
for the Ph.D. (Sc) Degree of Calcutta University

Report of Alain WISNER M.D., Sc. D. (Physiol.)
Psychol. Dipl., Professor of Work Physiology
and Ergonomics, Conservatoire National des
Arts et Métiers (Paris)

The thesis submitted by M. Pranab Kumar NAG is highly convincing of the scientific value of its author and I fully recommend on this basis the attribution of the title of Ph.D. (Sc) of Calcutta University to Mr P.K. NAG.

My opinion is not only related to the text of the thesis but also to the personnal knowledge I have of the scientific culture, the technical ability, the careful experimental thinking, the prudent interpretation capacity of Mr P.K. NAG since my visit at the brilliant laboratory of work physiology and ergonomics directed by the Professor Rabindra Nath SEN, in 1975. The high opinion I have of his capacities and scientific production was the reason why I have invited Mr P.K. NAG to visit the laboratory of Work Physiology and Ergonomics of the Conservatoire National des Arts et Métiers in Paris, for a semester

.../...

or two. This has not been possible to realise but I hope that in the future such a collaboration will be possible.

Coming back to the thesis of Mr P.K. NAG, I can support my high opinion from to view points : general scientific value, adequation to the social needs of India and more generaly of Asian countries.

The scientific value of the thesis of Mr P.K. NAG is very good if we consider all the usual criteria of physiological research. The knowledge of the litterature of Mr P.K. NAG is excellent and world wide and very well discussed in relation to his own work. The methods and experimental tools used are clearly described. Those who are classical are identified as such, those who are original are described and discussed. Among different aspects, one of the most interesting part is certainly the discussion about the estimation of body fat, where the formula used in western countries show clearly their unability to express the facts found on indian workers. In a more general way, these are an excellent demonstration of the limits given by physiological anthropology to the classical knowledge mainly acquired in the western countries.

If we consider the results obtained by the excellent methods of P.K. NAG, they are all very interesting in their different fields of physiology :

- static anthropometric measurements on workers with an excellent sampling directly connected to anthropological views, anthropometric measurements of cadavers obtained for the first time in India,
- energy expenditure measurements in different occupations : printing, agriculture, load carrying, with the different usual techniques used by the workers-subjects in their normal activities,
- relations between load carrying and altitude established among workers used to these conditions, trained both to altitude and load handling.

One of the most stimulating results of Mr P.K. NAG is the discrepancy between caloric intake and energy expenditure, if we use the usual nomograms established in western countries. There again, an excellent demonstration is given of the need of a differential physiology related to the specific characteristics of the different populations in the world related to their climate, nutritional status and working habits.

If we take the second category of criteria to evaluate the thesis of Mr P.K. NAG, the adequation of his researches to the social needs of India and more generally of the Asian countries, we realize how deep is his understanding of the physiological problems of the indian manual worker and how far he is able to suggest ergonomic solutions.

Mr P.K. NAG has seen how much the classical problems of physical effort and heat load remain of the utmost importance in industrialising countries, but also in so many activities of the countries where industry is dominant. He understands very clearly the relations of these aspects of work with the nutritional status and the socioeconomical strain on food intake. he has also very well seen how much training can influence the real work load of the workers. But perhaps, one of the most interesting aspects of Mr P.K. NAG approach is expressed in his study of the hight and fast printing work so typical of the jobs of mass production industries, more and more frequent in India and the Asians countries. He shows that a pure energy consumption evaluation of the work is not sufficient and that psycho-physiological studies are needed in complement.

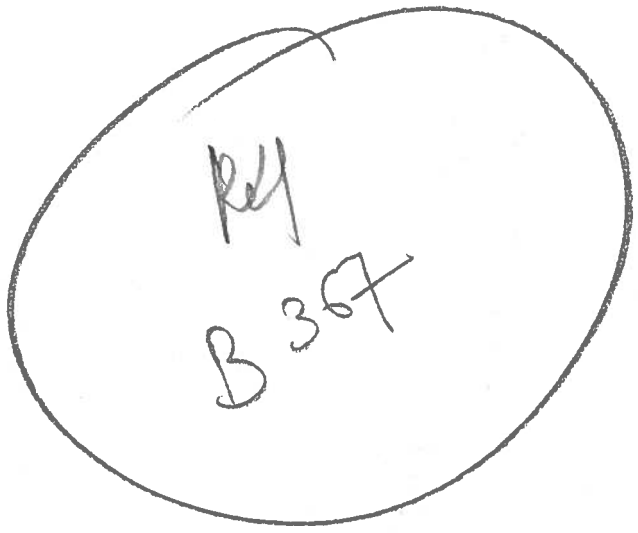
As it is written in the begining of this report, Mr Pranab Kumar NAG is really worthy of being recognized as Ph.D. (Sc) of Calcutta University and one the most promising young master of work physiology in the world.

233 21 11

FULL AGREEMENT FOR DOCTOR NAC VISIT TO OUR LABORATORY SECOND HALF APRIL. ~~DOCTOR~~ PROFESSOR LAVILLE ASSISTANT DIRECTOR OF OUR LABORATORY WILL BE IN VIZ ADAR. GREETINGS

WISNER

B. B. CHATTERJEE
NIOHEALTH
Meghaninagar
Ahmedabad 380 016
INDE



NATIONAL INSTITUTE OF OCCUPATIONAL HEALTH
(INDIAN COUNCIL OF MEDICAL RESEARCH)

राष्ट्रीय व्यावसायिक स्वास्थ्य संस्थान

Grams : NIOHEALTH
Phone : 66091-66092
67388-67319
Telex : 012-471

Meghaninagar
Ahmedabad-380 016.

Our Ref. 2/Sem.Symp./FV/84/461

DATE 21.12.84

To
Prof. A. Wisner
Work Physiology and Ergonomics Division
Conservatoire Nationale des Arts et Metiers
41, Rue Gay-Lussac
Paris 75005
France

Dear Prof. Wisner,

Dr P.K. Nag of this Institute, a scientist, specialising in the field of Ergonomics will be visiting Zadar, Yugoslavia from April 15 to 17, 1985 to attend the International Occupational Ergonomics Symposium, in which he would be presenting apaper entitled 'Influence of posture on muscle contraction behaviour in arm and leg ergometry', based on his work.

I was wondering if he could visit your Institute for about two weeks for observing and participating in some of your advanced research projects. Amongst the special areas of interest, I feel that an orientation in advanced techniques in the field of electromyography would be highly useful for the different projects in hand with him.

The period of placement is proposed to commence from the second half of April on a convenient date, if you are agreeable to the suggestion.

I would deem it a great favour if you could inform me of your consent on the above proposal telegraphically or by telex.

With regards,

Yours sincerely,

(B.B. Chatterjee)
Director

MINISTÈRE DES UNIVERSITÉS

CNAM CONSERVATOIRE NATIONAL DES ARTS ET MÉTIERS

Département des Sciences de l'Homme au Travail
PHYSIOLOGIE DU TRAVAIL — ERGONOMIE

Paris, le 18th October 1983

Mr Registrar
University of Bombay
BOMBAY 400 032
(Indes)

Dear Mr Registrar,

I am very happy to be invited to give my opinion on Dr Pranab Kumar Nag as a candidate to the position of Professor in the University of Bombay, department of Life Sciences.

I met for the first time Dr P.K. Nag in 1975, when he was the best student of my closed friend Pr R.N. Sen of the University of Calcutta. I was after a member of his thesis jury and have given a very high appreciation of which I send a copy under the same cover.

I have followed the researches of Dr P.K. Nag when he was after employed at Ahmedabad Nioh Institute as a senior physiologist. His works are so interesting that I have quoted them many times in my papers and teachings. I have invited Dr P.K. Nag to visit my laboratory for a few months in 1982, but he was not authorized to benefit of this proposal.

All what I know about Dr P.K. Nag convinces me that he would be an excellent professor of your most valuable University and I hope he will be choosen.

Truly yours,

A. Wisner

UNIVERSITY OF BOMBAY **BY AIR-MAIL**

No.TAU/ 6990 of 1983,

Bombay 400 032,

9th October, 1983.

Prof. A Wisner,
Professor of Ergonomics,
Conservatoire National des Arts et Metiers,
41 Rue Gay-Lussac
Paris 75005
France.

Dear Sir/Madam,

I have to inform you that applications were invited by this University for the posts of Teachers of the University, namely, Professors, Readers and Lecturers, vide advertisement dated 31st March, 1983.

2. In the application for the post of Professor in the University Department of Life Sciences, Smt Dr. Pranab Kumar Nag has mentioned your name as one of the persons to whom a reference may be made.

3. I have, therefore, to request you to kindly let me have your opinion about the suitability of the above-mentioned candidate, especially regarding merit/qualifications, etc. so as to enable me to place your opinion before the Selection Committee when it meets to consider the candidature. May I request you to kindly favour me with your opinion within a fortnight?

Thanking you,

Yours faithfully,

for Registrar.

RS:27983.

mgd./2.10.83

To
Prof Wilner,

With much respect, I wish you all happiness in the New Year.

I am delighted to receive a copy of your such a letter sent to Registrar, Univ. of Bombay.

You shall be glad to know that I have submitted a thesis to the Calcutta Univ. for the D.Sc. degree. The thesis deals with the perspectives of work organisation in traditional agriculture.

Sincerely Yours
Pranab

A happy New Year
Is my wish for you,
May life be pleasant
All hopes come true
May a happy year
Bring you joy and cheer.

1th April 1982

Dr D. NAG
NATIONAL INSTITUTE OF OCCUPATIONAL HEALTH
(INDIAN COUNCIL OF MEDICAL RESEARCH)
Meghaninagar
AHMEDABAD 380 016 (INDES)

Dr D. NAG,

Though I had no answer to my letter of 12th.I.82. I have continued to try and have obtained for you an allocation of 8.000 F. (≠1.300 US$) that you can receive in France, if your accept to visit us in October, November, December 82 or the beginning of 1983.
In this sum, you have to include the travel price. The cheapest, with start from Bombay is 3.100 F.F. two-ways.

Could you kindly reply me rather soon, so that I can plan for you and not loose the allocation. Of course I am ready to write any official letter that would be necessary.

Hoping to see you soon.

Truly yours.

A. Wisner

SECRÉTARIAT D'ÉTAT AUX UNIVERSITÉS
CONSERVATOIRE NATIONAL DES ARTS ET MÉTIERS
Département des Sciences de l'Homme au Travail
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One of the most stimulating results of Mr P.K. NAG is the discrepancy between caloric intake and energy expenditure, if we use the usual nomograms established in western countries. There again, an excellent demonstration is given of the need of a differential physiology related to the specific characteristics of the different populations in the world related to their climate, nutritional status and working habits.

If we take the second category of criteria to evaluate the thesis of Mr P.K. NAG, the adequation of his researches to the social needs of India and more generally of the Asian countries, we realize how deep is his understanding of the physiological problems of the indian manual worker and how far he is able to suggest ergonomic solutions.

Mr P.K. NAG has seen how much the classical problems of physical effort and heat load remain of the utmost importance in industrialising countries, but also in so many activities of the countries where industry is dominant. He understands very clearly the relations of these aspects of work with the nutritional status and the socioeconomical strain on food intake. He has also very well seen how much training can influence the real work load of the workers. But perhaps, one of the most interesting aspects of Mr P.K. NAG approach is expressed in his study of the hight and fast printing work so typical of the jobs of mass production industries, more and more frequent in India and the Asians countries. He shows that a pure energy consumption evaluation of the work is not sufficient and that psycho-physiological studies are needed in complement.

As it is written in the begining of this report, Mr Pranab Kumar NAG is really worthy of being recognized as Ph.D. (Sc) of Calcutta University and one the most promising young master of work physiology in the world.

Prof. A. WISNER
PROF OF WORK PHYSIOLOGY & ERGONOMICS
CONSERVATOIRE NATIONAL DES ARTS
ET METIERS
41, RUE GAY-LUSSAC
75005 PARIS
FRANCE

Prof. A. Wisner
Prof. of Work Physiology & Ergonomics
Conservatoire National des Arts et Metiers
41 Rue Gay-Lussac
Paris 75005

23.7.82

Respected Sir,

On my way home from Philadelphia, I have bought ticket of Air France to go via Paris; obviously with the intention to see you at the airport. Because of baggage rules, I could not break the journey in Paris.

I shall be arriving Paris by Air France AF 070 flight from New York at 8-05 AM on 29th July, 1982. My next flight for Bombay is AF 176 at 1-30 PM.

If nothing inconvenient for you, I shall be very glad to see you at the Air France desk of the transit lounge, and have some time to talk to you.

With very best personal regards,

Yours sincerely,
Pranab
(P. K. Nag)

Dear Sir

I apologize for my writing so late in response to your letters Again. I am so much mystified and disgusted of government procedures in victimizing research workers like me. Repeated government circulars over muting the previous axes, put more restrictions on our movement. I tried my best through our director, but to come out with an abvious answer as you must be rightly guessing „No", such invitation can not be exteriorized by government organizations" we are allowed to apply only to those which are advertised through ministry.

Sir, I consider you as my teacher You'll be able to realize my feeling If, some day, I take a drastic step this is to be my all cumulative effects.

I am sorry that I could not honour you by coming to your laboratory for the proposed visit during the period October to December 1982. Recently, D. Sen was with me at Ahmedabad. He is also aware of my position. He also accused me of writing a few lines to you explaining my case

With my very best personal regards.

- brillant chercheur indien à qui j'avais proposé une bourse NEB

Prof. A. Wisner

dt. 30.5.82

Dear Sir,

I apologize for my writing so late, in response to your letters. Again I am so much mystified and disgusted at Govt procedures in victimizing research workers like me. Repeated Govt circulars, overruling the previous ones, put more restrictions on our movement. I tried my best through our director, but to come out with an obvious answer, as you must be rightly guessing, "NO". "Such invitations can not be entertained by Govt. organisations". We are allowed to apply only to those which are advertised through ministry.

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Yours sincerely,

Pranab

Prof. A. Wisner

dt. 30.5.82

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With my best personal regards,

Yours sincerely,

Pranab

MINISTÈRE DES UNIVERSITÉS
CONSERVATOIRE NATIONAL DES ARTS ET MÉTIERS

Département des Sciences de l'Homme au Travail
PHYSIOLOGIE DU TRAVAIL — ERGONOMIE

Paris, le 12th January 1982

Double

Dear P.K. NAG
NATIONAL INSTITUTE OF OCCUPATIONAL HEALTH
(INDIAN COUNCIL OF MEDICAL RESEARCH)
Meghaninagar
AHMEDABAD 380 016 (INDES)

Dear Dr NAG,

I have received your letter of 16 Sept and your good wishes. I thank you for both. I send you also good wishes for youself, your family, you work and your country.

