power system ab

Measurements of electrostatic field.

Electrostatic field generated by VDU displays and by the human body can be measured by a field mill. This instrument measures the magnitude and polarity of an electrostatic field.

Displays

In front of the display the field mill will be installed (see fig 2). A metal net will be mounted on the field mill and grounded. This metal net prevents disturbens from the surounding which has an influence of the electrostatic field generated by the display.

The field mill must be grounded.

Via the display on the field mill you can directly see the magnitude and polarity of the electrostatic field.

The human body

The measurement of body potentials is made in the following way. An ungrounded field mill is held up against an ungrounded metalplate.

The metalplate is reference electrode and the electrostatic field generated by the human body is displayed on the field mill. By using this methode you have to take into account that reversed polarity is shown on the field mill display.

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Electrostatic fields in display enviroment

Displays

Displays using cathode ray tubes are the most common on market. These type of displays are using high voltage to generate the electric fields that accelerate the electron beam on to the phosfors covering the inside surface of the viewing screen.

In this type of displays a pontential of 15000 volt or more are common (see figure 1).

The field extend via the tube into the air if that is not satisfactory shield.

The field varies from different manufacturer of displays and may vary with in the same type of display model.

The human body.

If the enviroment indoor is unfavourable that means that material as clothes, shoes, furniture and carpets is of such kind that our body will be charged and can have a potential of up to minus 6000 volt.

A discharge of this potential is very much depending on the humidity of the ambient air, type of carpets and if high isulated shoes is used or not. A fast discharging happen if touching ground and an unpleasent eletrical shock can be expected.

Displays/the human body.

The electric field from a display has a positiv polarity and the human body has in most cases a negativ polarity. this gives a total electric field of the total amount of both field.

Example:

Display	+10000 volt/meter
Human body	- 2500 " "
Total	12500 " "

Which in above example gives an electric field of 12500 volt in the face of an user. (see fig. 2)

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Indoor air pollution

Indoor aerosol

During the last years our knowledge of indoor aerosols role has increased in the human exposure to air pollentants.

A number of studies have shown that the level of indoor pollution can be high compared to outdoor pollution and that the indoor aerosol is a mixture of outdoor pollutants and contamitants aerosol which orginate from indoor.

Of special interest are particles with diameter of 0,1 um to 1 um. Particles of this size existing outdoors are generated by various processes in the atmosphere, such as chemical reactions vapor condensation, droplet evaporation and coagulation of fine primary particles into courser aggregates. These particles commenly consitute a significant part of the ambient aerosol.

Among the most important compounds found in this form are sulfates orginating from reactions of gaseous SO_2 with other pollutants present in the air. As a consequence of the distribution of SO_2 in the atmosphere particulate sulfates (most notably ammonium sulfate $(NH_4)_2SO_4$ commonly constitue a major fraction of the submicron aerosol.

Other common compounds are hydrocarbon oxydation and nitrates, and another important source is the chemical reactions between gaseous and particles from ocean spray.

In addition to compound generated by atmosphereic processes, the submicron aerosol may contain chemical species generated by local sources mainly through combustion. Example of such species are lead, bromine, arsenic, antimony various metal oxides and a large number of carboncours substances.

This particular generate through discribed processes is generally to small to be retained by the filters used in ventilation system and therefore this size of fraction are present in the same concentration indoors as outdoors. Measurements have shown this.

Through the human activities indoor a large number of pollutants may orginate for example tobaccosmoke, ash, paper and textile fibers, graphite and paint particles, cosmetic spray residues of these tobaccosmoke is likely to contribute to the submicron fraction.

A number of organic compounds emitted by building materiels or other substances present in the indoor enviroment may be associated with the submicron fraction as a result of chemical or physical interactions with the suspended particles.

In indoor enviroment tobacco smoke contributes to the total aerosol mass. Studies shown that the concentration of respirable particles in smoking areas are more than 10 times higher than in non smoking area.

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Aerosol deposition in the presence of electric fields.

Charge on suspending particles

A number of experimental investigation have shown that most aerosols carry appreciable charge. Uncharged or electrically neutral particles are quite rare. Normally both positiv and negative charges coexist so a specific aerosol may be nearly neutral.

In absence of any extraneous charging mechanism an equilibrium state of charge will prevail in this minimum state particles in the size of 0,05um that carry charge will be closed to 40% and in the size of 1 um 80% will carry charge.

The charge of indoor aerosols may differ due to a variety of charge modifying processes that may exist in the enviroment, such as contact electrification, molecular transformation and particle interaction. The last charge mechanism inplies a transferral of charge from air ions (ionized molecules or molecular cluster) to the suspended particles. The charged fraction if the aerosol is often called "large ions".

A particles having an electric charge will be induced to move if influenced by an electric field. The electric movement will be difined as the final velocity reached in a unit field will be a function both of the charge and the size of the particle. (see fig).

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Particle deposition and adhesiion mechanisms

In the absence of electrostatic fields the mechanisms of particle deposition on passive surfaces are interception, impaction, gravitational sedimentation and diffusion. If the aerosol carries a unipolar charge (that means, one polarity dominates), the electric field generated by the particles themselves will cause a net outward particle movement and this give rise to an additional deposition mechanism, called space-charge precipitation.

Because of the strong dependence on factors as particle size distribution and air turbulance can it be difficult to predict these deposition mechanism.

As said earlier a charged aerosol fraction will be induced to move in presence of an external field resulting in an increased rate of deposition.

A large number of existing devices for measurement and control of fine particle take advantage of the fact that this deposition mechanism will dominate in the submicron size range even at a low fields.

The deposition process is completed when an aerosol particle have adhere to a surface. In the case of dry deposition van der Waahls forces are effective and if either the particle of the surface is wet, capillary forces may act as well. For submicron particles these cohesive forces may act as well. For submicron particles these cohesive forces are strong enough to assure adherence as soon as the touch a surface or the human body.

SUMMARY of particle deposition

1. A rise of the electrostatic field of both polarity increase dramasticly the particle deposition and also the preçipitation of the submicron particles and has therefore an inpact of the air hygienic.

2. The size of the precipitation is very much depending of the difference in potential inbetween the display and the human body. The higher field the more is the precipitation.

3. The amount of the precipitation can reach 10000 particles (with a diameter 0,07mm or more) per mm^2 surface and hour.

   This number is at least 10 times more than absence of an electric field.

4. Deposition specially from aminousulfates has an influence on skin and even dry lips can be caused of destroied ions.

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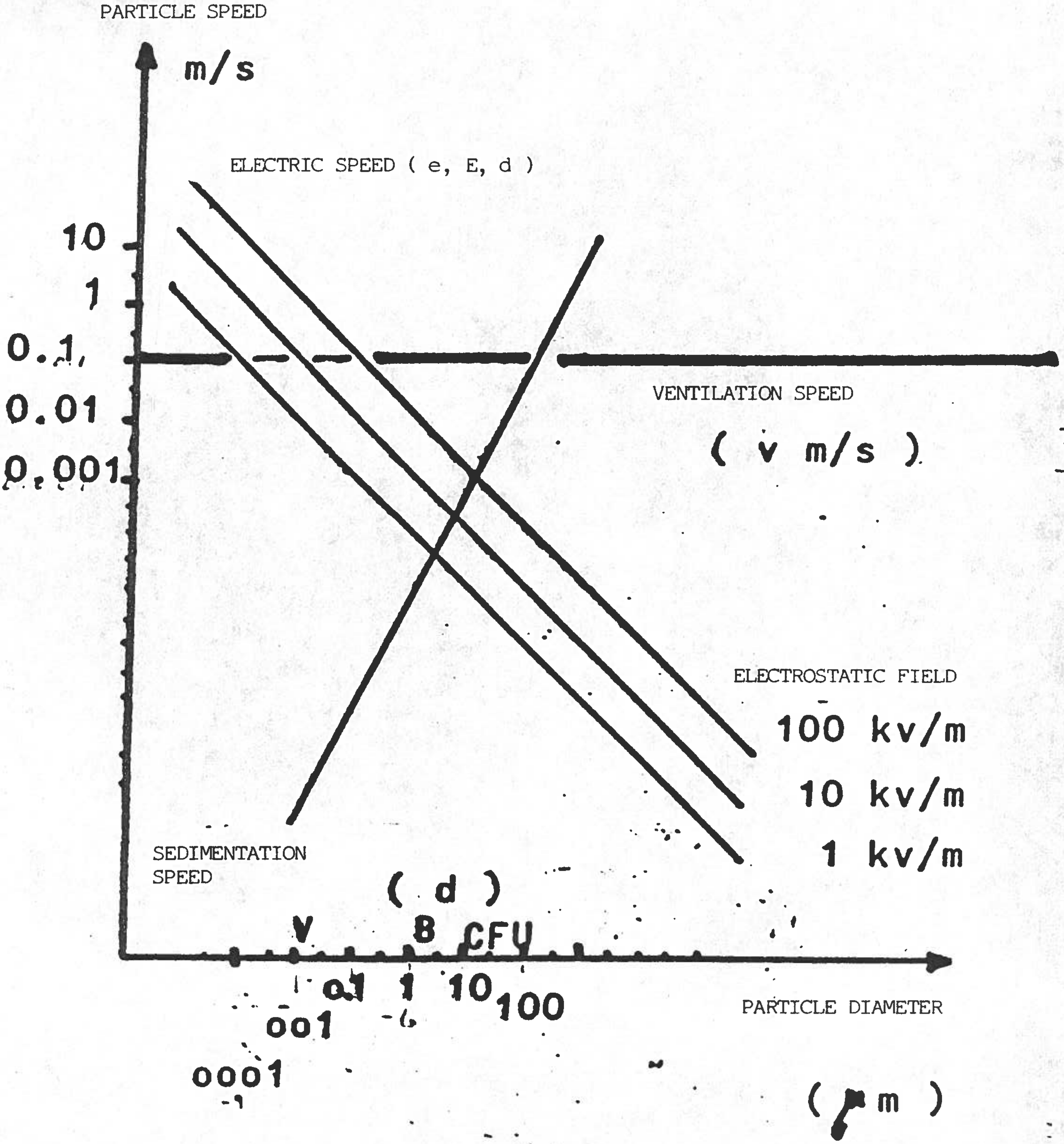
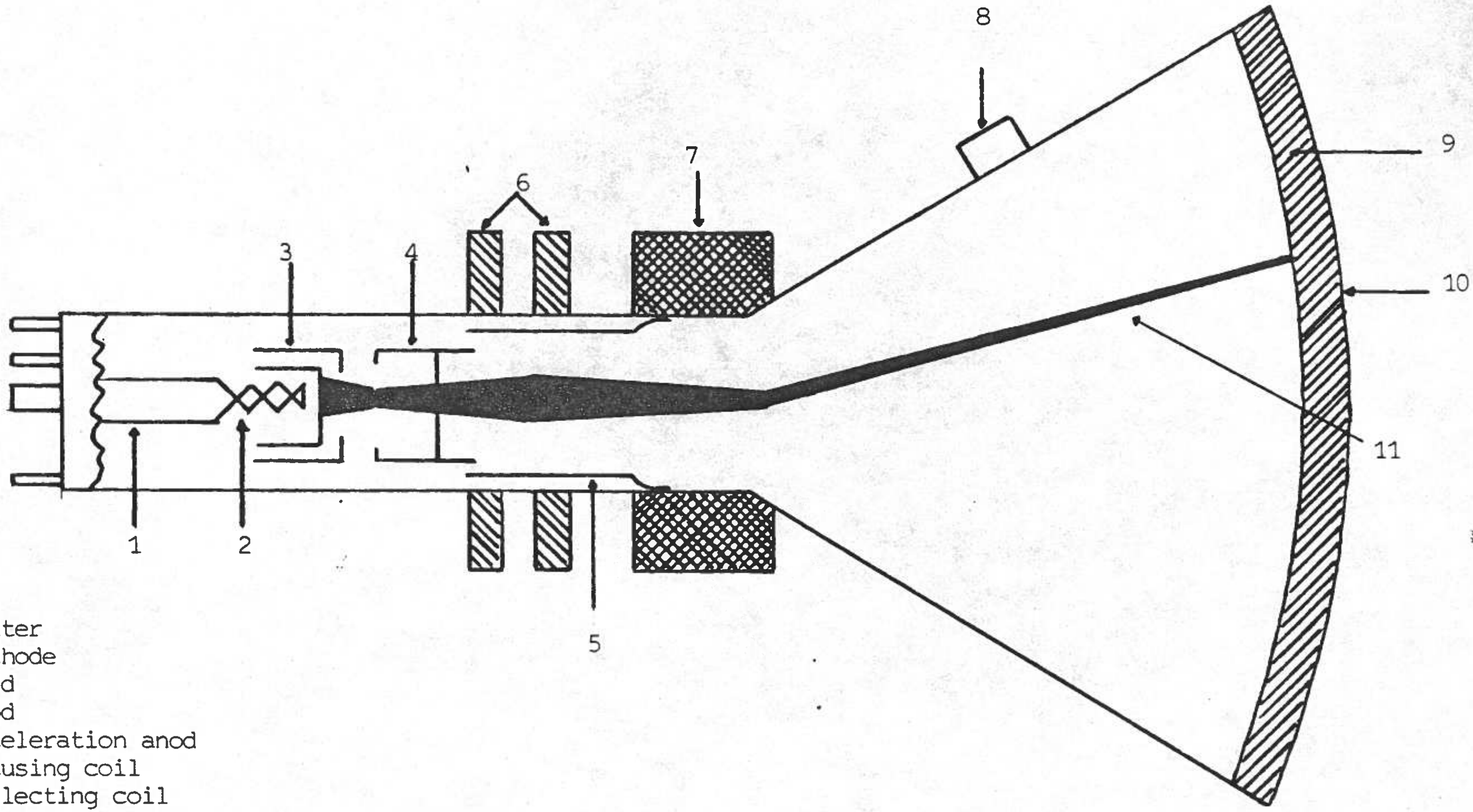
COMPONENT SPEED AND SIZES



CATHODE RAY TUBE



1. heater
2. cathode
3. grid
4. anod
5. acceleration anod
6. focusing coil
7. deflecting coil
8. high voltage 12-18 kilovolt
9. fluorescing phospor
10. face plate
11. electron beam