I have read with great interest your four papers who are all very interesting and conviking. I am sure that you are able to present an excellent Doctor of Science Thesis with all the experimental facts and the critical concepts you have produced.

I am so interested by your production that I have carefully examined the possibility of visiting you at the occasion of the AHMEDABAD symposium in February but it has appeared as impossible. In fact, the new french government is very good for science and specially ergonomics but it gives us a lot of work in reports and meetings.

I understand your wish to take part to the world movement in ergonomics, but, in fact, the ressources of the international organisations are rather small now, in relation with the world economical crisis. I hope that the french government will do something more for international exchanges specially in the field of human aspects of transfer of technology and specially with India, which is one of the three countries with wich M. Mitterand wishes to have special connections. I am myself involved in this sort of stories and have written a small book in french on anthropotechnology but the money is not yet there.

What I can do, if you wish, is to invite you at the lab in October, November, December 1982 or the beginning of 1983 with a small grant that I can ask, if you agree, It will not be more than 5000 F.F. that is less than 1000 US for travel and expanses From Paris, you could you to GENEVA (500 km) and visit ILO and WHO.

If you consider this idea as interesting, please write to me.

Truly yours.

A. WISNER

AIR MAIL

BY AIR MAIL
PAR AVION
हवाई डाक से

To

Prof. A. Wisner,

Prof. of Work Physiology and Ergonomics,

Conservatoire National des Arts et Metiers,

41, Rue Gay-Lussac,

Paris 75005

France

NATIONAL INSTITUTE OF OCCUPATIONAL HEALTH
(INDIAN COUNCIL OF MEDICAL RESEARCH)

राष्ट्रीय व्यावसायिक स्वास्थ्य संस्थान

Grams : NIOHEALTH
Phone : 66091-66092
67388-67319
Telex : 012-471

Dr P.K. Nag

Meghaninagar
Ahmedabad-380 016.

Our Ref.

DATE 16.9.81

To

Prof. A. Wisner,
Physiologie Du Travail- Ergonomie,
Departement des Sciences de l'Homme au Travail,
Conservatoire National Des Arts et Metiers,
41, Rue Gay Lussac,
75005 Paris,
France

Respected Sir,

I was glad to receive the action policy paper that you presented at ILO, Asia/Pacific Tripartite regional seminar, Bangkok 24-28 Nov., 1980. I liked the concept of socio-technical island, very much. On a similar line I have sent a paper (Ergonomics approach: a newer perspective in Indian agriculture) to International Labour Review, for publication.

For quite some time I was planning to discuss certain things with you for your elderly valued guidance.

My work on the application of ergonomics in Indian agriculture has come to a shape. I like to submit a thesis to the Calcutta University for Doctor of Science degree, by the end of this year. A portion of the thesis is dealt with policy decision of implementing ergonomics in traditional agriculture. I intend to send a draft write up to you for critical views.

As a career conscious research worker, I do not find here much opportunity of ergonomics research. I am trying to change the place. I applied for ILO assignment and received reply from New Delhi office, vide letter No. PER-102 (G)/2180, dated 30 April, 1980, that my application continues to be registered on candidates active roster for future reference.

If you think that I may be absorbed in any international organisation dealing with research, I will be very much glad and oblige. I want more to know and contribute. I am in need of a place where I can utilize myself better. My attempt in writting a book on Methods in Ergonomics is also shelved due to lack of availability of library materials.

Awaiting for your reply at your earliest convenience.

With very best personal regards,

Yours sincerely,

Nag

Indian J Med Res 74, July 1981, pp 111-119

Voluntary muscular contraction with reference to agricultural tasks

Pranab Kumar Nag and S.K. Chatterjee

Occupational Physiology Division, National Institute of Occupational Health, Ahmedabad

Received September 20, 1980; revised article received January 15, 1981

Endurance capacity and electromyogram of brachialis and brachio-radialis muscles of five agricultural workers in voluntary static muscular contractions were evaluated. Pulling front, pushing downward and pulling upward were sustained at different force levels on a Servo-indicator and the bipolar action potentials of the muscles were recorded in a Beckman rectilinear Dynograph R 612. Maximum voluntary contractions were the same, irrespective of the procedures. However, the endurance times were widely different at submaximal contractions. An exponential decline of the endurance time with increased constant loading on the muscle was evident, while EMG of the muscles also augmented with loading. Average EMG was relatively high in case of pulling upward. Brachialis showed considerably high activity than brachio-radialis muscle in all cases. Initially to start with the pushing or pulling, EMG activity was high in both the muscles, subsequently declining and again being followed by a gradual increase in activity. The action potentials, with preponderance of polyphasic spikes, gradually declined at the end phase of endurance contraction, suggesting exhaustion of the muscle fibres. Since most of the agricultural tasks are intermittent in nature and with frequent interruptions either for changing tasks or taking rest, the endurance times at 20 to 30 per cent of MVC may well be within an acceptable range of constant loading for agricultural tasks.

Agricultural work demands strength and ability to perform skilful actions of various groups of muscles in the form of static muscular contractions in dynamic works as and when grasping and holding tools, and postural control of trunk and head in relation to awkward postures required in day-to-day activity[1,2]. In dynamic work several groups of muscles participate in an alternate fashion, *i.e.* a group of muscles which activates in flexion shows minimum activity in extension. In static work a large number of muscular motor units remain active throughout the duration of work. The amplitude of myopotential and firing rate of the motor units decrease near the end of sustained contraction. With the accumulation of acidic metabolites in the muscle due to sluggish blood circulation, the action potential propagation velocity declines[3]. According to De Luca and Forrest[4], the probability of motor units ceasing to fire after previous firing decreases

exponentially with respect to elapsed time. Thus, the static work is relatively more fatiguing than the dynamic work.

In view of the above, for a human performance assessment of agricultural work, the present study was undertaken to evalute the endurance capacity of subjects in different working positions with special reference to static muscular work as revealed by electromyography.

Material and Methods

Five young healthy male subjects who were habituated to a moderately heavy type of activity, voluntarily participated in the study. Their age ranged from 23 to 28 yr, body weight from 46 to 52 kg and their height from 162 to 169 cm.

Instrumentation : To measure maximum voluntary contractions (MVC) and sustained muscular contractions at different force levels as relative load of MVC, a Servo Indicator (Technolab, India), capable of accepting AC signals of magnitude as obtained from load cell transducers, was used. The Servo indicator is frequently calibrated against standard weight on the load cells. The indicator was accurate to 0·25 per cent.

Bipolar electromyogram (EMG) of two groups of muscle, *i.e.*, brachialis and brachio-radialis of the upper limb of the right arm was recorded in a Beckman rectilinear Dynograph Model R 612. The action potentials of the muscular motor units were picked up by the specially made non-polarisable silver disc electrodes and the Beckman 461 D preamplifiers (9852A EMG integrating coupler and 9856A universal coupler) with low frequency cut off to 5·3 Hz, and amplified through the power amplifiers 412 series with maximal high frequency response. Orienting to the direction of the muscle fibres, disc electrodes were placed close to the anatomical centres of the muscles, with an inter-electrode spacing of 2·5 to 3·0 cm. The subject and instruments were grounded to overcome extraneous radio interferences.

Experimental design : The subjects were instructed to attend the laboratory in the morning hours before being involved in any high physical activity. They were required to visit the laboratory for 5 to 6 days to complete the protocol of the investigation.

Since most of the agricultural tasks involve pushing and pulling in different ways, the load cell transducers were placed with harness in the following ways (Fig. 1) to put musclar exertion while standing.

Pulling front : Right arm (hand supinated) extended forward horizontally at 100 cm height from the ground and pulled load towards body.

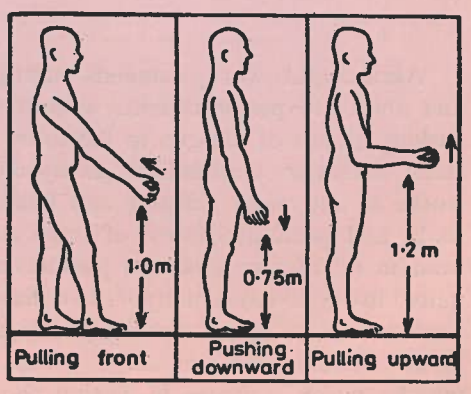

Fig. 1. Three procedures of voluntary muscular contractions.

Pushing downward : Right arm (hand pronated) hanging on the side and pushed load vertically downward at 75 cm height from the ground.

Pulling upward : Right upper arm hanging and forearm flexed (hand supinated) at elbow at an angle of about 90°C and pulled load vertically upward at 120 cm height from the ground.

MVC *i.e.*, the maximally exerted force of the subjects with the above procedures were recorded. Further, the subjects were indoctrinated to exert muscular force at any of the procedures randomly selected to a constant level of MVC, *i.e.* 20, 30, 40 per cent MVC and 50 per cent MVC only in case of pulling front. Endurance time, *i.e.*, sustained contraction at constant force to the longest possible duration in each case was noted. At the end phase of contraction, the force level tended to change due to fluctuations in the effort by the individual. But in no case did it vary beyond 5 per cent of the initial contraction level. Only two contraction levels were chosen for a subject during a day, with a considerable time gap between the contraction, thereby avoiding the influence of repercussions of prolonged muscular contraction to the other. EMG of brachialis and brachio-radialis muscles were continuously recorded for the whole period of endurance contraction. The firing rate and the phasic nature of muscle spikes were obtained[5] from direct EMG recorded through the universal coupler. The signals were of a very high frequency, and therefore for integration, these were routed through the coupler 9852A directly into the input transformer of the preamplifier. After amplification, the signal was passed back into the coupler for further amplification by a single stage transistor circuit in order to provide sufficient signal amplitude for linear rectification by full wave diode rectifier and integration by a low pass filter. The signal turned to DC was then coupled to the power amplifier for recording. Area integration of the records by the planimeter gave the resultant Emg.

Results and Discussion

The MVC of the subjects in pulling front, pushing downward and pulling upward were $28{\cdot}8\pm3{\cdot}7$, $28{\cdot}6\pm3{\cdot}4$ and $26{\cdot}5\pm1{\cdot}3$ kg respectively. Differences in the values were not statistically significant. However, the endurance times at submaximal voluntary contractions varied widely among the procedures (Fig. 2). Endurance time in case of pulling front at 20 per cent MVC was 1940 sec; whereas in case of pushing downward and pulling upward, the endurance times were only 1855 and 680 sec respectively. Such differences are also evident in other submaximal levels. Mathematically the relationship of endurance time and relative load of MVC was formulated as: $Y=ae^{-bx}$ where Y is the endurance time in seconds and X is the percentage of MVC. A pattern of exponential decline of endurance time with increased constant loading on the muscle was observed. The correlation coefficients between the variables for three procedures of contraction varied from 0·833 to 0·983, which are highly significant ($P<0{\cdot}01$). The individual values were : Pulling front, $Y=10^3{}_*11{\cdot}5\ e^{-0.085}X$; $r=-0{\cdot}983$ ($P<0{\cdot}01$). Pushing downward, $Y=10^3{}_*14{\cdot}3\ e^{-0.11}X$; $r=-0{\cdot}883$ ($P<0{\cdot}01$). Pulling upward, $Y=10^3{}_*8{\cdot}97\ e^{-0.13}X$; $r=-0{\cdot}933$ ($P<0{\cdot}01$). The coefficients a and b of the exponential equations are different in each type of contraction.

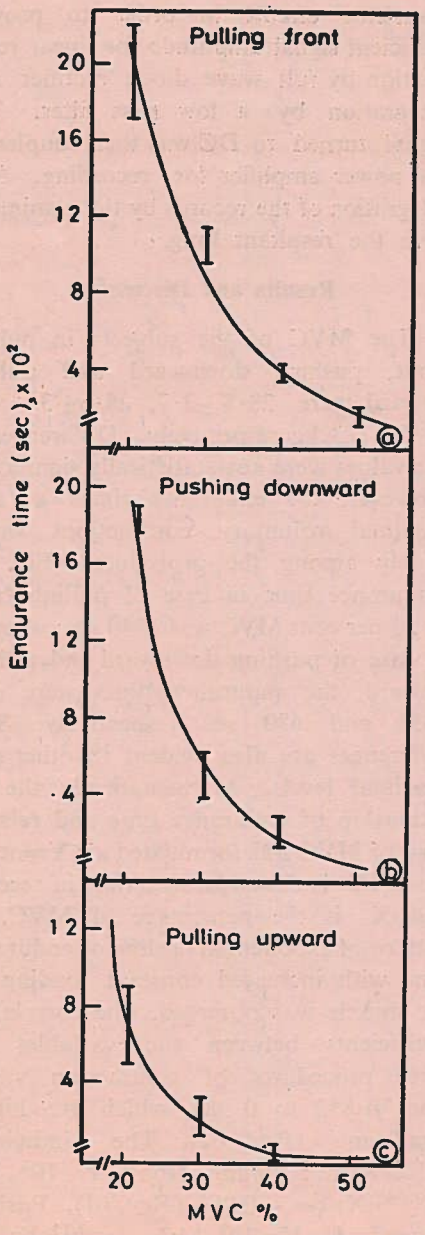

Fig 2. Endurance time versus submaximal levels of MVC in different types of static contractions.

EMG of brachialis and brachio-radialis muscles at the mid contraction phase of pulling front at 20, 30, 40 and 50 per cent MVC are shown in Fig. 3. The r.m.s. values of the resultant summated waves of EMG as mV/sec for three procedures of contraction are shown in Table. Brachialis muscle a 'flexor par excellence of the elbow joint'[6] was relatively more active than brachio-radialis muscle. Brachialis acts mainly across the long axis of the forearm providing acceleration along the path of motion and on the other hand, brachio-radialis remains more or less parallel to the forearm and acts mainly along the long axis of the forearm to provide the centripetal or shunt force and the required stabilization at the elbow joint[7]. However, the EMG of either groups of muscles gradually increased with increase constant loading. The EMG activity was relatively high in case of pulling upward. Minimum EMG activity of brachialis was observed in case of pulling ront. Higher rate of firing (*i.e.* 40 to 45 per sec) was noted in pushing downward both in brachialis and brachio-radialis muscle, though average EMG of the latter muscle was minimum during pushing downward.