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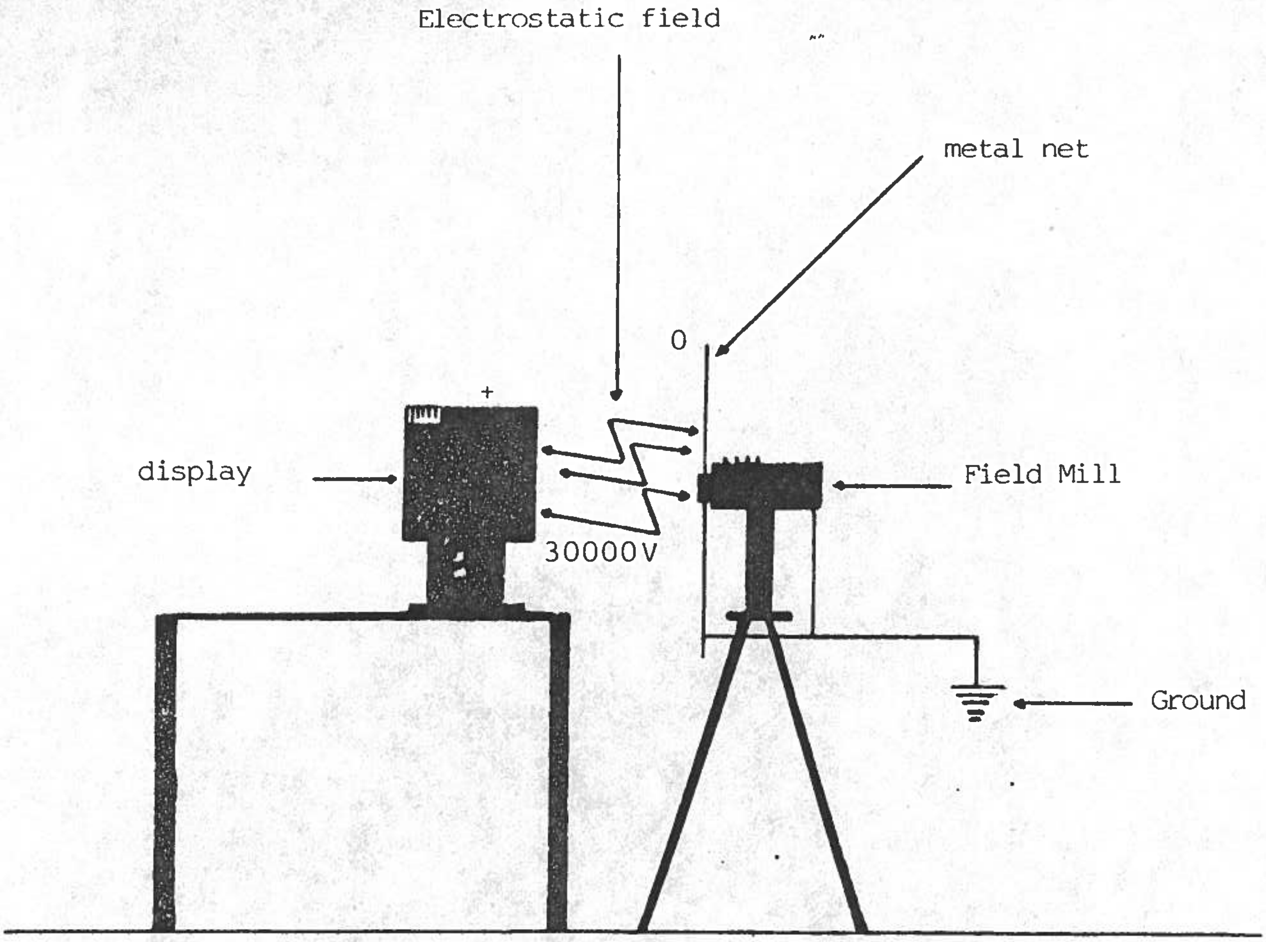
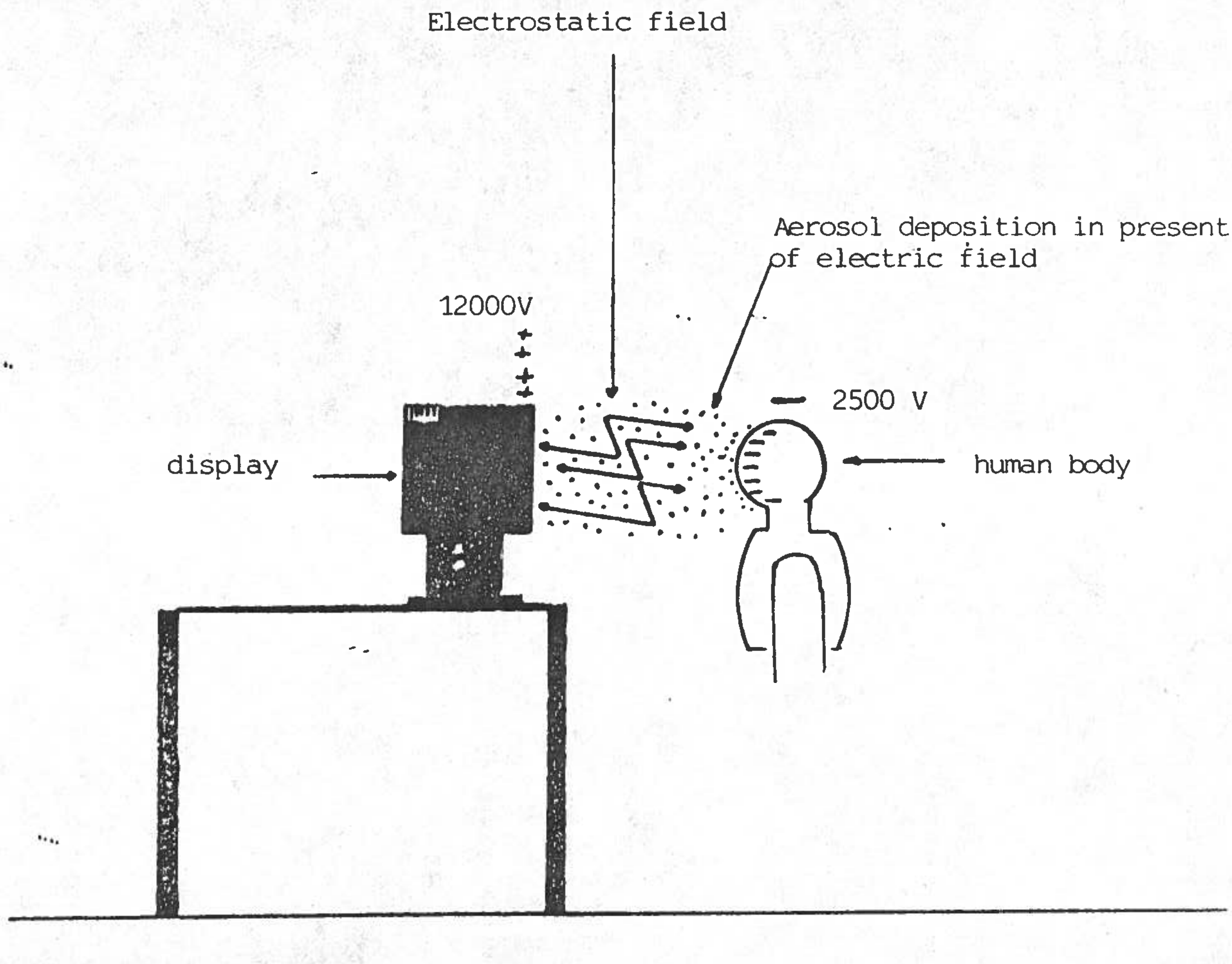
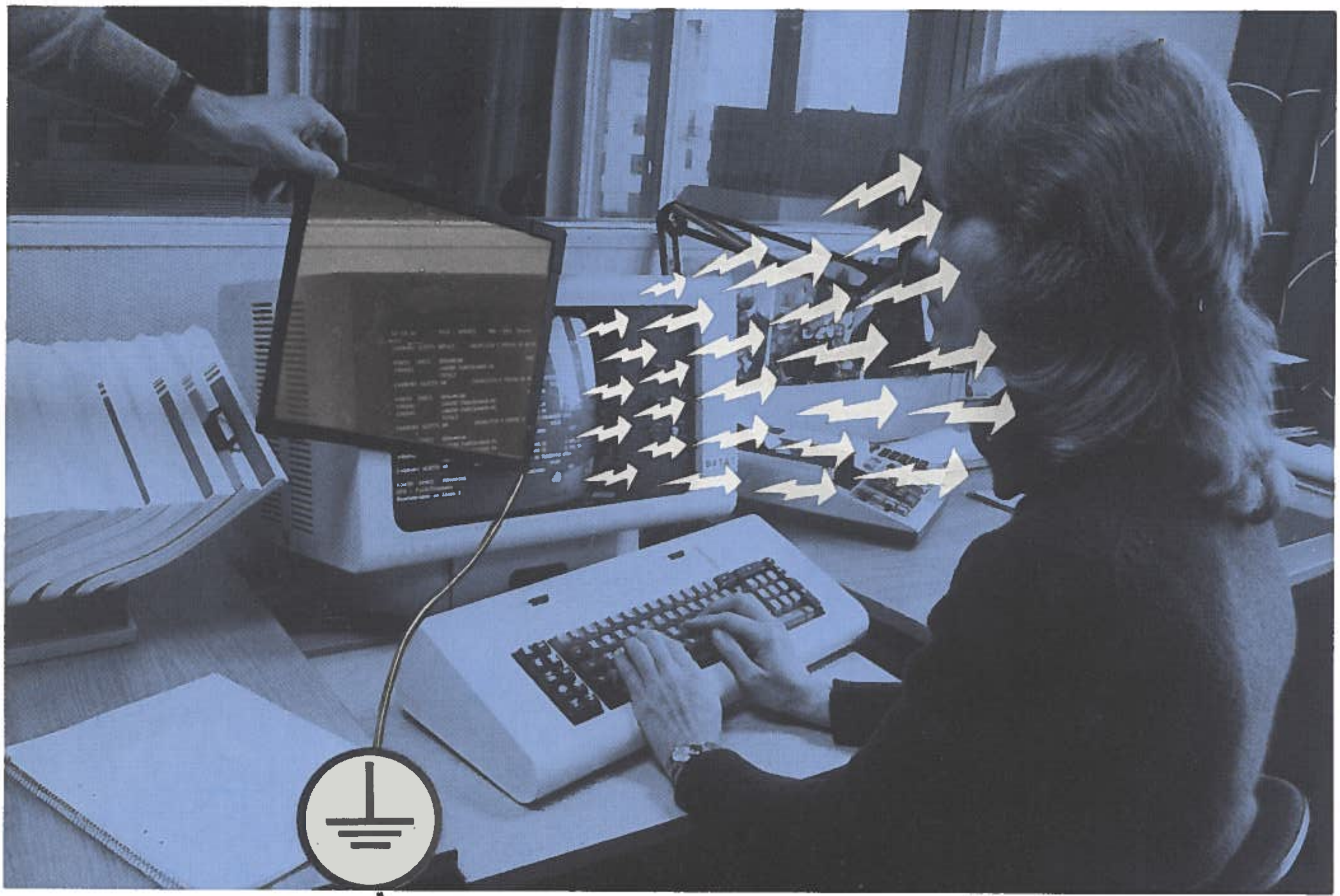

Electrostatic field
metal net
0
+
display
Field Mill
30000V
Ground


Electrostatic field
Aerosol deposition in present of electric field
12000V
display
2500 V
human body

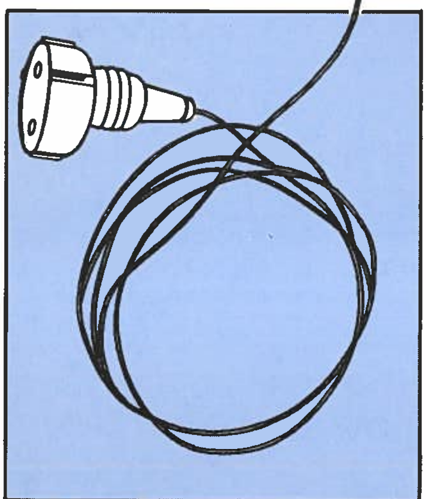
Antiflex with Power screen®



THE FILTER with COMBINED EFFECT

That eleminates both

...ELECTROSTATIC CHARGE and GLARE



The special plug is connected to a normal earthed wallsocket, The plug may vary in each country.