The EMG changes during sustained contractions are presented in Figs 4 to 9. To start with the pulling or pushing as the case may be, the EMG activities were high in both the muscles at all levels of MVC. Subsequently, there was a fall followed by a gradual increase in EMG activity. Since surface recorded EMG is attenuated muscle action potentials, a slight alteration of active muscles due to delicate changes in postures or grasping patterns of the hand, may lead to changes in endurance time and EMG during prolonged contractions. EMG of brachialis muscle was consistent through-

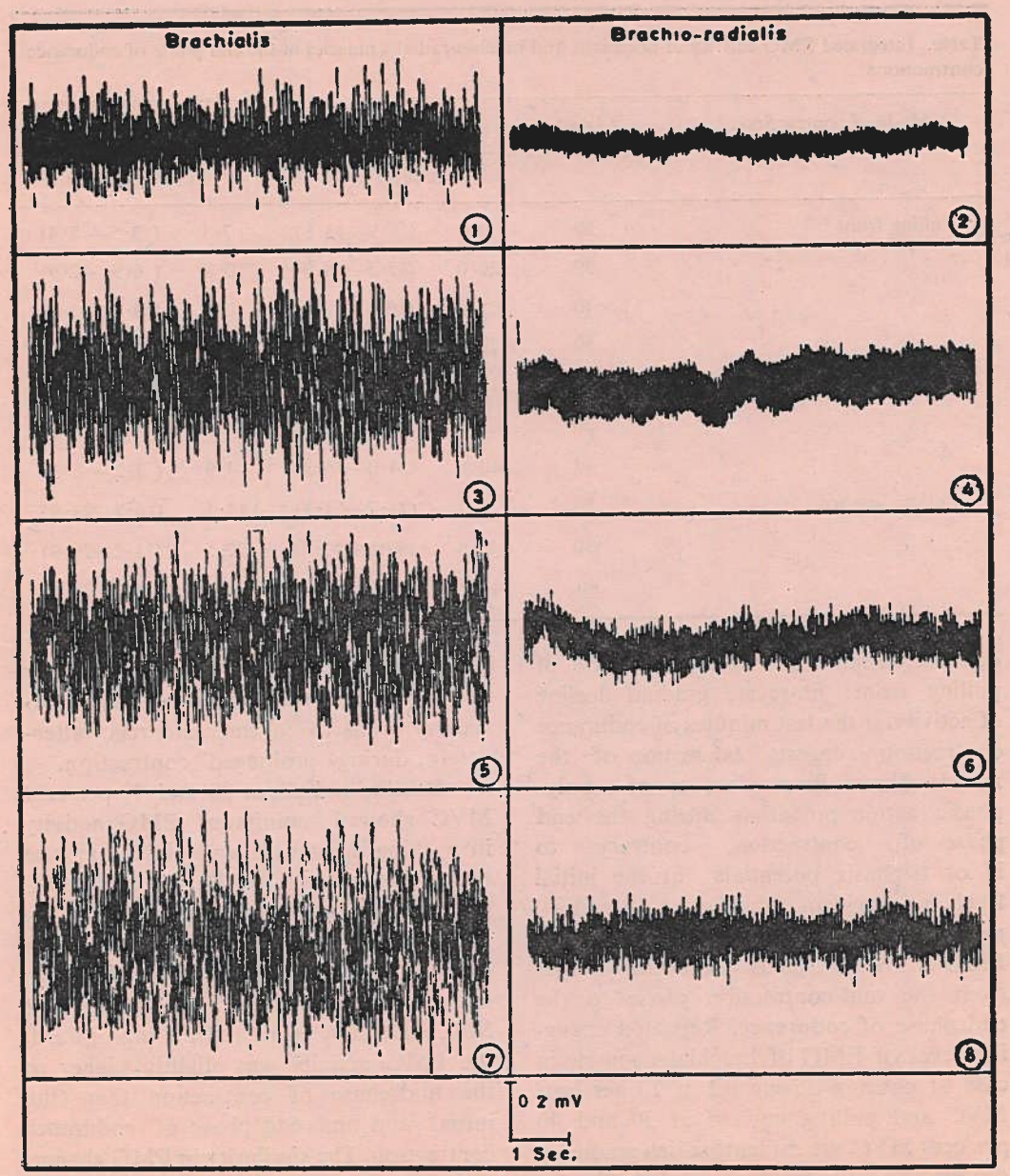

Fig. 3. EMG of brachialis and brachio-radialis muscles at the mid phase of endurance contraction of pulling front.

Table. Integrated EMG activity of brachialis and brachio-radialis muscles at the end phase of endurance contractions

Mode of contraction	Load (% of MVC)	EMG activity (mV/sec) (Mean and range)			
		Brachialis		Brachio-radialis	
Pulling front	20	9·6	(6·9—13·8)	7·3	(3·5— 8·4)
	30	20·0	(15·5—24·3)	10·8	(6·9—12·9)
	40	25·3	(16·5—28·3)	12·0	(8·8—13·4)
	50	29·9	(18·8—39·4)	12·9	(9·1—13·5)
Pushing downward	20	19·8	(6·3—25·5)	3·9	(2·8— 5·8)
	30	23·5	(20·0—26·2)	3·0	(2·1— 3·8)
	40	40·1	(24·0—46·3)	4·9	(3·2— 6·3)
Pulling upward	20	37·3	(21·7—53·3)	11·1	(6·7—23·9)
	30	40·6	(30·9—46·0)	22·5	(11·2—29·9)
	40	44·9	(38·4—52·5)	30·9	(28·9—32·8)

out the sustained contraction in case of pulling front; however, gradual decline of activity at the last minutes of endurance contraction suggests exhaustion of the muscle fibres. Preponderance of polyphasic action potentials during the end phase of contraction, contrary to bi or triphasic potentials at the initial level, was evident, whereas at 30 and 40 per cent MVC of pushing downward the EMG of brachialis muscle declined sharply from the mid-contraction phase to the end phase of endurance. Repeated changing level of EMG of brachialis muscle in case of pushing downward at 20 per cent MVC and pulling upward at 30 and 40 per cent MVC are evident, which gradually declined to a very low level from the moderate EMG activity at the mid-contraction phase. A theoretical explanation of the typical phenomenon that is of frequent changing level of EMG activity at the mid-contraction phase may be that the activated muscle fibres are taken over by recruiting fresh group of fibres to activity so as to contract and relax alternately during prolonged contraction.

Brachio-radialis at 20 and 40 per cent MVC showed minimum EMG activity in pushing downward and highest in case of pulling upward. At 30 per cent MVC the patterns were same both in pulling front and pushing downward. Only in case of the former, absolute EMG was more. On the other hand, at 20 per cent MVC in pulling front and pulling upward, the EMG activity was slightly higher at the mid-phase of contraction than the initial and final end phase of endurance contraction. The similarity in EMG changes with time were noted both in pulling front and pushing downward at 40 per cent MVC, beside absolute difference in EMG. Such trends are also maintained at 50 per cent MVC both in brachialis and brachio-radialism uscles during

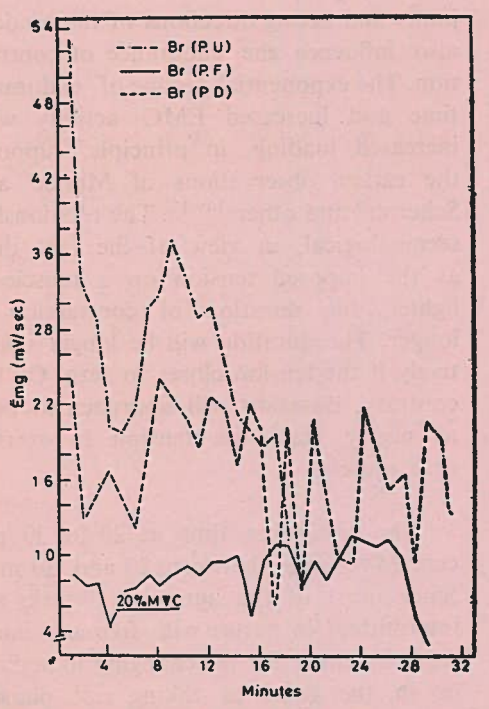

Fig. 4. Summated EMG of brachialis muscle at 20 per cent MVC.

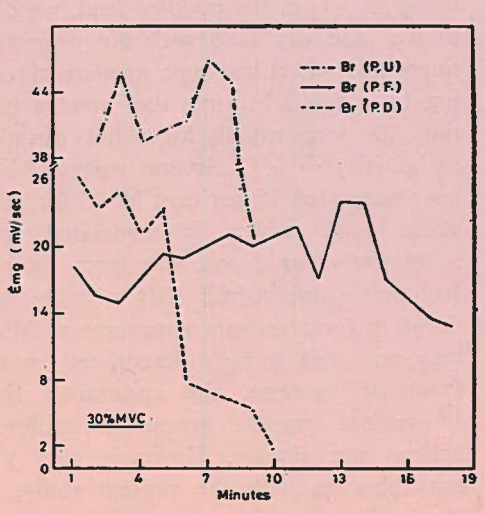

Fig. 5. Summated EMG of brachialis muscle at 30 per cent MVC.

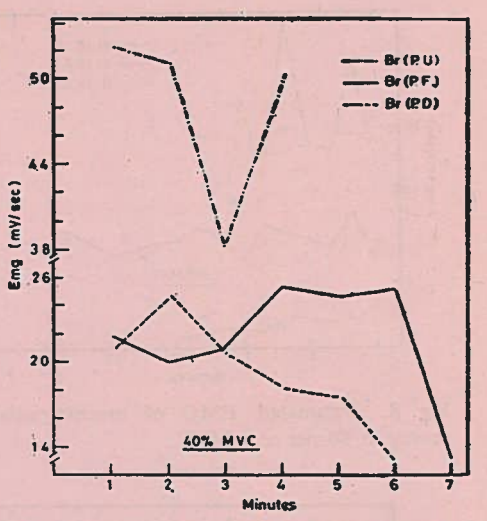

Fig. 6. Summated EMG of brachialis muscle at 40 per cent MVC.

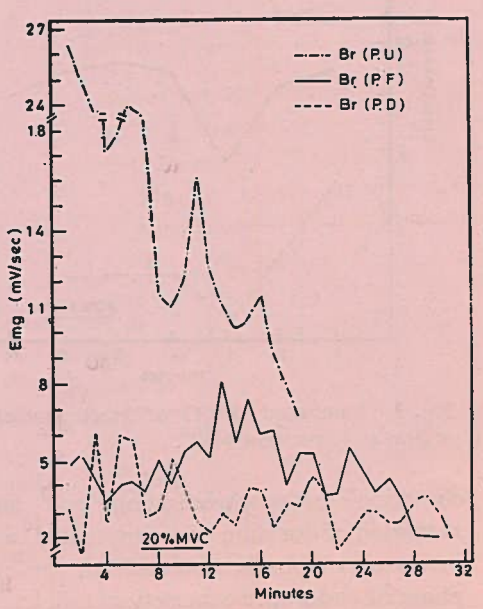

Fig. 7. Summated EMG of brachio-radialis muscle at 20 per cent MVC.

pulling front. The time varying functions of EMG at different levels of MVC clearly indicated fascinating patterns of muscular actions. The study supports the earlier

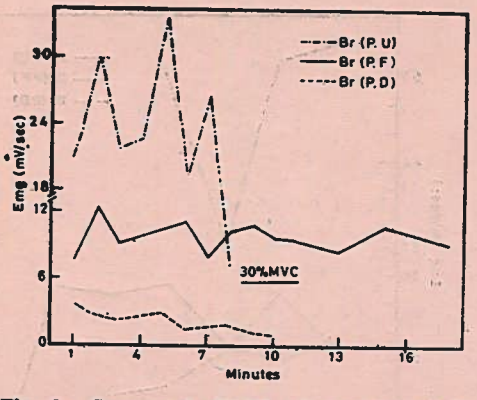

Fig. 8. Summated EMG of brachio-radialis muscle at 30 per cent MVC.

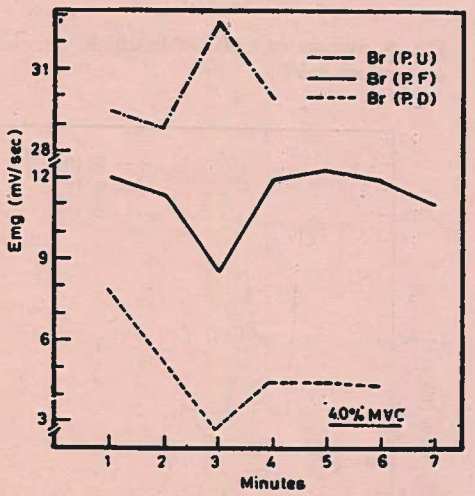

Fig. 9. Summated EMG of brachio-radialis muscle at 40 per cent MVC.

contetion[8] of synchronisation and augmentaion of duration of myopotentials and increased olyphasic potentials at the end phase of endurance contractionat all levels.

The foregoing analysis of results suggests that the endurance time and EMG to static contraction is primarily limited by the circumstances of muscle actions. Constructive differences of the contracted muscle including configuration of the joints and acting directions of the tendons also influence the endurance of contraction. The exponential decline of endurance time and increased EMG activity with increased loading, in principle, supports the earlier observations of Monod and Scherrer[9] and others[10–12]. The relationship seems logical, in view of the fact that, as the imposed tension on a muscle is lighter, the duration of contraction is longer. The duration will be longer infinitively if the tension closes to zero. On the contrary, duration will approach to zero as nearly maximum tension is exerted on a muscle.

The endurance time at 20 to 30 per cent MVC range between 20 and 30 min. Since most of the agricultural tasks are intermittent in nature with frequent interruptions either for the changing in activity or in the form of taking rest pauses, the workers need not sustain static contraction at a stretch for more than 15 to 20 min. Tasks like pulling bullocks, laddering, ploughing, puddling, seedling using seeders in the puddled field, weeding in wet and dry land with the projection finger and wheel hoe type weeders, threshing by manual beating, *etc.* involve high muscular force usually for a short duration of activity[1,2,12,14]. Several workers[9,12,15] have suggested 15 per cent MVC for daily static work which is associated with a relatively rapid recovery from fatigue. Rohmert[12] emphasized that a maximum duration for a certain percentage of MVC may not need to be differentiated by the forms of exercise, the endurance time to various muscle groups in different actions are similar. However, this was not the case with the present study, as the endurance time in pulling upward was much less than pulling front and push-

ing downward, which was further substantiated by high EMG activity. It appears that the endurance time in case of 20 to 30 per cent MVC is within acceptable range of constant loading in agricultural work. The exponential relationship of the endurance time with increased loading suggests that the duration of specific task involving high muscular force may be so arranged as to avoid exhaustion on the muscle fibres. Since rural India does not have the infrastructure to use highly advanced heavy agricultural machineries, there is tendency for large scale placement of smaller implements to minimise overall man-hours involvement and channelise labour power to other tasks. Further studies on both tonic and phasic muscle actions in different postures would be necessary to utilize information in ergonomic designing of indigenous agricultural tools.