Your VDU screen generates an electrical field of about 10.000 - 30.000 volt/meter, and in some cases, even more.

Discomforts such as dry irritated skin, itchiness, red eyes as well as a dry throat, tongue and lips can be suffered by the operator as a result of this electrical field.

Power screen mounted in front of the terminal face eleminates the electrostatic charge and creates a more pleasent operator enviroment.

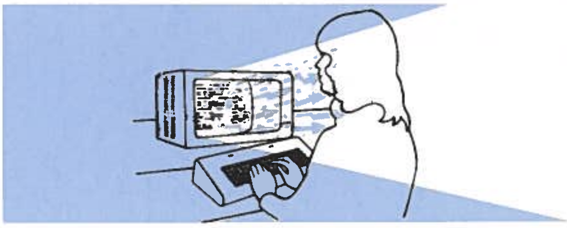
Power screen®
The new generation
GLAREFILTER.

The new generation GLAREFILTER !

The new Antiflex with power screen®

- reduces operator fatigue
- eleminates electrostatic charge
- earthed connection gives constant protection
- reduces eyestrain
- eliminates VDU screen reflections and glare
- gives a sharper clearer image
- easily fitted to all terminals

WITHOUT POWER SCREEN



The VDU screen generates an electrical field of about 10.000-30.000 volt/meter, in some cases more. Dust, smoke and other particles in the surrounding air start to move into the operators face and so cause uncomfortable working conditions.

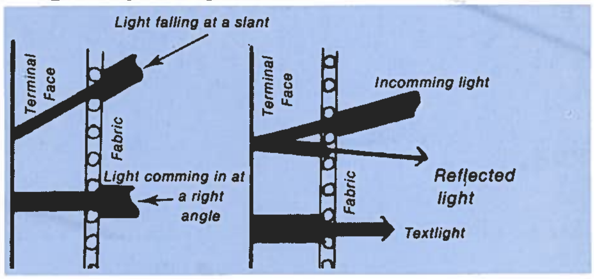
USING POWER SCREEN

With Power Screen mounted to the front of the VDU screen, the operator has a more pleasent working enviroment. The conductive Power Screen filter with an earted connection eliminates the electrical field and prevents dust and other particles from being attracted to the operator.

GLARE REDUCING FACTORS :

Glare reduction is caused by the thickness of the microfilter, the reflection properties of the fabric and the distance between it and the terminal.

FUNCTION



ASSEMBLY

Power Screen should be mounted at least 5 mm and not more than 30 mm from the front of the VDU screen. If mounted directly onto the screen, the amount of glare suppressed is not sufficient and can cause disturbance or so-called "Newtons Rings". The assembly requires no tools or outside help.

Power Screen is a combined filter which eliminates electrostatic charge, reflections and glare, protecting the operator from unpleasent working conditions and giving a sharper, clearer image on the VDU.

Antiflex with power screen®

- NUMBER ONE ON THE MARKET -

Patent.

Manufacturer
power system ab
Box 263, 701 04 Örebro Sweden

Handikappinstitutet

May 31, 1983

Adapting Work Sites for People with Disabilities: Ideas from Sweden

The design of work environment determines, whether an impairment will result in a vocational handicap. The efforts needed to enable a disabled person to obtain or maintain employment do not always imply complicated or advanced measures. Sometimes only small adaptations in combination with a little imagination can work wonders!

A labour market accessible to disabled persons is an advantage to everyone. This is the central message in a publication from The Swedish Institute for the Handicapped.

The book has now been printed in English, and its title is "Adapting Work Sites for People with Disabilities: Ideas from Sweden".

In order to make the book available to those who are active within the field of vocational rehabilitation in your country, we send you a copy of the English version.

We think that the methods and examples described could be of interest, e.g. to some of the following authorities or institutions in your country:

Employment Service Staff
Rehabilitation Personnel
Occupational Safety and Health Inspectors
Occupational Safety Committees
Personnel Administrators
Production Engineers
Personnel in Company Health and Services
Organizations of Disabled

An idea can provide a starting point for discussions with employers concerning the types of technical modifications that can be made at work sites.

Additional copies can be ordered from

Handikappinstitutet
Åke Olsson
Box 303
161 26 BROMMA
SWEDEN

USA citizens can also order the book from

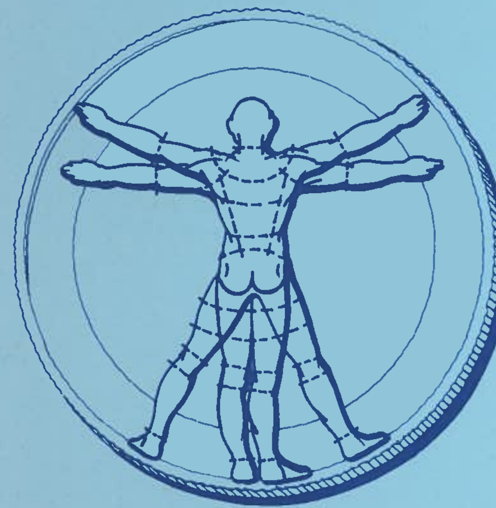
World Rehabilitation Fund
400 East 34th Street
NEW YORK, N.Y. 10016
USA

A small fee will be charged according to the number of copies ordered.

bel byggergonomi laboratoriet

Ergonomics

the human aspect with a profitable effect



Aren't Swedish machines and tools unbeatable when it comes to quality and efficiency? They are certainly impressive with their high performance, durability, handsome styling, efficient operation and much more besides. Product development engineers in manufacturing companies are continuously accumulating experience and knowledge about their own products and those of their competitors. They modify, improve and renew. But all too often they fail to include the ergonomic factor in their calculations. And it is there that they fall short of perfection.

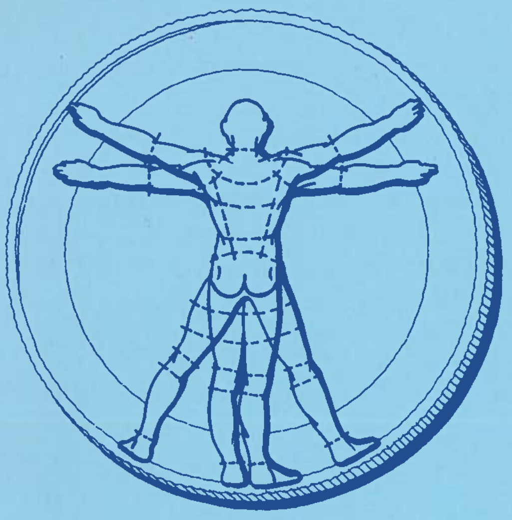
Expressed in simple terms, it could be said that ergonomics is adapting work operations to human beings. And in point of fact we have a long way to go in this respect. And much to gain — for ergonomics is closely associated with economy and profitability.

The Laboratory of Construction Ergonomics — a pioneer

The construction of houses, roads and plants of various kinds is one of the most demanding branches of industry from the working environment viewpoint. Many jobs are performed outdoors, often in cold, damp of dark conditions. The work may give rise to considerable noise and air pollution. Frequently it is necessary to lift heavy items and adopt uncomfortable working positions.

The construction industry has long been aware of the unfavourable working conditions associated with it and their attendant danger to health and safety. The Foundation for Industrial Safety and Health in the Construction Industry has been working for many years on these questions where building sites are concerned.

Are these activities sufficient if there is a genuine desire to get to the bottom of all this and improve the working environment? After all, work at building sites is dependent on the conditions at hand. If manufacturers put unwieldy machines and tools into the hands of construction workers, then they have no choice but to use them. If planners and architects think solely in terms of the ultimate shape and design of the building and disregard factors that may affect the production phase, then it is the construction workers who will be faced with extra demanding work tasks. A poorly considered choice of materials may similarly have an unfavourable effect. In many cases it is actually a question of ergonomics.



Several years ago a construction ergonomics laboratory – a pioneer of its kind – was set up for the construction industry. It is situated at the Royal Institute of Technology in Stockholm and is financed primarily by the Swedish Council for Building Research. The duties of the laboratory research group are to develop working methods and equipment that are adapted to human beings.

The ergonomic method of approach assumes that the problems are tackled by interdisciplinary research. It is a matter of understanding the interaction between various factors, and it embraces physiology, medicine, technology, sociology and psychology.

How are research projects chosen?

Activities were started by mapping out the working conditions of the construction industry. Observations were carried out at building sites, discussions were held with employers, supervisors and workers, connections were established with manufacturers of machines and tools and also with various scientific specialists.