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Indian J Med Res 72, September 1980, pp 408-415

Effective heat load on agricultural workers during summer season

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Received September 17, 1979; revised article received March 13, 1980

Effective heat load due to environmental heat, and metabolic heat production of agricultural workers was determined during summer season. ET, CET and WBGT were 30·8°, 31·2° and 30·9°C respectively. Deep body temperature increased to 36·9° and 37·1°C for light and moderate activity of 20 min. Weighted average skin temperature for light and moderate activities were 33·2° and 33·9°C. While radiative heat exchange was 115 W, convective heat transfer was only minus 2.5 W. Effective heat load varied from 171 to 632 W depending on sitting rest to extremely heavy activity. For moderate activity, the heat load was in the range of 403 W. E_{max} was only 96 W and E_{res} amounted to 12 and 25 W for light and mode rate activity. Heat storage rates for light and moderate activity were 25 and 29 W, *i.e.* evaporation occurring through skin varied from 232 (light) to 374 W (moderate work). P_4SR was equivalent to 255 and 580 watt-h for light and moderate activity. E_{req}/E_{max} varied largely from 1·77 to 6·58 (*i.e.*, resting to extremely heavy work). Environmental heat load on the workers performing light and moderate activities was 40 and 27 per cent of total heat load respectively suggesting that with the increased metabolic heat production the relative load due to environmental routes was progressively less.

Heat load on human beings has two facets : external or environmental *i.e.* by means of convection, conduction and radiation, and internal or metabolic. Whenever heat load is imposed on the body, the resulting strain causes physiological reactions in various forms. Many complex factors are related to the heat exchange phenomena between human body and environment[1]. Ultimate adjustment is the steady state of the internal body temperature. Stolwijk and Nadel[2] reconfirmed the view with a provision for applicability up to a certain range of ambient temperature variations.

Agricultural workers in the tropical countries are exposed to environmental heat, along with wide variation in metabolic heat production[3]. The sum total of these sources is the effective heat load on the workers, which has been studied in the present communication.

Material and Methods

To evaluate the heat load on agricultural workers, the traditional use of various heat stress indices were employed. The study was undertaken during summer season in the eastern part of the country. Thermal data were recorded from 120 locations and average thermal value of each location was used for subsequent analysis. On the basis of prediction

equations or nomograms, the empirical thermometric scales like effective and corrected effective temperature[4,5] and wet-bulb-globe temperature (WBGT) index[6] were recorded. These indices gave quantitative assessment of cumulative environmental load. Physiological scales such as predicted 4 h sweat rate[7] with due correction of metabolic heat in wet-bulb increment were calculated using appropriate equations and/or nomograms. The indices of Belding and Hatch[8], Givoni[9] and McKarns and Brief[10] give consideration to the total heat flow by various avenues between man and his environment. Thus, instead of taking individual indices, heat transfer in different avenues were determined on the basis of various equations. Necessary modification of the co-efficients of transfer equations were made for use in Indian subjects.

Twenty two males, (age 21—46 yr) who were apparently free from any disease, volunteered as subjects for the investigation. Physical characteristics *i.e.*, age, body weight, body height and surface area were $32{\cdot}8\pm1.1$ yr, $44{\cdot}3\pm1.8$ kg, $158{\cdot}1\pm2{\cdot}4$ cm and $1{\cdot}50\pm0{\cdot}04$ sqm respectively. In order to see the extent of physiological reactions *i.e.* metabolic heat production and thermo-regulatory responses, physical exercises were performed by them on a Fahrrad's bicycle ergometer. Experiments were done in a field laboratory which was about 50 yards apart from the actual place of work *i.e.* under similar climatic conditions as in occupational work. The braking loads ranging from 30 to 170 W, were selected in such a manner that the physiological demand in terms of VO_{2max} would yield to up to 25, 26 to 50, 51 to 75 and beyond 75 per cent respectively, which were termed as light, moderate, heavy and extremely heavy type of muscular activity. Average VO_{2max} of the subjects[11] was $38{\cdot}37\pm1{\cdot}09$ ml/min/kg, ranging from 35·73 to 42·85 ml/min/kg. The subjects were motivated to continue pedalling at 60 rev/min for longer duration in all workloads.

Deep body temperature was recorded, using a special type of electric thermometer designed by the Medical Research Council, UK (Type NPT2, Deep body thermometers Ltd., England), before, during and after exercise. Skin temperatures of different parts of the body were recorded before and after work with the help of telethermometer thermistor probe (Type FM6, Aplab Electronics Ltd., India). Weighted average skin temperatures were calculated from the fractionated weight of different segments[12] (*i.e.* per cent : head, 8·4; trunk, 55·4; upper arms plus lower arms, 6·60; hands, 1·4; upper legs plus lower legs, 18·6; feet; 3·6 of body weight; and the rest is the central blood), and the surface area of the segments from Meeh[13] constants. Weighting factors of different segments are given below to calculate average skin temperature :

T_{sk} (°C) (Body)$=0{\cdot}08$ T_{sk} (Head) $+0{\cdot}33$ T_{sk} (Trunk)$+0{\cdot}15$ T_{sk} (Arms) $+0{\cdot}05$ T_{sk} (Hands) $+0{\cdot}31$ T_{sk} (Legs) $+0{\cdot}08$ T_{sk} (Feet).

Converging skin and deep body temperature, weighting[14] with 0·10 and 0·90 respectively, the mean body temperature was obtained.

Mathematical treatment of the data was done in a mini computer (Hindustan Computers Ltd, MICRO 2200).

Results and Discussion

Thermometric scales : Different thermometric scales described are given in Table I. The dry-bulb (DB) and wet-bulb (WB) temperatures were 34·3° and 28·9°C respectively and difference between globe temperature and DB was 1·7°C. Data suggested that the environmental heat load varied largely due to difference in the air velocities (mean : 0.43/m sec, with a co-efficient of variation of 120 per cent).

Effective, corrected effective temperature and WBGT were 30·8°, 31.2°, and 30·9°C respectively. Interestingly, prediction of environmental heat load by these indices were similar (CV : 2 per cent) over a large number of data points. Average value of corrected effective temperature is much nearer to the upper prescribed limit (31°C) for heat acclimatised men[6]. When corrected effective temperature is 29°C or above, there is a risk of heat injury for unacclimatised persons, performing moderate activity[6]. Goelzer[15] suggested the permissible heat exposure threshold limit value for WBGT in case of continuous light and moderate work as 30·0° and 26·7°C respectively; and for 50 per cent work and 50 per cent rest in each hour, the corresponding values are 31·4° and 29·4°C respectively. However, agricultural workers are habituated to work at these high heat level. Average working hours of the agricultural workers was about 8·2 h, of which sitting and standing light work involves 2·75 h, sitting and standing rest : 2·33 h, walking : 0·80 h, moderate work : 1·72 h, heavy and extremely heavy work involve 1·20 h respectively. Hence, these subjects are expected to show the evidence of physiological acclimatization to heat.

Table I. Thermometric values recorded in agricultural field during summer season

(Data are mean±SE)

Parameter	
Dry-bulb temperature (°C)	34·3±0·3
Wet-bulb temperature (°C)	28·0±0·2
Globe temperature (°C)	36·0±0·3
Air velocity (m/sec)	0·43±0·05
Vapour pressure (mm Hg)	37·2±0·7
Effective temperature (°C)	30·8±0·1
Corrected effective temperature (°C)	31·2±0·1
Wet-bulb-globe temperature (°C)	30·9±0·2

Body temperature : Deep body thermometer has the advantage of recording temperature fluctuations continuously, even when the duration of work is as short as 10 min. However, the only difficulty was the unequal duration required for the temperature pad to get stabilized with the internal body.

Temperature of the body reached to a level depended to a great extent upon the resting temperature prior to exercise. Since body temperature could not be recorded during actual work, the temperatures were recorded in the laboratory as close to the field condition as possible and at the same levels of metabolic heat production as in usual work. However, the subjects could not continue pedalling for more than 20 min in heavy and extremely heavy type of load, in spite of motivation. Thus, deep body temperatures recorded only for rest, light and moderate work are presented in Table II. Deep body temperature during rest was 36·7°C; with light and moderately heavy work the temperature increased to only 36·9° and 37·1°C within a period

Table II. Body temperatures (°C) of agricultural workers in different degrees of work

(Data are mean±SE)

Temperature	Rest	Light work	Moderate work
Deep body temperature	36·7 ±0·14	36·9 ±0·12	37·1 ±0·12
Skin temperature weighted	33·2 ±0·76	33·2 ±0·12	33·9 ±0·22
Mean body temperature	36·5 ±0·14	36·6 ±0·14	36·8 ±0·12
Heat storage rate (watt-h)	—	25·4 ±8·2	29·1 ±12·9

of 20 min. Average skin temperatures for rest, light and moderate type of work were 33·2°, 33·2° and 33·9°C respectively *i.e.*, the skin temperature was more or less constant.

Mean body temperature during rest and in light to moderately heavy work varied from 36·5° to 36·8°C. Heat storage rate per hour for light and moderate activity were 25 and 29 W respectively. As suggested by Olsen and associates[16], the constancy in mean body temperature (*i.e.*, 36·5°C to 36·8°C) probably implies the allowable limit at which effective thermoregulation may be achieved.

Radiative heat exchange : In the agricultural field solar radiation contributing directly to effective radiant field was measured[1] from black globe temperature recorded in a diffuse area and converting to mean radiant temperature with due correction for skin-coloured globe. The total radiant heat exchange (W) was calculated from the equation :

$$R = A_r\ h_r\ (T_r - T_{sk})\ F_{cl}$$

in which A_r is the effective radiant surface area, T_r is the mean radiant temperature and T_{sk} is the skin temperature. F_{cl} is the non-dimensional thermal efficiency factor of clothing. Due to the complex shape of human body, the effective radiant surface area varies depending upon postural changes of the body. Effective radiant surface area to whole body surface area has been found to vary from 70 per cent for sitting to 73 per cent for standing, which were obtained by integrating projected areas obtained by photographing the human subject[17] from many directions. By using optical methods, Fanger[18] could get a somewhat smaller value *i.e.*, 72·5 per cent for standing subjects and 69·9 per cent for sitting subjects. Radiant heat transfer co-efficient (h_r varied from 5·4 to 5·6 W m^{-2}/°C for dry to wet skin respectively[19]. The radiative gain (Table III) was calculated as 115 W with

Table III. Heat transfer through different avenues

(Data are mean±SE)

Heat exchange parameters (W) :	
Convection	−2·5±3·2
Radiation	115±21
Maximum evaporative power E_{max}	96±14
Evaporation through respiration :	
Resting	5±0·4
Light work	12±0·9
Moderate work	25±1·8
Heavy work	37±2·7
Extremely heavy work	49±3·6
Convection through respiration :	
Resting	−0·4±0·1
Light work	−0·3±0·7
Moderate work	−1·0±0·5
Heavy work	−2·9±0·7
Extremely heavy work	−3·5±0·9

a co-efficient of variation of 177 per cent indicating that the range of data was quite large. Usually, the clothing represents a layer of insulation in transfer. But for practical purposes, the male agricultural workers, wear shorts and banians. The insulative value of clothing[20] was calculated as 0·10 to 0·20 Clo. Since clothing was meager, no correction was made in the radiative exchange.

Convective heat transfer : Forced convection of air gives rise to convective heat exchange in the body which is expressed as : $C=A_c\ h_c\ (T_a—T_{sk})\ F_{cl}$ in which C is the convective heat transfer rate in W, A_c is effective body surface area, h_c is convective heat transfer co-efficient. T_a and T_{sk} are the air and skin temperature respectively; and F_{cl}, the factor of clothing, is ignored. Convective heat transfer co-efficient is dependent on air velocity. Nishi[21] derived the convective co-efficients of different segments of the body in different postures, which varied widely from 2·5 (chest, standing mannikin) to 17·0 $W\,m^{-2}{}^{\circ}C^{-1}$ (upper arm, free walking at 6·4 km/h). Based on an investigation which is being reported elsewhere, using thermo-anemometer within the microclimate of different segments of the body, weighted average convective co-efficient was taken as 5·8 $Wm^{-2}/^{\circ}C$ in the present consideration of the agricultural workers. Average convective heat transfer (Table III) was only minus 2·5 W, indicating no average heat gain through this route.

Metabolic heat exchange : Severity of most of the agricultural work varied from light to moderately heavy[3,22]. When the whole day energy expenditure was taken into account, the time-weighted average energy demand was around 14·6 kJ/min, which corresponds to moderate activity. Indicative values representing light, moderate, heavy and extremely heavy work were up to 565, 1130, and 1690, and above 1690 kJ/hr respectively. About 14 per cent of the total working hours were occupied by heavy and extremely heavy activity. Hence, all the categories were considered individually with the environmental heat load to arrive at the effective heat load. A portion of metabolic cost is utilised for performing a certain amount of mechanical work. The ratio of mechanical work to metabolic heat, representing mechanical efficiency was considered negligible in light and moderate agricultural tasks (*i.e.* laddering, fertilizing, cutting crops, irrigating, uprooting, weeding, sowing, transplanting, winnowing *etc.*), as these require mostly stationary activities. However, for heavy to extremely heavy work (*i.e.* weeding, threshing, ploughing, digging soil, bund trimming *etc.*) the efficiency of work was estimated to be around 10 per cent *i.e.* equivalent to about 47 to 62 W. The effective heat load of the workers (given in Table IV), varied from 171 to 632 W (expressed per hour) depending on sitting rest to extremely heavy activity. Since the light and moderate activities required respectively 23 and 63 per cent of the total manhours involved in agricultural work[3], it may be considered that the rate of heat gain is maximum in the range 403 W.

Evaporative heat transfer : Total heat load needs to be balanced by evaporative loss so as to avoid hyperthermia. The classic heat balance equation describing thermal exchange is : $S=M—E—W\pm R\pm C$, where S is rate of heat storage by the body (W); M is rate of metabolic heat production; E is the rate of evaporative

Table IV. Effective heat load on the agricultural workers

(Data are mean ± SE)

Total evaporation required (E_{req}, W)	
Resting	171 ± 10·5
Light work	257 ± 7·6
Moderate work	403 ± 6·4
Heavy work	500 ± 6·0
Extremely heavy work	632 ± 5·7
Predicted 4-h sweat rate	
Light work (l)	1·232 ± 0·04
(Watt-h)	255 —
Moderate work (l)	2·788 ± 0·06
(Watt-h)	580
E_{req} E_{max} *100	
Resting	177 ± 30
Light work	268 ± 61
Moderate work	419 ± 94
Heavy work	521 ± 170
Extremely heavy work	658 ± 176

heat transfer (minus for net loss); W is rate of work (plus for positive work); R and C are the rate of radiant and convective heat exchange (plus for net gain). Thus, the maximum evaporative power calculated from the equation[23], $E_{max}=10{\cdot}3\ V^{0{\cdot}4}\ (P_{sk}-P_a)$, ($P_{sk}$ and P_a, are the vapour pressure at skin surface and of ambient air respectively) was only 96 W.

A portion of heat loss is possible through respiration as evaporation and convection. Evaporation of water from the respiratory tract was calculated from the equation[24], $E_{res}=0{\cdot}0023\ M(44-P_a)$ where E_{res}=respiratory evaporative heat loss in W m^{-2}; M=metabolic rate in W m^{-2}; P_a=water vapour pressure of inspired air in mm Hg. Instead of 44 mm Hg, 42 mm Hg vapour pressure was used, taking into account the water vapour pressure of expired air temperature. Convective respiratory heat transfer was similarly obtained from : $C_{res}=0{\cdot}0014\ M\ (33-T_a)$. Respiratory evaporative loss from light to extremely heavy work varied from 12 to 49 W, while for moderate work it amounted to 25 W. On the other hand, convective respiratory heat transefr values were negative (*i.e.*, minus 0·3 W for light activity and minus 3·5 W for extremely heavy activity). However, variations in respiratory convective heat transfer were more compared to the evaporative loss.

The rest of the total evaporation required to achieve no heat storage, takes place through the skin in two distinct ways : the evaporation of water diffusing through the skin and evaporation of water secreted at the surface of the skin by sweat glands. Since heat storage rate for light and moderate activities were 25 and 29 W, as indicated earlier, evaporation occurred by the above mentioned routes for light and moderate activity amounted to only 232 and 374 W. Predicted 4-h sweat rate calculated for light and moderate metabolic demand was 1·232 and 2·788 l (*i.e.* equivalent to 255 and 580 watt-h respectively).

The ratio of E_{req} to E_{max} expressed as percentage is given in Table IV. When the ratio exceeds unity (100 %), the level of discomfort and physiological strain increases. However, E_{req}/E_{max} varied largely from 177 to 658 (*i.e.*, from resting to extremely heavy work), suggesting a substantially wide range of heat load on the agricultural workers. Considering all factors, it is noted that during light and moderate activities, the environmental heat loads on the agricultural workers were about 40 and 27 per cent

of the total heat load respectively *i.e.* with increased metabolic heat production the relative load due to environmental routes was progressively less. In order to reduce the effective heat load on the agricultural workers, the other alternative would be to adjust the internal metabolic demand accordingly, by a downward adjustment of occupational work load.

Acknowledgment

The authors express their sincere gratitude to Dr S.K. Chatterjee, Director of the Institute for his keen interest in and valuable suggestions for the study. Thanks are due to Shri. M.S. Vaghela for technical help.

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J. Human Ergol., **8**: 13–21, 1979

EFFECTIVENESS OF SOME SIMPLE AGRICULTURAL WEEDERS WITH REFERENCE TO PHYSIOLOGICAL RESPONSES

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Seven different weeders used in agricultural operations were studied with reference to physiological responses and area weeded per unit time by using each method, and manual weeding. Five young skilled agricultural workers were used for the study. Average work pulse rate varied from 105 to 120 beats/min in weeding operations using blade- and rake-type, projection finger-type and double sweep-type weeders. The lowest cardiac response was observed with the wheel hoe-type weeder. Blood pressure responses were also higher with other three weeders mentioned above. Pulmonary demand was around 27 *l*/min with all the weeders; but the highest oxygen uptake (56% of the maximal oxygen uptake) occurred in case of a projection finger-type weeder. The maximum area was weeded (1.42 m^2/min) by the wheel hoe-type weeder. Comparing physiological demand, work performance and preference of the workers, the wheel hoe-type of weeder was found to be the best for Indian workers.

Agricultural operations in developing countries like India, are mostly labour-intensive. Individual farmers lack the capital to purchase tractors or combine harvesters. Some government sectors like block-developing organizations, agricultural universities, and research institutes may be provided with sophisticated machinery, but the huge labor force does not have technical training, nor experience to operate such machinery.

It is, therefore, of great importance for the ergonomists in developing countries to critically observe different agricultural operations with a view to providing laborers with low-cost indigenous tools at nominal cost that are simpler to operate, but better in performance. Thus, the total energy demand of the workers can be minimized and the work performance can be increased. The present report deals with the most commonly employed agricultural operation of "weeding," which is done manually as well as with the use of different types of

Received for publication June 17, 1979.

indigenously fabricated weeders. The physiological responses of the habituated skilled agricultural workers in different operations are compared.

DESCRIPTION OF WEEDING AND THE WEEDERS

Unwanted weeds growing in among cultivated plants, such as rice, wheat, potato, etc., need to be removed by the roots in order to get best utilization of the land and fertilizers. Of total man-hours involved in agricultural work during the cultivating season, as much as 15 percent labor is spent on cutting weeds from watered or dry land. The operation is commonly called weeding. Both males and females are employed in this work.

Weeding is usually done in two postures. On dry land, workers sit on the ground with one or both legs flexed at the knee and remove the weeds using a sickle. On watered land, workers bend forward in a stooping posture and remove the weeds by hand (Fig. 1a, b). Although some simple weeders are available nowadays, these are not used by most farmers, because they rely on traditional work methods.

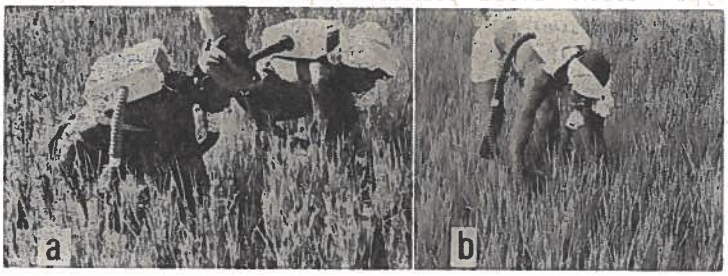

Fig. 1. Weeding operations. (a) sitting, with one or both legs flexed at knee; (b) bending posture.

We found different kinds of weeders for use in the present study. The objective was to compare the physiological responses and the man-hours involved in weeding per unit of land with different weeders. The description of each weeder is given below (Fig. 2, a–g).

DESCRIPTION OF THE WEEDERS

Projection finger-type weeder. Just as the projected fingers of the hand are used in scratching this weeder works in the same prehensile fashion. It has two long sweeps of 26 cm each in the front row and two short sweeps of 17 cm length fitted with a handle bar. The sweeps are made up of iron rods. The length of the bar varies depending upon the choice of the user. This weeder is specially designed for dry lands, but it can be equally used in wet lands in some of the

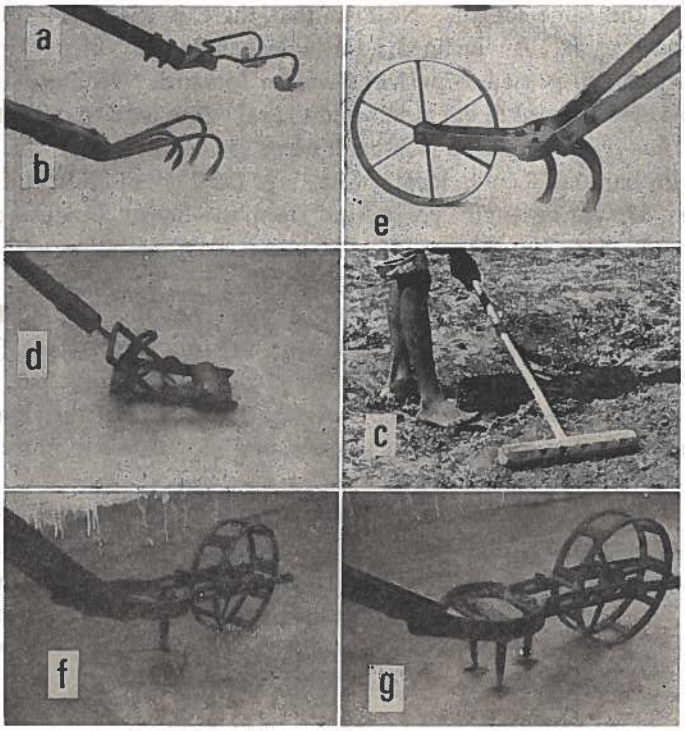

Fig. 2. Different agricultural weeders to cut and uproot unwanted weeds. (a) double sweep-type; (b) projection finger-type; (c) single-row, multiple sweep-type; (d) blade-and-rake-type; (e) wheel hoe-type; (f) single sweep-wheel-type; (g) triple sweep-wheel-type weeder.

eastern states of the country.

Double sweep-type weeder. Unlike the projection finger-type, it has only two sweeps (*i.e.*, 25 cm length) with a sharpened arrow (8.2 cm length) attached with a wooden handle. The distance between the sweeps is 13 cm and the length of the handle was 140 cm. This can be used for dry as well as wet lands. This type of weeder is not, however, frequently used.

Single row, multiple sweep-type. It has a wooden bar of approximately 40 cm in length in a multiple number (usually six) of sharp wooden rakes attached. Each rake is about 9 cm long. The handle bar is fixed at an angle of about 45° to the rakes. As the weeder is pulled over the ground a very large area can be weeded at a time. This weeder is not usually used in rice cultivation (as the space between two rice plants is not enough for a such weeder), but is most commonly used in the cultivation of crops such as potatoes, onions, melons, ground nuts, etc. It is commonly used in the western part of India.

Blade-and-Rake-Type. It has a rectangular metal frame with a blade of 10.6 cm in length and 3 cm in width. Adjacent to the blade is a roller (5 cm

diameter) of the same length. Next to that there is a row of four rakes of 4 cm in length each. An inclined adjustable handle bar, 140 cm in length, is fixed backward, and is used to push the weeder forward. While rolling over the dry land, the blade is used to cut weeds and the rakes are used to uproot the weeds.

Wheel hoe-type. It has an iron-band wheel (33 cm diameter) which is attached to an iron bar, 6 to 8 cm in length, with three fixed hoes of different sizes. Two handle bars, 120 cm in length, project out from the hoes. Because of the hoes and two handle bars, this weeder is better balanced in operation and is relatively easy to push.

Single sweep-wheel-type. Unlike wheel hoe-type, this has a sharp broad sweep of 16 cm in width, and is fixed with an iron band wheel (25 cm diameter). The angle of the sweep can be varied. A handle bar, 136 cm in length, is also attached to the sweep. As the sweep passes through the soil it can weed more area at a time, and it also requires more force to move it forward. However, this type of weeder is preferred by many workers.

Triple sweep-wheel-type. It is almost similar in appearance to the single sweep-wheel-type weeder. Instead of a simple broad sweep, there are three sweeps, each 4 to 4.5 cm in width, attached with an iron band wheel and an adjustable handle bar. As far as preference of the workers is concerned, there is a similarity in opinion about the use of a single and triple sweep-wheel-type weeders.

PHYSIOLOGICAL MEASUREMENTS

Five healthy young (age: 23.4±1.0 years) male subjects skilled in agricultural work took part in the experimental trials. The study was done in the morning of a work day during the summer season. The average dry-bulb and wet-bulb temperatures were 34.3 and 28.9°, respectively. The average physical characteristics of the workers are given in Table 1.

Table 1. Physical characteristics of agricultural workers.

Variables	Mean	Standard error	Coefficient of variation
Age (years)	23.4	1.9	18.5
Body height (cm)	165.6	1.9	2.6
Body weight (kg)	49.9	0.8	3.6
Body surface area (m^2)	1.61	0.02	3.0
Lean body weight (kg)	42.4	0.6	3.0
Maximal oxygen uptake (*l*/min) STPD	2.065	0.360	39.3

Initial physiological measurements, including metabolic rate, pulse rate and blood pressure, were recorded after allowing the subject to take a sitting rest for more than 15 min. The physiological responses were recorded while the subject performed the weeding job, manually in two postures and using the above-mentioned weeders. The total area of the land weeded per unit time by each method was recorded using the work study technique.

Metabolic rate was determined using the traditional open-circuit method. The expired air of the subject was recorded through a K-M respirometer and the oxygen content of the sample of the expired air, collected through a side tube of the respirometer, was analysed using a Beckman paramagnetic oxygen analyser. The pulse rates were obtained from the stop-watch time required for 10 pulse beats immediately after cessation of work. The blood pressure was noted at the end of work while the subject was sitting on the ground.

The maximal oxygen uptake of the subject was determined by an all-out exercise using bicycle ergometry and the relative load of the weeding operations were calculated in terms of percentage of the maximal oxygen uptake.

RESULTS AND DISCUSSION

The average body weight of the subjects was 49.9 kg and the average lean body weight was 42.4 kg. The subjects were well motivated and skilled in doing agricultural jobs. The average daily energy intake level was 11.72 MJ, of which 85 of the total energy was derived from carbohydrate diets. As low as 8.6 and 4 percent of the total energy were obtained from protein and fat, respectively. The muscular growth of the subjects was similar to the average eastern Indians (SEN, NAG and RAY, 1977). The average maximum oxygen uptake of the present workers was 2.065 *l*/min per kg body weight (*i.e.*, 41.3 ml/min/kg). This average value is slightly on the higher side compared to our other agricultural workers (National Institute of Occupational Health, 1976; NAG, *et al.*, 1978) of the same age group. The average maximum hand grip strength of the subjects measured by a dynamometer was found to be 32.4 kg, *i.e.*, 20 percent of the maximum value is 6.5 kg, the level at which the subjects may be allowed to work where the static muscular contractions are much involved (ROHMERT, 1973; LIND, *et al.*, 1976).