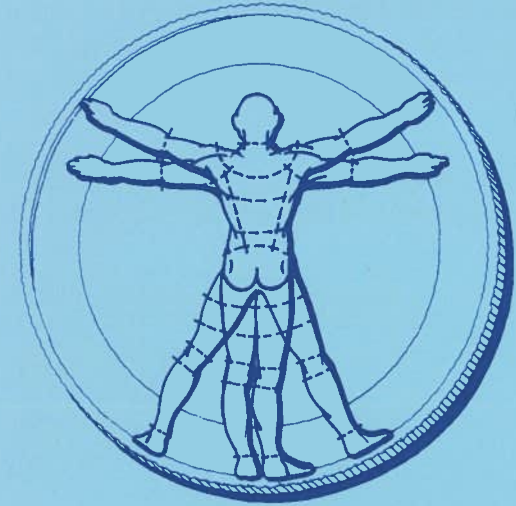
This revealed where the need for development was particularly acute in regard to working methods, machines and other aids. A list of interesting project ideas for research activities was prepared. The laboratory develops and nails down the projects in consultation with a reference group which includes representatives of the construction industry parties, the National Board of Occupational Safety and Health, the Foundation for Industrial Safety and Health in the Construction Industry and certain government bodies associated with building and construction activities. A working group consisting of directly interested parties such as manufacturers of materials, machines and tools, is attached to every project.

The laboratory works on finding solutions to problems that are of interest for practical application. The results should preferably lead to a better working environment and less strain on human beings when performing various work operations. Projects which do not lead in this direction are of no interest to the laboratory – and in actual fact to no-one else either.

A unique resource for industry

Research and development carried out by industrial companies is strictly governed by the need to create products which fill a market need. The products must also suit the production machinery, know-how, organization, market conditions, etc. of the company. There is not much scope left for conducting general studies of different working conditions free from demands that they be subordinated to a target-oriented product development programme.

The Laboratory of Construction Ergonomics occupies a unique position. Through the ergonomic angle of attack it is not interested solely in the mode of operation of an individual tool. It is the interaction between a number of different factors that must be analyzed and evaluated. This might result in a recommendation consisting of a series of measures – perhaps a redical change in the entire working process involving the design of a new tool, modification of a machine, etc. The objective is to enable people to perform the work without excessive or downright harmful strain on the body. Then the work will also be done safer, better and faster. As a rule, an improvement in production economy will also be gained into the bargain.



As a result of this free form of working, the laboratory has excellent prospects of developing a broad base of knowledge. It can allow itself the luxury of trying out conventional project ideas which may sometimes fail and which may sometimes hit the bull's-eye. It can latch on to ideas from companies who do not themselves have either the time or the resources to develop them. It can assist industrial companies with advice and by presenting its views.

The Laboratory of Construction Ergonomics has its own workshop and full-scale laboratory. But project work is carried out to a very large extent directly on building sites where methods and equipment can most easily be studied. The laboratory also maintains close contact with the working environment laboratory and a group for occupational accident research at the human engineering unit at the Royal Institute of Technology in Stockholm.

Cooperation in two directions

It may be assumed that all are agreed on the desirability of developing efficient working methods and practical aids. But this calls for an overall approach to solving problems which will become reality only if carried out ergonomically.

It is high time for the construction industry to grow accustomed to thinking ergonomically. User demands for a good working environment from all points of view are a driving force behind such development and it is backed up by legislation. This assumes cooperation between users and manufacturers. The Laboratory of Construction Ergonomics has already established cooperation in both directions. But this cooperation can and should be expanded if the ergonomic approach is to spread and take root in earnest.

To the industry it may result in interesting profitability aspects which may also lead to good export products. There is a chance here for Sweden to gain an international advantage.

The Laboratory of Construction Ergonomics holds the door wide open for more extensive contact with the industry. The Laboratory acts in an advisory capacity and can undertake research assignments. Idea seminars are arranged at regular intervals to which interested parties are invited.

Welcome to
The Laboratory of Construction Ergonomics
Fiskartorpsvägen 15 D
Tekniska högskolan
S-100 44 Stockholm
Sweden
Telephone: 08-787 89 85

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SWELLING OF THE LOWER LEG IN SEDENTARY WORK—A PILOT STUDY

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On the basis of a literature study a hypothesis was put forward, claiming that swelling of the lower legs during prolonged sedentary work increases the risk of peripheral venous disorders in the legs. Thus, swelling of the left lower leg during sitting has been studied. The aim was to examine the effect of rest pauses involving leg movements.

In *a field study* three healthy women performed light work for eight hours while sitting on standard office chairs adjusted according to lower leg length. In all, the study comprised nine normal and nine experimental days. On the normal days the subjects sat all the time except for lunch and for two coffee breaks. During the experimental days the subjects were required in addition to take a two-minute walk every fifteen minutes. A lower leg swelling of 3.4–5.5% was observed during the normal days, and 1.8–2.7% during the experimental days. Additionally, the subjects experienced less discomfort in the left lower leg during the experimental days.

In *a laboratory study* two healthy women sat relaxed for one hour each. Changes in the volume of the lower leg were measured. At various intervals the lower leg was exercised for one minute. For all intervals and in all tests this caused an elimination of the swelling accumulated during the previous period of relaxed sitting.

Line of development. Extensive mechanization and automation in the industrialized countries over recent decades have drastically changed the physical load pattern in working life. Machines are taking over the heavy jobs in industry and to an increasing extent computers are controlling production. The remaining jobs are often sedentary. Also, in the public sector, the number of jobs designed for a sitting posture is increasing, *e.g.* VDU work (VDU: *v*isual *d*isplay *u*nit).

This development is illustrated in Fig. 1. The curves apply to both Sweden and West Germany (Östberg, 1977; Peters, 1976). The fraction of the labour force occupied at the primary and secondary production levels is decreasing

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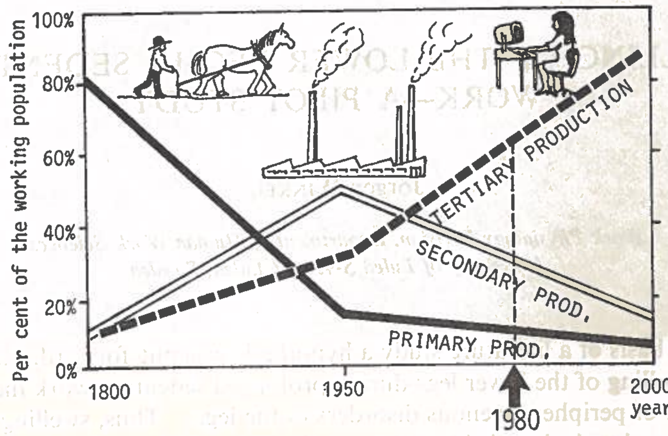

Fig. 1. The distribution of the working population in Sweden and West Germany at three production levels as a function of time. Primary production: the first link in the production chain. *e.g.* forestry, agriculture, mining. Secondary production: all refinement of the primary products: *e.g.* processing industry, manufacture. Tertiary production: services. *e.g.* public administration, communication, education, commerce (according to PETERS, 1976; ÖSTBERG, 1977).

Fig. 2. A work-place for microscope work, prototype (WINKEL, 1979).

while still more people find employment within the service sector. At the same time the variations in the types of work are decreasing, which makes it possible to develop so called purpose-designed work-places.

In Sweden, several designers are experimenting with tailor-made seated workplaces for different tasks. Figure 2 shows a prototype for microscope work. The load on the muscles and joints is much reduced, as is the energy output for

performing the task.

To summarize the line of development, the trend seems to be:

— *more sedentary work*
— *physical passivation*
— *fewer distinct work-types*
— *more comfortable sedentary work-places*

This is in line with one of the trends in classical ergonomics, which has been to reduce the physical work-load. But there is also a lower limit to work activity, below which we might expect detrimental effects, not only on the psychological, but also the physiological functions of the human body.

Prolonged sitting and leg complaints. One of the main problems in ergonomics for the 1980's will be to establish recommendations concerning the need for physical activity and change in prolonged sedentary work, in order to prevent detrimental effects on body function, for example, blood circulation in the legs. Several investigators have described high frequencies of complaints concerning the legs among people working mostly in the sitting posture (*e.g.*, GRANDJEAN and BURANDT, 1962; GUNNARSSON and ÖSTBERG, 1977; University of Lund, 1977). The study of Gunnarsson and Östberg covered 72 computer terminal operators of whom 24% experienced pain in their legs. Most of these operators were below the age of 30.

Swelling of the foot and calf during prolonged sitting is well known and has been demonstrated by POTTIER *et al.* (1969) and DUPUIS and RIECK (1980).