The physiological responses of the subjects are shown in Table 2. Each of the ways of doing the weeding operation requires postural maintenance as well as voluntary contractions in pulling or pushing of the weeders through dry or wet soil. Thus, the physiological responses varied in a characteristic manner in each of the operations. The cardiovascular repercussions are observed from pulse frequencies, and systolic and diastolic blood pressure, and the respiratory demands are noted from pulmonary ventilation and oxygen uptake in terms of maximum oxygen uptake. The average work pulse rate varied from 105 to 120

Table 2. Physiological responses of the agricultural workers in weeding operations.*

Weeding operations	Pulmonary ventilation (*l*/min) BTPS	Oxygen uptake (*l*/min) STPD	Energy expenditure (kJ min^{-1})	Average work pulse rate (beats/min)	Blood Pressure (mm Hg)		Relative cost of V_{O_2} max (%)
					Systolic	Diastolic	
Weeding (sitting with one or both legs flexed at the knee)	17.7±1.2 (23.5)	0.573±0.040 (25.3)	11.90±0.85 (25.4)	113.3±3.6 (8.4)	115.2±6.5 (12.6)	79.0±3.8 (10.7)	27.8±5.1 (40.7)
Weeding (bending)	16.6±3.2 (38.4)	0.578±0.120 (41.5)	12.18±2.51 (41.2)	114.0±2.7 (4.7)	120.4±4.5 (10.2)	82.0±6.0 (8.5)	28.0±4.3 (34.0)
Projection finger-type weeder	27.7±1.3 (10.2)	1.158±0.223 (43.1)	20.70±1.86 (20.1)	119.6±5.3 (9.8)	130.0±2.7 (4.6)	70.8±7.0 (22.0)	56.1±7.8 (31.2)
Double sweep-type weeder	27.8±1.0 (8.0)	0.998±0.078 (17.6)	20.88±1.66 (17.7)	120.4±7.3 (13.5)	128.0±6.0 (9.3)	83.0±3.1 (7.5)	48.3±7.6 (35.9)
Single row, multiple sweep-type weeder	17.7±2.3 (32.3)	0.569±0.049 (21.1)	11.91±1.02 (21.1)	—	—	—	27.6±3.7 (30.0)
Blade-and-rake-type weeder	27.3±2.7 (22.2)	0.932±0.153 (36.7)	19.61±3.20 (36.4)	120.4±7.7 (14.3)	130.0±5.9 (8.9)	70.0±6.2 (17.6)	45.1±9.2 (45.8)
Wheel hoe-type weeder	28.0±2.6 (20.7)	0.996±0.116 (26.1)	20.91±2.44 (26.1)	105.2±3.7 (7.9)	119.2±2.3 (4.4)	70.0±5.4 (17.2)	48.2±10.9 (50.7)
Single sweep wheel-type weeder	26.3±1.7 (13.2)	0.853±0.106 (25.0)	17.93±2.23 (24.9)	116.7±8.0 (13.6)	126.8±5.0 (8.8)	66.4±5.4 (18.2)	41.3±3.9 (21.0)
Triple sweep wheel-type weeder	27.6±0.7 (15.9)	0.898±0.047 (11.6)	18.01±1.38 (17.1)	113.4±7.2 (14.1)	126.4±4.5 (8.0)	70.8±6.0 (18.8)	43.5±7.8 (39.9)

* Values are means±standard errors and the coefficient of variation in the brackets.

beats/min, of which repurcussions in case of the blade-and-rake-type, the projection finger-type and the double sweep-type weeders are slightly on the higher side compared to other types and manual jobs. The lowest cardiac response was observed in the case of wheel hoe-type weeder. This weeder needs relatively less muscular exertion while pushing through, and it is liked by many of agricultural workers. Even the manual weeding operations in the sitting and bending postures demand more cardiac strain (*i.e.*, 113 and 114 beats/min) than in case of the wheel hoe-type weeder. These responses are further substantiated from the blood pressure variations. In each case of weeding operation, maximum systolic blood pressures (*i.e.*, 128 to 130 mm Hg) were noted with the blade-and-rake-type, the projection finger-type and the double sweep-type weeders. The interindividual variations, as observed from the coefficient of variations, were also not very large in blood pressure responses with the above-mentioned weeders. Relatively less blood pressure was observed in case of the wheel hoe-type weeder (*i.e.*, 119 mm Hg), which is more or less similar to the blood pressure level in manual operations in either of the postures. The high systolic blood pressure in weeding operations with some of the weeders suggests relatively more static contractions involved in this work. On the other hand, the diastolic blood pressure in weeding operations with different weeders, except the double sweep-type, are relatively less than the manual weeding and a constant diastolic pressure of 70 mm Hg was noted with different weeders.

The pulmonary ventilation for manual weeding varied only around 16 to 17 *l*/min at BTPS. But with other weeders the pulmonary demand was around 27 *l*/min, which is almost constant. Except in one or two cases, the co-efficient of variations were also within 20 percent, suggesting minimum interindividual variation. However, the variations of pulmonary ventilation in case of manual weeding (bending and sitting) were quite large, as the coefficient of variations were 38.4 and 23.5 percent in bending and sitting, respectively.

On the other hand, the oxygen uptakes for manual weeding were only 0.573 and 0.578 *l*/min per 50 kg body weight, which represent about 27 percent of the maximum oxygen uptake. And the oxygen uptakes with all the weeders varied from 0.898 to 1.158 *l*/min per 50 kg body weight, (*i.e.*, the relative cost varying from 43 to 56 percent of the maximum oxygen uptake). Although weeding with the projection finger-type weeder is relatively simple, the physiological demand is highest (*i.e.*, 56 percent of the maximum oxygen uptake). The intermediate values, *i.e.*, 43 to 48 percent of the maximal oxygen uptake, correspond to weeding with the blade-and-rake-type, the double sweep-type, the triple sweep-type and the whole hoe-type weeders. It can be stated that the dynamic muscular components involved in work with the above mentioned weeders are almost similar, as the variations in pulmonary ventilations and oxygen uptakes, the parameters better related to the rhythmic muscular component, are limited within a certain range. The operation, however, can be

categorized as moderately heavy as these operations demand energy cost within 50 percent of the maximum oxygen uptake.

As regard the efficiency of the weeders compared to manual weeding, the total land weeded per unit time was noted. Needless to say, the performance with the weeders was much more than the manual hand weeding, but the variations in performance, as the area weeded per unit time with the different weeders, were very large. The area covered by the skilled workers using the projection finger-type and the blade-and-rake-type weeders were only around 0.41 and 0.38 m^2 per min, respectively. With the double sweep-type, the single sweep wheel-type and the triple sweep wheel-type weeders, the average workers weeded the area of 0.72, 1.09 and 1.06 m^2 per minute, respectively. The maximum performance was obtained with the wheel hoe type weeders (*i.e.*, 1.42 m^2/min).

As a matter of fact, much of deviation of the centre of gravity from its most supportable vertical line was observed only in case of the projection finger-type and the blade-and-rake-type of weeders and thus demand more of postural support. That was also partly reflected in the higher oxygen uptake compared to others. Beside the manual weeding, it is mentioned earlier, the projection finger-type of weeders are commonly used in the eastern India and the multiple sweep-type of weeders are very common in the western India. As the wheel hoe-type weeder is mostly preferred by the agricultural workers and the physiological demand with this weeder is minimal and as area weeded the performance is maximum, it is suggested that the initiative may be taken to replace manual weeding and weeding with the projection finger-type weeders by the wheel hoe-type weeders for Indian workers.

The authors sincerely acknowledge the kind permission and the keen interests of Dr. S. K. Chatterjee, Director, National Institute of Occupational Health, Ahmedabad, and Dr. C. Pande, Director, CRRI, Cuttack, Orissa to carry out this collaborative study. Technical assistance of Mr. N. C. Sebastian, Mr. M. G. Mavlankar and Mr. M. S. Vaghela of NIOH is gratefully acknowledged.

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ERGONOMICS, 1980, VOL. 23, NO. 2, 91–102

Occupational workload of Indian agricultural workers

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The occupational workload of 13 agricultural workers was determined during a summer season, on the basis of cardio-respiratory responses and individual capacity to perform work. Thirty different agricultural operations were observed during the actual working season. $\dot{V}O_2$max of the workers was 34·8 $cm^3\,min^{-1}\,kg^{-1}$, ranging from 28·6 to 41·5 $cm^3\,min^{-1}\,kg^{-1}$. Pulmonary ventilation during the operations varied from 14 to 411 min^{-1}; only water lifting, bund trimming in dry-land and pedal threshing operations demanded more than 301 min^{-1}, and these were found to be the heaviest jobs in agricultural work. About 29% of total man-hours are involved in light work, 64% in moderate work and only 6% in heavy work. Daily energy expenditure of the workers varied from 10·3 to 11·7 MJ, of which 53 to 56% energy was expended during the working day (*i.e.* the time-weighted work demand was about 30 to 40% of $\dot{V}O_2$ max) and about one-fifth of total heat production of the body was external thermal load.

1. Introduction

Physiologists and ergonomists have determined the energy needs of many industrial workers and miners in India during occupational work and leisure-time activity (Banerjee *et al.* 1959, Chakraborty and Guha Ray 1963, 1966, Sen *et al.* 1964 a and b, 1966, Sen and Nag 1974, 1975). Similar studies on agricultural workers (Nag *et al.* 1978 b, Ramana Murthy and Belavady 1966, Rao and Saha 1965) have been sporadic and scanty. The authors have recently reported some important agricultural work operations in the western part of India (NIOH report 1977).

The present paper reports the energy used by agricultural males in different types of work and leisure-time activity, with a hope that activity levels could be quantified and standardised for man-power management. The occupational workload of the agricultural workers must be set, not only in relation to energy expenditure as it has often been done by earlier investigators, but also in terms of individual capacity to perform work under various environmental conditions.

2. Materials and methods

The investigation was carried out in two phases in the Eastern and Western part of India during the summer months of April and May. Thirteen healthy young male workers, apparently free from any disease were selected. They were solely dependent on farming economy. Physical characteristics, *e.g.* age, body height, body weight and skinfold thicknesses of the workers were measured. The lean body mass and body fat were calculated.

A month-long observation on the nature of agricultural work was undertaken and a large number of elements of work were noted using standard work-study techniques. The man-hours involved in each of the elements of work were recorded during a one week period. In total, thirty agricultural operations were studied. Many other operations were done only by female workers. Some non-occupational farm activities were performed by the workers and these are not taken into account in man-hours calculation. Food intakes of the workers were recorded using a standard technique (Weiner and Lourie 1969).

0014-0139/80/2302 0091 $02·00

2.1. *Physiological measurements*

During actual work, physiological responses were measured using the traditional techniques. To measure pulmonary ventilation, the expiratory side of the low resistance respiratory valve was connected to a calibrated *Kofranyi-Michaelis respirometer* and an aliquot (0·6) sample of each expired breath was collected through the side-tube of the respirometer. The oxygen content of the expired air was measured using a *Beckman paramagnetic oxygen analyser*. The radial pulse rates of the subjects were recorded from stop-watch time for 10 pulse beats. Energy expenditure was calculated from the oxygen consumption and the weighted average of the coefficient of energy equivalent of one litre of oxygen, which was obtained from mixed nutrients, i.e. total protein, fat and carbohydrate consumed by the workers. The average energy equivalent of one litre oxygen was found to be $20{\cdot}86 \pm 0{\cdot}025$ kJ. The whole-day energy expenditure was calculated from the detailed time-records of daily activities of the workers. Thermal data was recorded at the work place, using a whirling psychrometer, katathermometer and globe thermometer.

The step-increase exercises were performed by the workers under similar climatic conditions on a *Fahrrad's bicycle ergometer* in order to determine the maximum oxygen uptakes. Most of the workers were accustomed by bicycle riding; thus training on the bicycle ergometer was not required. However, prior to the tests the workers were acquainted with the experimental protocol. A similar procedure to that of Åstrand and Rodhal (1970) was followed to select the workloads, and the workers pedalled at the rate of 60 rev min^{-1} for 4 to 5 min, starting from 50 W. Oxygen uptake was determined using the methods described above, and the exercise heart rates at intervals of one minute were obtained from a continuous ECG record. The criteria for attaining maximum oxygen uptake were volitional exhaustion, a heart rate of more than 190 beats min^{-1}, and/or no material change in oxygen uptake with the increase of workloads.

3. Results and discussion

The physical characteristics of the agricultural workers are given in table 1. The ages of the subjects ranged from 19 to 36 y, with a mean of 26·8 y. The average body weight of the subjects was 44·6 kg, and the body fat was only 8% of the body weight. All of them were regularly engaged in agricultural work.

It was reported earlier (Nag *et al.* 1978 b, NIOH 1976) that the energy requirement levels of Indian agricultural workers are above subsistence threshold. The diets are heavily weighted towards less preferred starchy staples. The average daily energy intake of the present workers was $11{\cdot}9 \pm 1{\cdot}1$ MJ, of which 82% of the total energy was obtained from carbohydrate. Only 8·5 and 9·2% of the total energy respectively were derived from fat and protein. Most of the protein was derived from vegetable sources and animal protein was negligible.

The average maximal oxygen uptake of the workers was $34{\cdot}85 \pm 2{\cdot}42$ cm^3 min^{-1} kg^{-1}, ranging from 28·6 to 41·5 cm^3 min^{-1} kg^{-1}. Of the thirteen subjects, 3 subjects had maximal oxygen uptake of less than 1·5 l min^{-1}. The average values of the present workers were slightly less than those of Indian industrial workers (Sen 1967, Ramaswamy *et al.* 1964) and similar to our earlier group of agricultural workers (Nag *et al.* 1978 a). The maximal oxygen uptake for an average subject of 23 y of age was 42·8 cm^3 min^{-1} kg^{-1}, and for a subject of 34·8 y of age the value was only 35·7 cm^3 min^{-1} kg^{-1}. The maximal oxygen uptake values were used to express the relative cost of different agricultural work, as a percentage of $\dot{V}O_2$max.

Table 1. Physical characteristics and nutritional status of Indian agricultural workers.