Furthermore, an epidemiological study has suggested prolonged sedentary work as one causative factor of *varicose veins* (SANTLER *et al.*, 1956). Other data by the same authors, however, have shown less striking and convincing results. Today with limited information at hand, it is generally difficult to say whether a given correlation is a true or a spurious one. The lack of clear epidemiological submission of evidence might be due to the lack of reliable and tested statistical data. Thus, varicose veins are, in spite of the absence of scientific evidence, generally regarded as a disease, which might partially be caused by prolonged sitting and standing (BORSCHBERG, 1967).

Even *thrombosis* of the deep veins in the lower leg might be due to prolonged sitting (HOMANS, 1954; HAEGER, 1966). Although clear epidemiological evidence is lacking in this case too, patho-physiological data suggest a correlation. The causes of thrombosis have been summarized by VIRCHOW (1856) in his classical triad: vascular injury, decreased flow and changed coagulation conditions. These are widely accepted to-day (NILSSON, 1971). WRIGHT and OSBORN (1952) reported a reduction of the venous blood flow on change of position of the subjects from lying to sitting in a chair. During passive lowering of the leg 50 cm below the mid-axillary line in the supine position, HENRIKSEN and SEJRSEN (1977) found a 50% decrease of venous blood flow in the lower leg. Thus, a decrease of blood flow during prolonged sitting might be a causative factor of thrombosis. A reduced flow also occurs in a partly comparable but more extreme situation of physical inactivity, prolonged bed-rest. This is the most common situation associated with thrombosis, and the incidence among patients has been shown to increase with the duration of confinement to bed (GIBBS, 1957).

Prevalence and incidence of peripheral venous disorders (PVD). Data in the literature on the prevalence and incidence of PVD vary, depending on the selected population and difficulties in separating a pathological state from a "normal." A study among 4,529 apparently healthy, skilled workers demonstrated the following prevalence of complaints from the legs (WIDMER, 1978): In a personal interview, the complaints such as feeling of tension, heaviness, swelling, *etc.*, were reported by 44% of men and 70% of women. Varicosities existed in 55% of the subjects examined. Alterations related to chronic venous insufficiency were observed in 15% of the examined subjects, of whom 6% already had skin changes, and 1% ulcus cruris. A question on pulmonary embolism was answered affirmatively by 2% of men and 3% of women. Unfortunately the subjects were not interviewed for their occupational history.

If prolonged sedentary work is a causative factor of PVD, their incidence should have increased during recent decades along with the increase in the sitting habit. BURKITT (1976) claimed a rising prevalence of varicose veins in the economically more developed countries. On the other hand, BORSCHBERG (1967) and BURKITT (1976) stated that varicosities are practically unknown in many developing countries. This might partly be due to a higher level of physical activity. Furthermore, Burkitt indicated similar prevalences in black and white Americans which should eliminate ethnic differences as a causative factor. REIZENSTEIN (1975) claimed a rising frequency of thrombosis in the Swedish population. An increasing incidence of thromboembolic disease has recently been observed in the United States (Kendall Co., 1974).

However, a more accurate analysis of epidemiologic data is questionable and often meaningless as long as accurate data on prevalence and incidence of the PVD are not available. The statements might be a reflection of improved diagnosis. Furthermore, the observations of increased incidence of the disorders mostly cover patients in hospitals.

Hypothesis behind the project. One etiological mechanism of the PVD might be an increased hydrostatic pressure in the veins of the lower legs in the sitting posture—see Fig. 3. According to this model the "response", *i.e.* the degree of disorder, depends on the "dose," *i.e.*, the degree of leg activity and the duration of sitting. Probably one or more predisposing factors have to be present in order to develop the disorders.

In the light of the proposed model the following was postulated:

A job which demands sitting for 8 hr every day will always increase the risk of work-load disorders in the legs—regardless of the ergonomic design of the work-place.

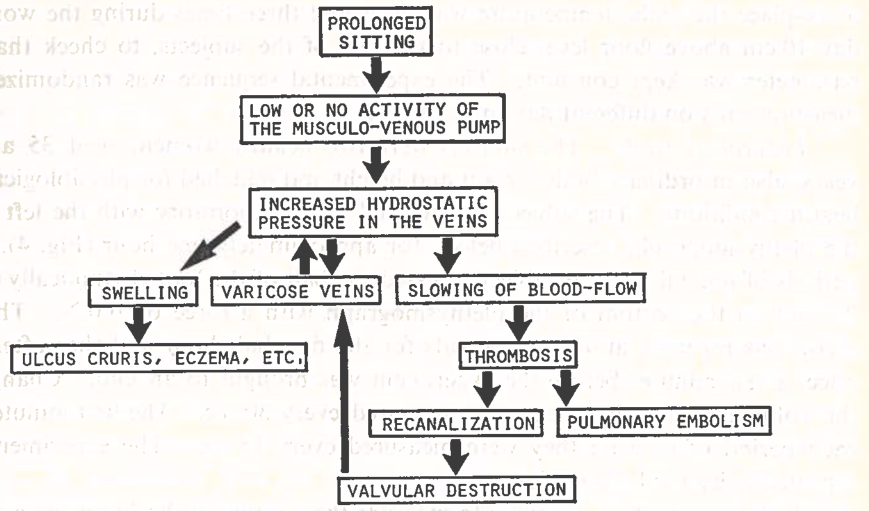

Fig. 3. A proposed model illustrating one mechanism of etiology of peripheral venous disorders.

Aim of the experiments. The purposes of the pilot study were (1) to measure the amount of swelling of the lower leg and the simultaneous perception of discomfort occurring in healthy subjects working 8 hours at correctly dimensioned sedentary work-places, (2) to investigate whether "activity pauses," during which the subjects perform rhythmic contractions of leg muscles, affect the swelling and the perception of discomfort in the lower legs.

MATERIALS AND METHODS

Subjects, work tasks and experimental procedure

Field study. Three healthy women of ordinary body weight and height, aged 34, 41 and 44 years and matched for physiological and health conditions, were studied. They performed their ordinary 8 hours of sedentary work while sitting on standard office-chairs adjusted to each subject's lower leg length. Furthermore they had a one hour lunch break in the middle of the day and a 15 min coffee break in the morning and in the afternoon. During these three rest pauses they were allowed to leave their work-place and walk to the cafeteria. Two subjects worked as keyboard-operators and one as a secretary, typewriting all the time. They were requested to wear the same shoes and stockings every day. The study comprised three normal and three experimental days for each subject. During the experimental days the subjects were required to walk for two minutes on the working premises after every 15 min during the working periods. All measurements on the subjects were performed in the laboratory to which they were taken by car at the beginning and at the end of the working-day. At their work-place the globe temperature was measured three times during the working-day 10 cm above floor level close to the feet of the subjects, to check that this parameter was kept constant. The experimental sequence was randomized for measurements on different days and subjects.

Laboratory study. The subjects were two healthy women, aged 35 and 38 years, also of ordinary body weight and height and matched for physiological and health conditions. The subjects sat relaxed in the laboratory with the left leg in the plethysmograph, described below, for approximately one hour (Fig. 4). For periods of one minute the subjects pressed the ball of the foot rhythmically (every 2.5 sec) on the bottom of the plethysmograph with a force of 100 N. This exercise was repeated at 7-min intervals for the first half hour and thereafter only once, a few minutes before the experiment was brought to an end. Changes of the volume of the lower leg were measured every 30 sec. The first minute after each period of exercise they were measured every 15 sec. The experiment was repeated twice for both subjects.

Plethysmography. In order to measure the volume of the lower leg a simple water-plethysmograph was constructed (Fig. 4). During the measurements the tank was placed on a balance scale in order to check whether the leg muscles were relaxed. Even weak contractions influenced the measurements, probably because of a reduction of blood in the venous system of the leg. The principle consisted of measuring the volume of water displaced by the swollen leg compared to the non-swollen leg at the beginning of the trial (ATZLER and HERBST, 1923; TURNER *et al.*, 1930; WATERFIELD, 1931; POTTIER *et al.*, 1969; KILBOM, 1971; THULESIUS *et al.*, 1973; DIEBSCHLAG, 1975). On top of the tank was a collar through which foot and leg could be introduced, and up into which the water level rose. The

Fig. 4. The set-up for measuring the volume of the lower leg.

collar was as small as was compatible with the entrance of the foot, so that a small change in leg volume would produce a measurable change in water level. By measuring only up to the thickest part of the lower leg a high accuracy was obtained. A change of one millimeter in water level corresponded to about five milliliters in volume change.

The water temperature before the lower leg was introduced was equal to the constant room temperature (21°C). Thus, the physiological effect on the leg volume described by WATERFIELD (1931), was eliminated. The water level was read on a millimeter scale on the tank wall before and after the working-day. The water, which had a little detergent added to reduce surface tension, remained in the tank between the measurements. The tank was closed with a plastic film to prevent evaporation. After the morning measurement, when the leg was withdrawn, it was blotted dry, using previously weighted paper towels, and a correction for the water removed (2–3 ml) was added to the next reading at the end of the day. In accordance with the swelling of the leg during the day, the water rose to a higher level during the second measurement. The amount of water drawn off in order to reach the same level as in the morning, corrected as above, was a measure of the swelling. It was expressed in % of the lower leg volume in the morning. The measurements were only carried out for the left leg. The right leg operated a pedal during the working-day and this might have affected the swelling.