Variables	Mean ± Standard error	
1. Age (y)	26·8	1·8
2. Body height (cm)	157·6	1·7
3. Body weight (kg)	44·6	1·4
4. Body surface area (m^2)	1·49	0·03
5. Lean body weight (kg)	41·0	1·3
6. Daily energy intake (MJ)	11·9	1·1
7. Energy from carbohydrate (%)	82·0	2·6
8. Energy from protein (%)	9·2	0·5
9. Energy from fat (%)	8·5	2·8
10. Energy equivalent of one litre oxygen (kJ)	20·88	0·03
11. Maximal oxygen uptake ($cm^3\ min^{-1}\ kg^{-1}$) STPD	34·85	2·43

3.1. *Physiological responses in work*

Different agricultural operations included in the study are presented in table 2, and some of the typical operations are shown in figures 1–9. On the basis of severity of physiological responses, (i.e. pulmonary ventilation, energy expenditure, heart rate and the relative cost of the work as percentage of the maximal oxygen uptake), the operations are graded in sequence, as shown in table 2. Pulmonary ventilation, oxygen consumption and energy expenditure are expressed per 50 kg reference body weight of Indians (Sen, Nag and Ray 1977). The pulmonary demand due to the operations varied from 14 to 41 l min^{-1} (BTPS). As many as seventeen operations out of thirty, demanded pulmonary ventilation within 20 l min^{-1} (BTPS). Only three operations (*i.e.* water lifting, bund trimming in dry-land and pedal threshing) demanded more than 30 l min^{-1} pulmonary ventilation. Though the difference between the two adjacent pulmonary ventilation, as given in table 2, are not marked in most cases, the large coefficient of variations in each case suggests wide inter-individual variation. There were also large variations in the oxygen uptakes in different operations for the same pulmonary demand. Usually, the oxygen uptakes varied from 0·37 to 1·407 l min^{-1} (STPD). As many as nineteen agricultural operations lie within the oxygen uptake of 0·65 l min^{-1}. Operations such as laddering (by two men) to level the ploughed ground (7·82 kJ min^{-1}), fertilising (9·7 kJ min^{-1}) and cutting crops (10·25 kJ min^{-1}) *etc.* are the lightest jobs, and ploughing (20·96 kJ min^{-1}), water lifting (22·05 kJ min^{-1}) bund trimming (wet land and dry land: 23·11 and 29·54 kJ min^{-1} respectively), threshing of paddy pennacles using a pedal thresher (27·56 kJ min^{-1}) *etc.* are the heaviest jobs in agricultural work. The present values are similar to some earlier Indian studies (Rao and Saha 1965, Ramana Murthy and Belavady 1966). Out of eight agricultural operations, Ramana Murthy and Belavady (1966) observed that puddling and bund trimming were the heaviest agricultural work.

When the observations of all the field operations were pooled, the oxygen uptake had a good statistical relationship ($r = 0{\cdot}8183$), *i.e.* significant at the 1% level, with the pulmonary demand. The corresponding regression equation is:

$$\underset{(\text{l min}^{-1})\ (\text{STPD})}{\text{Oxygen uptake}} = 0{\cdot}034 \times \underset{(\text{l min}^{-1})\ (\text{BTPS})}{\text{Pulmonary Ventilation}} \pm 0{\cdot}001\ (\text{SEM})$$

Table 2. *Physiological responses of agricultural males in different agricultural operations.

Agricultural operations	Pulmonary ventilation ($l\,min^{-1}$) BTPS	Oxygen uptake ($l\,min^{-1}$) STPD	Energy expenditure ($kJ\,min^{-1}$)	Average work pulse rate (beats min^{-1})	O_2 pulse ($cm^3\,beats^{-1}\,kg^{-1}$)	Relative cost (%$\dot{V}O_2$ max)
Sitting leisurely work: (counting grains, levelling etc., watch-keeping to scare birds)	11·9 ±0·5 (10·8)	0·214 ±0·022 (37·9)	4·49 ±0·50 (39·9)	75·5 ±2·8 (13·5)	0·059 ±0·007 (42·7)	12·8 ±1·5 (38·9)
Laddering (by two men)	14·5 ±0·5 (13·1)	0·370 ±0·040 (37·8)	7·82 ±0·72 (33·1)	114·0 ±3·3 (10·4)	0·075 ±0·003 (13·3)	21·6 ±3·2 (53·3)
Fertilising by broad-casting	16·4 ±1·6 (32·2)	0·433 ±0·056 (46·2)	9·07 ±1·20 (46·6)	126·3 ±2·6 (5·8)	0·107 ±0·001 (4·2)	24·9 ±4·0 (57·2)
Walking with tools etc.	14·6 ±1·2 (29·5)	0·449 ±0·050 (36·9)	9·41 ±1·00 (36·8)	108·6 ±4·0 (13·1)	0·098 ±0·013 (49·1)	25·8 ±3·0 (40·7)
Cutting crops using a sickle	14·2 ±1·1 (28·1)	0·488 ±0·058 (40·3)	10·25 ±1·14 (40·3)	—	—	28·0 ±2·0 (27·2)
Plucking vegetables	15·8 ±0·7 (15·9)	0·495 ±0·027 (18·5)	10·35 ±0·58 (18·5)	—	—	28·4 ±2·8 (35·0)
Water supply	15·6 ±1·5 (35·0)	0·515 ±0·058 (37·0)	10·76 ±1·10 (37·1)	—	—	29·6 ±3·7 (42·8)
Uprooting (sitting with one or two legs flexed at knee)	15·5 ±1·2 (26·7)	0·539 ±0·053 (35·6)	11·30 ±1·1 (36·1)	109·6 ±2·4 (8·2)	0·100 ±0·010 (31·8)	30·7 ±3·4 (39·7)
Sowing	15·7 ±1·1 (25·9)	0·583 ±0·100 (50·6)	11·83 ±1·62 (49·6)	—	—	33·1 ±5·0 (57·4)
Weeding (sitting with flexed knee)	17·7 ±1·2 (23·5)	0·573 ±0·040 (25·3)	11·87 ±0·85 (25·7)	113·3 ±2·6 (8·4)	0·109 ±0·007 (24·5)	32·9 ±3·9 (40·7)
Levelling of surface by some auxiliary wooden rake attached with a handle bar	17·6 ±1·6 (32·3)	0·569 ±0·039 (21·1)	11·90 ±0·70 (21·1)	—	—	32·7 ±2·7 (29·9)
Winnowing (sitting on the ground with flexed knee)	14·2 ±2·3 (57·4)	0·578 ±0·118 (71·3)	12·08 ±2·52 (71·3)	—	—	33·2 ±5·2 (55·5)
Weeding using bending posture	16·6 ±1·8 (38·4)	0·578 ±0·067 (41·5)	12·18 ±1·51 (4·2)	114·0 ±1·5 (4·7)	0·103 ±0·010 (36·1)	33·3 ±3·2 (34·0)
Cutting cane sugar	21·7 ±1·7 (28·9)	0·586 ±0·024 (16·1)	12·24 ±0·54 (16·1)	—	—	33·6 ±0·6 (7·3)
Transplanting (bending)	17·4 ±0·8 (17·5)	0·618 ±0·024 (15·8)	13·00 ±0·57 (15·9)	109·2 ±2·0 (6·2)	0·113 ±0·004 (13·1)	35·5 ±1·7 (15·2)
Laddering (by one man)	17·5 ±0·6 (13·5)	0·632 ±0·045 (25·4)	13·26 ±0·93 (25·4)	133·7 ±1·0 (3·2)	0·095 ±0·007 (25·8)	36·3 ±3·0 (29·3)
Pedal threshing helper	20·1 ±1·2 (21·6)	0·643 ±0·053 (29·5)	13·53 ±1·11 (29·5)	120·3 ±5·5 (16·5)	0·113 ±0·014 (43·3)	36·9 ±4·7 (44·8)
Uprooting (bending)	19·2 ±1·5 (28·3)	0·653 ±0·100 (52·8)	13·70 ±2·0 (52·8)	117·8 ±2·5 (7·3)	0·119 ±0·014 (42·2)	37·5 ±5·7 (54·4)
Spraying of pesticides etc.	18·3 ±1·2 (23·5)	0·656 ±0·066 (37·2)	13·72 ±1·42 (37·4)	125·5 ±3·0 (8·5)	0·124 ±0·023 (60·5)	37·7 ±4·2 (41·0)

Carrying loads (20 to 25 kg)	21·2 ±1·8 (30·0)	0·676 ±0·042 (22·6)	16·27 ±2·05 (43·7)	126·5 ±3·4 (8·5)	0·103 ±0·013 (46·9)	38·8 ±7·1 (65·9)
Weeding with projection finger type weeder in wet land.	24·4 ±2·8 (26·9)	0·793 ±0·069 (31·3)	16·70 ±1·50 (31·4)	116·3 ±2·0 (5·1)	0·137 ±0·012 (31·9)	45·5 ±3·4 (26·0)
Winnowing (standing)	22·9 ±1·2 (18·9)	0·808 ±0·043 (19·2)	17·06 ±1·00 (19·4)	124·3 ±2·0 (5·2)	0·132 ±0·010 (22·6)	46·4 ±3·0 (22·3)
Weeding with weeder in dry land	25·4 ±2·0 (28·5)	0·848 ±0·102 (43·1)	17·68 ±2·10 (43·3)	113·7 ±1·8 (5·6)	0·232 ±0·063 (56·0)	54·2 ±7·5 (49·6)
Manual threshing of paddy pennacle by beating	28·1 ±0·7 (8·8)	0·916 ±0·036 (13·7)	19·26 ±0·75 (13·6)	135·8 ±2·5 (6·5)	0·1[illegible] ±[illegible]·6 (16·1)	52·7 ±6·1 (43·5)
Ploughing	24·8 ±2·3 (32·7)	0·997 ±0·106 (39·9)	20·96 ±2·34 (40·0)	131·2 ±2·6 (6·7)	0·182 ±0·013 (26·0)	57·3 ±7·8 (48·9)
Water lifting using a device 'Donga'	31·2 ±1·6 (18·1)	1·050 ±0·069 (23·5)	22·04 ±1·48 (23·8)	153·8 ±1·8 (4·2)	0·138 ±0·010 (22·9)	60·3 ±4·5 (27·3)
Digging soil using spade (dry land)	27·4 ±1·7 (22·4)	0·948 ±0·070 (25·6)	22·58 ±1·15 (17·9)	131·2 ±3·1 (8·4)	0·163 ±0·007 (16·6)	54·4 ±4·7 (30·4)
Bund trimming (wet land)	28·2 ±1·7 (21·5)	1·100 ±0·074 (24·3)	23·11 ±1·18 (18·5)	131·0 ±3·1 (8·5)	0·178 ±0·007 (14·2)	63·5 ±9·8 (54·5)
Pedal threshing	41·2 ±0·7 (6·6)	1·310 ±0·095 (26·3)	27·56 ±2·20 (26·4)	140·8 ±2·7 (6·8)	0·188 ±0·014 (29·0)	75·2 ±10·1 (49·4)
Bund trimming (dry land)	34·6 ±2·1 (21·7)	1·407 ±0·092 (23·5)	29·54 ±1·98 (23·4)	133·3 ±5·3 (14·4)	0·213 ±0·007 (11·4)	80·8 ±3·5 (15·6)

* Values are means ± standard errors (coefficient of variation).

Many operations like weeding, uprooting and transplanting operations are performed by hand while sitting with one or two legs flexed at the knee and in bending postures. Removal of unwanted weeds from the cultivated land is one of the important agricultural operations and as many as 10% of the total man-hours are involved in weeding. Sometimes, it is performed with the help of some projection finger-type weeder, which is commonly observed in the eastern part of the country.

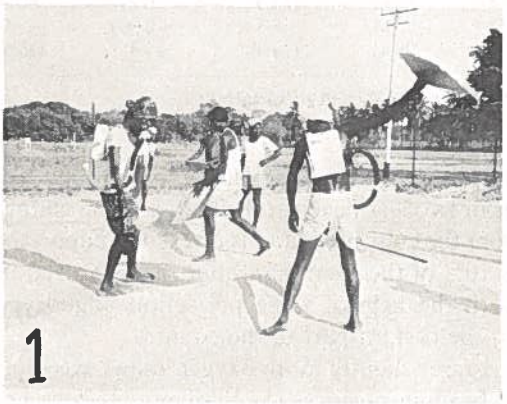
It was found that, though bending requires slightly more oxygen usage, weeding, either in the sitting (11·27 kJ min^{-1}) or bending postures (12·18 kJ min^{-1}) does not cause a marked difference. Whereas, uprooting rice plants demands a greater physiological cost of the bending posture (13·70 kJ min^{-1}) than in the sitting posture (11·30 kJ min^{-1}). Workers usually perform the work hapazardly in any of the postures. From an ergonomic point of view it is suggested that when work can be done in a sitting posture it should not be done in a bending posture.

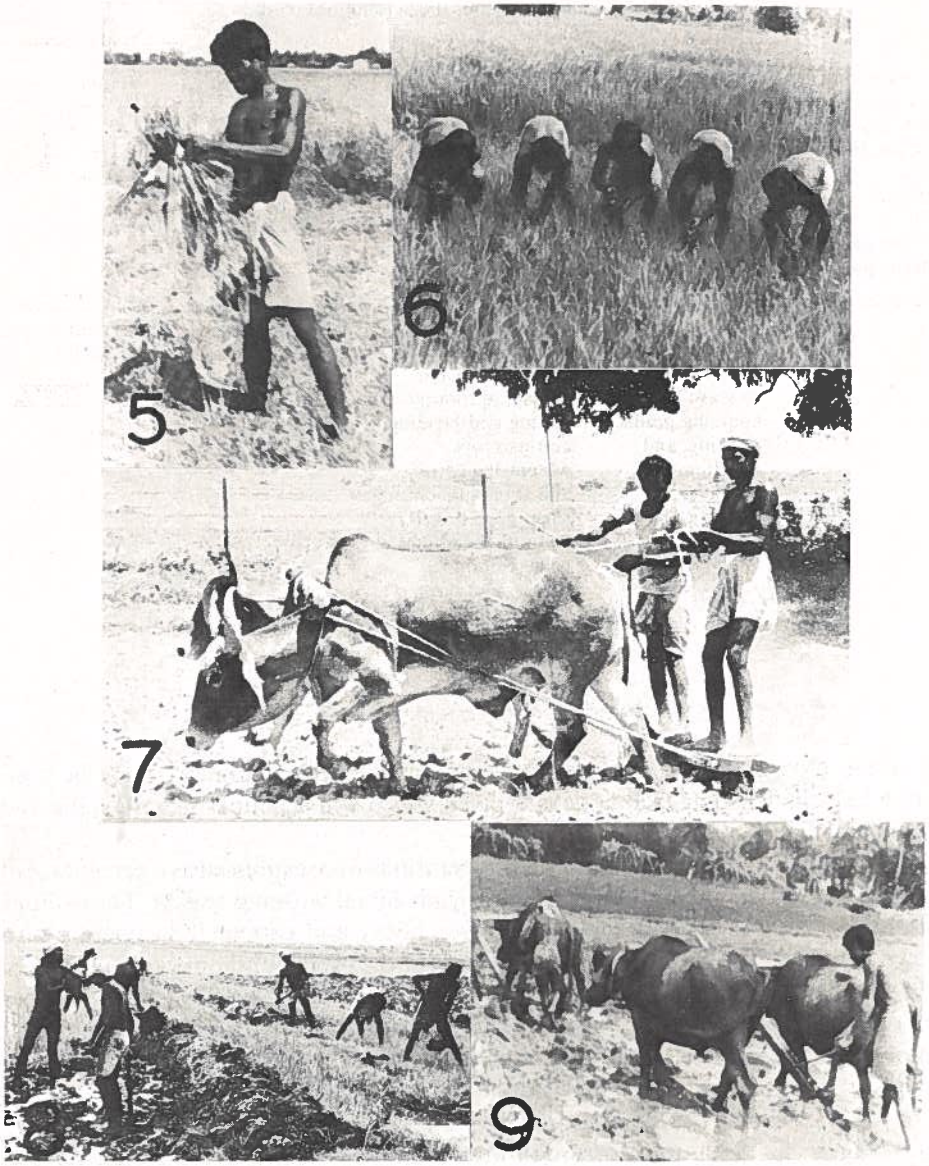
Unlike respiratory responses, it has been found that there was not much consistency in average work pulse rate response with the severity of work operations as graded on the basis of respiratory parameters. The average work pulse rate ranged from 108 to 153 beats min^{-1} in different agricultural work. However, for a large number of operations cardiac responses were less than 130 beats min^{-1}, which was considered as a moderate level of heaviness of work (Christensen 1953, Sen and Nag 1975). Only water lifting and pedal threshing operations required 153·3 and 140·3 beats min^{-1} respectively.

Much of the agricultural work involved varying degrees of static components in dynamic work. Static components were involved in grasping and holding tools and in postural control of trunk and head in work in awkward postures. Work with a mixture of static-dynamic components yielded a disproportionately high heart rate response (Knox 1951, Lind and McNicol 1967, Lind *et al.* 1976) in contrast to other physiological responses, such as pulmonary ventilation and oxygen uptake, which are more related to the rhythmic component of work. Certain inconsistency in cardiovascular repercussions (which are further reflected in the oxygen-pulse, the combined expression of cardiovascular and respiratory responses) in the present study suggest differential involvement of static muscular components in the operations.

3.2. *Categorisation of occupational workload*

Work intensity of the present operations are classified in terms of 'light', 'moderate', 'heavy' and 'extremely heavy', which correspond to up to 25%, above 25 to 50%, above 50 to 75% and beyond 75% of the maximal oxygen uptake respectively, obtained from rhythmic bicycle ergometry. The operations are shown in table 3. Indicative values of the energy cost of present gradations are somewhat different from earlier reported values (Malhotra *et al.* 1966, Ramanathan *et al.* 1967, Sen and Nag 1975) on Indian subjects. This is possibly because of the difference in maximum oxygen uptake of the respective population. It is noted that out of 30 agricultural operations, only five operations are considered as heavy but as many as seventeen are moderately heavy.





Figures 1–9. Some typical agricultural operations. (1) Winnowing; (2) Threshing of paddy pennacles by beating; (3) Lifting water using a device 'Donga'; (4) Threshing by pedal thresher; (5) Making bundles of paddy; (6) Weeding in wetland; (7) Laddering by two men; (8) Trimming bunds; (9) Ploughing.

The present authors agree with Petrofsky and Lind (1978) that a given percentage of maximal oxygen uptake for the particular job being done should be obtained and that it cannot be assessed in terms of percentage $\dot{V}O_2max$ obtained from other kinds of work. Since this type of experimentation is of a complex nature and will definitely vary from job to job, it will not always be possible to assess the stress of the job based on time-consuming experimentation. For assessment of metabolic needs the technique which is more important (i.e. the amount of oxygen uptake for the job) as compared to the

Table 3. Categorisation of the agricultural work.

Variables	Light	Moderate	Heavy	Extremely heavy
$\dot{V}O_2$ max (%)	Below 25%	Up to 50%	Up to 75%	Above 75%
O_2 consumption ($l\,min^{-1}$)	<0·435	0·436–0·870	0·871–1·305	> 1·306
Energy cost ($kJ\,min^{-1}$)	<9·10	9·11–18·15	18·16–27·22	>27·23
Man-hours involved in each category (%)	29·0	64·0	6·0	1·0
Operations in each category	Sitting work and rest during field activities, watch keeping to scare birds, counting grains, shelving, and labelling, etc. fertilising, laddering by two men.	Laddering (single), walking with tools etc., plucking vegetables, water supply, uprooting (sitting and bending, cutting crops, winnowing (sitting and standing), cutting sugar cane, transplanting (bending), pedal threshing helper, spraying, carrying loads, weeding with projection finger type weeder.	Ploughing, water lifting, digging soil, bund trimming (wet land), manual threshing by beating.	Pedal threshing and bund trimming (dry land)

maximum oxygen uptake obtained from standard bicycle ergometry, may be used until a less cumbersome technique is evolved which will account for both static and dynamic components.

The man-hours involved in each of the operations were expressed as a percentage of the total man-hours involved in work during an actual working season. The average man-hours of each category (light, moderate, heavy and extremely heavy) are also shown in table 3. It is interesting that only 29% of the total man-hours are involved in light work, 64% in moderate work and only 6% in heavy work. For only about one per cent of the total man-hours, the workers had to undertake extremely heavy work. Thus the physical activities in agriculture usually lies within a moderate level of activity, excepting for periodical short spurts of heavy activities.

It has been shown (Åstrand 1960, Åstrand *et al.* 1973, Bonjer 1968, Michaels *et al.* 1961, Nag *et al.* 1979), that for long duration work the activity levels should not exceed 35 to 50% of $\dot{V}O_2$max in excess of which a substantial amount of anaerobiosis occurs in the working muscles. On the basis of lifting work, Petrofsky and Lind (1978) also suggested that above 50% of $\dot{V}O_2$max heart rate and arterial lactate concentration increased rapidly, and lifting could not be continued for periods of more than 2 h.

In the present subjects the oxygen uptakes obtained in laboratory exercises and during field operations at different levels of pulse rates (figure 10) showed no statistically significant difference. The oxygen uptakes at the pulse rates of 120, 130, 140, 150 and 160 beats min^{-1} correspond to 43, 48, 55, 61 and 74% of maximal oxygen uptake *i.e.*, from 120 to 150 pulse beats min^{-1}, the relative load of work was increased by about 5 to 7% of maximal oxygen uptake for every increment of 10 pulse beats per minute. Thus, to choose the optimal activity level at about 40 to 50% of maximal oxygen uptake, one may take an approximate pulse rate of 120 to 130 beats min^{-1} as

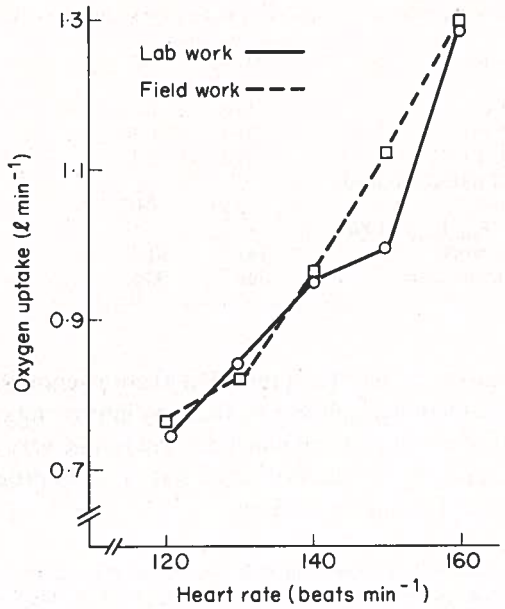


Figure 10. Oxygen uptake of the workers at different levels of heart rate during standard laboratory bicycle ergometric exercise and field operations.

the criteria for such a decision. By fixing the oxygen uptake it is also possible to arrive at 120 to 130 beats min^{-1}, representing a moderate level of activity. The total daily energy expenditure of the present group of workers varied from 10·3 to 11·7 MJ, of which 53 to 56% of the total energy (*i.e.*, about 5·6 to 6·6 MJ) was expended during a working day. While a time-weighted average of the whole-day activities amounts to 7·2 to 8·1 kJ min^{-1} (*i.e.*, the relative load was only around 20 to 22% of maximal oxygen uptake). Whereas, if the working day energy expenditure only is taken into account, the time-weighted average demand was around 10·9 to 14·6 kJ min^{-1} (*i.e.*, about 30 to 40% of maximal oxygen uptake). Considering occasional peak loads, it is suggested that the level of activity of Indian agricultural workers should be so adjusted that the demand of the body is maintained within a moderate level of activity (*i.e.*, within 50% of $\dot{V}O_2$ max). According to Wyndham and Sluis-Cremer (1969) the present group of agricultural workers may be capable of performing a moderate level of activity for a long duration, since their $\dot{V}O_2$max was more than 30 cm^3 min^{-1} kg^{-1}.

The heat stress indices were computed using suitable equations and/or nomograms, as given in table 4. The values suggest that there was a substantial amount of heat load on the workers during the summer months. The effective and corrected effective temperature, and wet-bulb-globe temperature varied around 31°C. The Heat stress Index (*i.e.*, $E_{req}/E_{max} \times 100$) (Belding and Hatch 1956) was found to be 345 for a moderate level of activity. It has been calculated that about one-fifth of the total heat production of the body was the external thermal load. Thus, at a moderate level of activity the exposure time was calculated as only 20 min h^{-1}. To reduce cardio-vascular repercussions and thermoregulatory stresses, under the existing climatic conditions, there is justification, to adjust the work load downwards with due consideration to the heat load.

Table 4. Heat stress and strain indices in Indian agricultural work.

Variable	Mean	SE
ET (°C)	30·6	0·33
CET (°C)	31·1	0·30
WBGT (°C)	31·3	0·33
P_4SR (litres)–moderate work	2·89	0·07
HSI ($E_{req}/E_{max} \times 100$)		
Light work	143	61·2
Moderate work	345	93·6

As a matter of relevance, it may be stated that there is enough scope to reduce further the workload of Indian agricultural workers by improving certain traditional work methods. Sophisticated agricultural machines will not be very useful for various reasons, even if they are provided to the workers. Studies are in progress to improvise simpler tools and methods for Indian workers.

The authors sincerely express their gratitude to Dr. S. K. Chatterjee, Director of the Institute for his keen interest and valuable suggestions in the study. Kind co-operation of Mr. P. Dutt and Dr. G. T. Kurup, Agricultural Engineering Div., Mr. S. Tutti, Farm Superintendent, CRRI, Cuttack, Orissa, and Dr. R. M. Patel, Campus Director, Dr. D. P. Patel and Dr. T. G. Maheshwary of the Department of Agronomy, B.A. College of Agriculture, Anand, Gujarat are gratefully acknowledged. Thanks are due to Mr. M. S. Vaghela and Mr. G. C. Shaikh, NIOH and Mr. D. Das, CRRI for their technical help.

Sur la base des réponses cardio-vasculaires et la capacité individuelle de travail, on a déterminé la charge de travail chez 13 ouvriers agricoles pendant l'été. Durant cette saison, 30 tâches agricoles différentes ont été étudiées. La $\dot{V}O_2$max des ouvriers était de 34,8 $cm^3\ mn^{-1}\ kg^{-1}$, allant de 28,6 à 41,5 $cm^3\ mn^{-1}\ kg^{-1}$. La ventilation pulmonaire variait, durant ces tâches, entre 14 et 41,1 mn^{-1}. Seuls la taille des haies de terre aride, le puisage d'eau et le battage au moyen d'une machine à pédales, qui exigeaient plus de 301 mn^{-1} pouvaient être considérés comme les opérations agricoles les plus astreignantes. Environ 29% des heures-hommes étaient consacrés au travail léger, 64% au travail modéré et 6% au travail lourd. La dépense énergétique journalière des ouvriers variait entre 10,3 et 11,7 MJ dont 53 à 50% étaient dépensés pendant la journée de travail (l'exigence de travail pondérée par le temps était d'environ 30 à 40% de la $\dot{V}O_2$max) et environ un cinquième de la production totale de chaleur corporelle était dû à la charge thermique externe.

Aus cardio-respiratorischen Reaktionen und der individuellen Arbeitskapazität wurde die berufliche Belastung von 13 Landarbeitern während der Sommersaison bestimmt. Während dieser Arbeitsperiode wurden 30 verschiedene landwirtschaftliche Tätigkeiten beobachtet.

$\dot{V}O_2$max der Arbeiter lag bei 34,8 $cm^3\ min^{-1}\ kg^{-1}$, bei einer Spannweite von 28,6 bis 41,5 $cm3\ min^{-1}\ kg^{-1}$.

Die Lungenventilation bei diesen Tätigkeiten variierte von 14 bis 41 l min^{-1}, nur beim Wasserschöpfen, beim Bearbeiten von trockenem Boden und beim Pedal-Dreschen war eine Ventilation höher als 30 l min^{-1} erforderlich, diese Tätigkeiten wurden als die schwarten bei der Landarbiet gefunden. Etwa 29% der gesamten Arbeitszeit wurde bei leichter Arbeit, 64% bei mittelschwerer und nur 6% bei schwerer Arbeit zugebracht. Der tägliche Energiemunsatz der Arbeiter variierte von 10,3 bis 11,7 MJ, wovon 53 bis 56% während des Arbeitstags aufgewendet wurde (d.h. die zeitgewichtete Arbeit verlangt etwa 30–40% von $\dot{V}O_2$ max); etwa ein Fünftel der gesamten Wärmeproduktion des Körpers ist auf die äußere Wärmebelastung zurückufüren.

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Manuscript received 24 April 1979.
Revised manuscript received 31 July 1979.