In the laboratory study of leg swelling, the plethysmograph was calibrated for each subject so that the time-consuming addition and removal of water was avoided. Hence, the volume changes during the one-hour experiments could be read directly on the millimeter scale.

Rating of discomfort

At the beginning and the end of the working-day in the field study the subjects were asked to express their level of discomfort in the left lower leg by drawing a mark on an eight-point scale developed for this purpose (Fig. 5). For analysis the values were rounded to the nearest half interval. To facilitate the rating the subjects were also asked to compare the perception of discomfort with previous assessments.

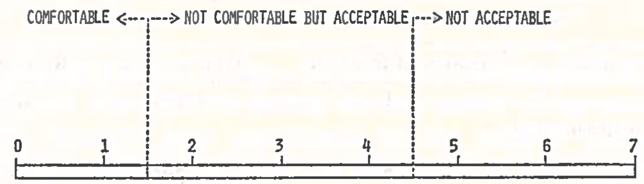

Fig. 5. The 8-point rating scale used in the field study to measure the perception of discomfort in the leg.

RESULTS AND DISCUSSION

The swelling of the lower leg in *the field study* was, on average, 4.0% (range: 3.4–5.5) during the normal days and 2.3% (range: 1.8–2.7) during the experimental days (Table 1). This corresponded to about 70–80 ml and 35–50 ml respectively. An analysis of variance is shown in Table 2. No significant interaction can be shown between treatments (normal days/experimental days) and subjects. Thus, the analysis of variance demonstrates a significance below the 0.001 level for the treatments and below the 0.05 level for the subjects. One subject was required to work two hours extra during both her first normal and first experimental day. These results have been excluded from the averages and the analysis of variance. It is notable that the swelling during these days is greater compared to that during the following days (see Table 1), and suggests that the effect of the two extra hours was measurable in an objective term.

The subjective rating of discomfort in the lower leg at the end of the working-day showed a correlation with the swelling (Fig. 6). The discomfort levels at the beginning of the working-day varied between the subjects, but were always the same for the individual (subject A: 0.0, B: 1.0, C: 3.0). It seems reasonable to expect that changes in discomfort level to some degree have a causal relationship to the swelling for subjects performing prolonged sedentary work.

In *the laboratory study* all four experiments illustrated the same characteristic volume changes in relation to the leg exercise. One example is given in Fig. 7. (1) The exercise reduced the volume of the leg. (2) Immediately afterwards the leg swelled rapidly. (3) Thereafter followed a slow increase, which continued until the next period of leg exercise. This triple response was particularly obvious

Table 1. Swelling of the left lower leg in the field study (%).

Subject	Normal days 1	Normal days 2	Normal days 3	Experimental days 1	Experimental days 2	Experimental days 3
A	3.67	3.61	3.40	2.03	2.08	2.32
B	4.95*	3.87	3.72	3.76*	2.51	1.78
C	4.13	5.50	4.34	2.60	2.69	2.73

* The subject worked two hours extra for reasons extraneous to the study.

Table 2. Analysis of variance table for replicate two-way factorial arrangement; lower leg swelling and subjects. Method of unweighted means (NETER and WASSERMAN, 1974).

Source of variation	Degrees of freedom	Mean square	Ratio of mean square
Treatment (normal days/experimental days)	1	$s_t^2=4.250$	$s_t^2/s_e^2=74.6$
Subjects	2	$s_s^2=0.386$	$s_s^2/s_e^2=6.8$
Interaction	2	$s_i^2=0.041$	$s_i^2/s_e^2=0.7$
Error	10	$s_e^2=0.057$	

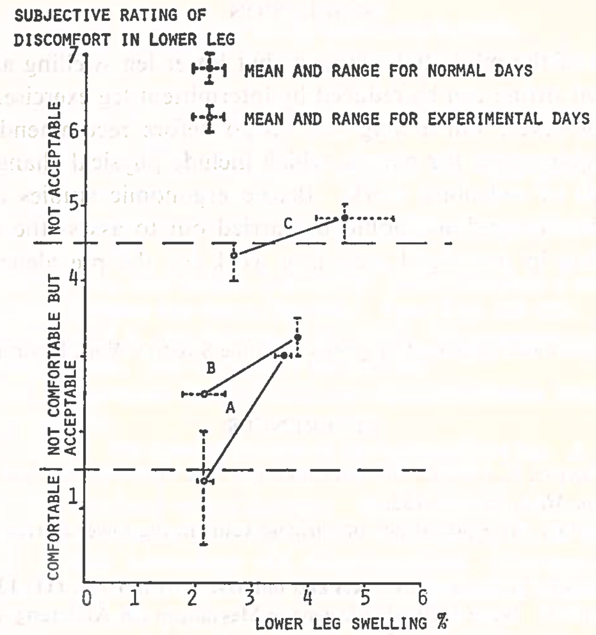

Fig. 6. Subjective rating of discomfort in the left lower leg at the end of the working-day as a function of the swelling. Three subjects: A, B, and C.

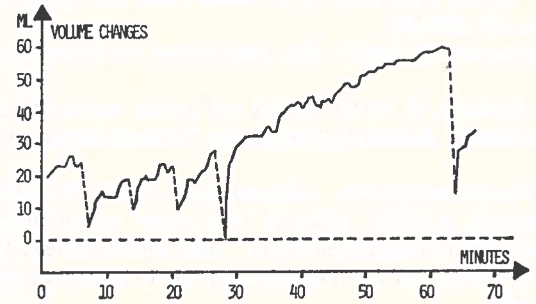

Fig. 7. Volume changes of the left lower leg as a function of time. One experiment with one subject. The lowest volume value during the test session is taken as the reference level. The dotted parts of the curve represent the one-minute periods of leg exercise.

during the last half hour of sitting. It is remarkable that most of the swelling during this period was removed during the last period of leg exercise. Simultaneously, the intensive pain experienced by the subjects disappeared. The observed responses after leg exercise are interpreted as constituting a reflux of venous blood to the leg followed by a formation of oedema, perhaps combined with a slow pooling of blood in gradually dilating veins.

CONCLUSION

The results of the pilot study suggest that lower leg swelling and discomfort during prolonged sitting can be reduced by intermittent leg exercise.

There is, however, still a long way to go before recommendations can be given on the requirements for pauses, which include physical change and activity in various kinds of sedentary work. Before ergonomic studies are continued, epidemiological investigations should be carried out to assess the significance of lower leg swelling in prolonged sedentary work for the prevalence/incidence of PVD.

This investigation was supported by grants from the Swedish Work Environment Fund.

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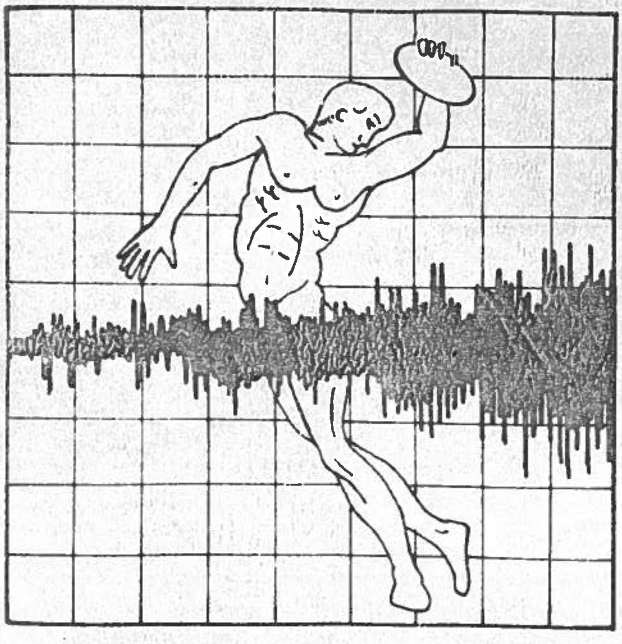
PROCEEDINGS OF THE 4th CONGRESS OF THE INTERNATIONAL SOCIETY OF ELECTROPHYSIOLOGICAL KINESIOLOGY



5 - 10 AUGUST 1979

BOSTON, MA., U.S.A.

ELECTROMYOGRAPHIC EVALUATION OF MOPPING AND SWABBING IN CLEANING WORK

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INTRODUCTION

Many Swedish investigators have among cleaners found high frequencies of disease and discomfort, originating from the locomotor system. In a questionaire answered by 279 cleaners, 40 per cent reported complaints from the shoulders, 33 per cent from the neck. The general work task that was considered to be the heaviest physically was floor cleaning. This is usually performed either by mopping or swabbing. In mopping, a moist short-threaded cloth is wiped in S-formed curves on the floor, similarly in swabbing, a long-threaded wet cloth is used. The cleaners experience a heavier physical load on the shoulders when swabbing compared to when mopping. The aim of the present study was to investigate whether swabbing gives a heavier muscular load on the shoulders and which shoulder muscles are under strain during the work procedure.

EXPERIMENT

Six experienced (employed > 1 year) healthy female cleaners age 20 to 41 years were studied. A few days before the experiments the subjects were examined and found to have ordinary body size and normal muscle strength in shoulder elevation, shoulder abduction and power grip.

The experimental task consisted of continuous swabbing and mopping of a 16 m^2 area for one hour each. The subjects were to maintain their normal work rate for the sheduled hour. Between the mopping and the swabbing one hour of rest was given. The myoelectric activity was recorded on tape by bipolar surface electrodes from the right and left descending part of the trapezius muscle and at the left middle part of the trapezius muscle, and by bipolar wire electrodes from the right supraspinate muscle.

The experiments started with a series of test contractions for the investigated muscles in order to obtain the EMG-force relationship. This was done by a simultaneous recording of myoelectric activity and force during a slowly increased submaximal contraction for shoulder elevation, retraction and abduction.

DATA ANALYSIS

For muscular load evaluation, vocational electromyography offers the possibility to estimate the contraction levels of a muscle. However, in an occupational situation the contraction levels are rapidly fluctuating and for ergonomic evaluation it is necessary to get a measure of the distribution of contraction levels over a certain period of time. By estimating the amplitude probability distribution function (APDF), such a measure is offered, exposing the static, the median, and the maximum contraction level for the time studied (Hagberg, 1979).

The myoelectric and force signals were determined as root-mean square (RMS) values by computer aided analysis from a tape recorder (Ericson and Hagberg, 1978). By power function regression analysis of the EMG levels versus force levels during the test contractions, the EMG-force relationship was established. Regression in reverse procedure of this relationship transformed the APDF of the EMG-signals during work to an APDF of contraction levels for the different muscles. The RMS versus time regression (exponential) was estimated for the first 15 minutes and the significance of the slope estimators (increase in RMS) was tested by the Student's t-test ($p < 0.05$).

RESULTS

The distribution of load levels was evaluated for the first five minutes during swabbing and mopping to avoid influence of fatigue on myoelectric signal amplitudes. High static load was found for the right upper part of the trapezius muscle and for the right supraspinate muscle (figure 1) during both mopping and swabbing. Significant differences in static load between the two cleaning methods could only be found for the middle part of the trapezius muscle, although the static load levels for this muscle were low. However for the maximal contraction levels (figure 2) there was a significant difference between the two cleaning methods for three muscles. The maximum load level ratio (average for the six cleaners) swabbing/mopping was for the upper part of the right trapezius muscle: 1.30 (sign. $p < 0.10$), for the upper part of the left trapezius muscle: 1.49 (sign. $p < 0.05$), for the middle part of the trapezius muscle: 1.78 (sign. $p < 0.05$) and for the supraspinate muscle: 1.16 (non-sign.).

Significant increase ($p < 0.05$) in RMS values for the first 15 minutes of work occurred for the right and left upper part of the trapezius muscle in four respectively six work tasks, for the middle part of the left trapezius and supraspinate muscle in one respectively six work tasks. No difference in RMS-value change over time was found between the two cleaning methods for the first 15 minutes. The time for each 16 m^2 cleaning was 51 per cent longer in swabbing compared to mopping. The work performance velocity was approximately constant during the first 15 minutes of swabbing and mopping.

DISCUSSION

For both mopping and swabbing the mean static load (mean for six cleaners) for the upper part of the right trapezius muscle and the right supraspinate muscle exceeds suggested limits (2-5 per cent MVC) for continuous long term contractions (Jonsson, 1978). This may be due to the equal stabilizing engagement by the right trapezius and supraspinate muscles in the shoulder. Preliminary clinical examinations of cleaners with cervico-brachial disorders show a dominance of complaints from the muscles concerned.

The higher maximum contraction levels found for the swabbing procedure were not high enough to promote local muscle fatigue to a higher extent compared to mopping, measured as an RMS-increase the first 15 minutes.

CONCLUSIONS

Both mopping and swabbing should probably not be performed continuously for a long time without intermittent rests in order to avoid fatiguing processes in the shoulder muscles.

ACKNOWLEDGMENT

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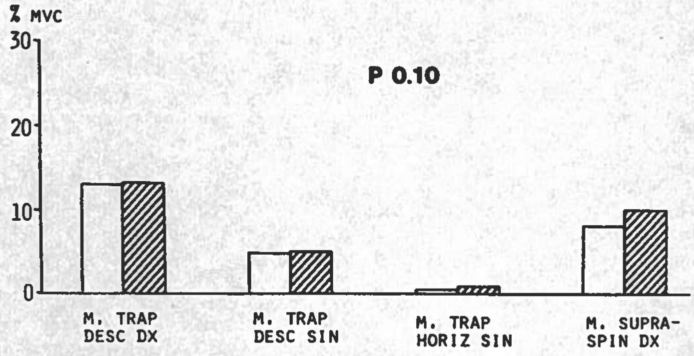

Fig 1 The static (p 0.10) load levels (mean for six subjects) for the fist five minutes for the muscles during mopping (blank area) and swabbing (shaded area)

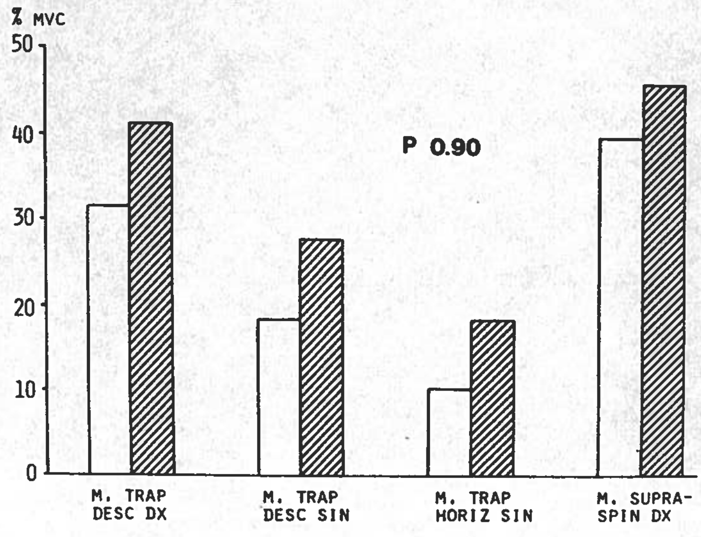

Fig 2 The maximum (p 0.90) load levels (mean for six subjects) for the first five minutes for the muscles during mopping (blank area) and swabbing (shaded area).

XXIXe CONGRES INTERNATIONAL DE MEDECINE AERONAUTIQUE ET SPATIALE

NANCY - FRANCE
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XXIXth INTERNATIONAL CONGRESS OF AVIATION AND SPACE MEDICINE

sous les auspices de
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AERONAUTIQUE ET SPATIALE

et de
LA SOCIETE FRANÇAISE DE PHYSIOLOGIE
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THE INTERNATIONAL ACADEMY OF
AVIATION AND SPACE MEDICINE

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THE FRENCH SOCIETY OF AVIATION
AND SPACE PHYSIOLOGY AND MEDICINE

RESUMES DES COMMUNICATIONS
ABSTRACTS OF PAPERS

AN ERGONOMIC EVALUATION OF WIDE-BODY CARTS USED BY CABIN ATTENDANTS IN CIVIL AVIATION AS A BASIS FOR JOB REDESIGN

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Physical strain in manual handling tasks is a frequent problem in many occupations (Snook, 1978). The prevention of complaints has traditionally been attempted by (1) careful selection of workers, (2) good training procedures, and (3) designing the job to fit the worker. According to Snook (1978) the latter is the most effective.

Cabin Attendants (C/A) and their work in civil aviation (SAS-Sweden) have been studied. In a questionnaire answered by 799 C/A, 85 per cent considered their work heavy due to unsuitable equipment. In an open question, 21 per cent were of the opinion that trolleys create the most serious problems on board (Orring & Östberg, 1980). The most troublesome trolleys are the wide-body carts used on long flights for transport between the galley and the passengers. Each cart is usually handled by two C/A. In the new A300 aircraft, one-man operated wide-body carts are used and might also be introduced in the DC9 in order to increase the efficiency of cabin work. As these aircraft are used for short flights, the cabin floor slopes for a relatively long part of the flying time, thereby increasing the handling forces. Thus, an ergonomic evaluation of wide-body carts has been carried out as a basis for job redesign.

MATERIAL AND METHODS

The subjects were 11 healthy females (non-C/A) aged 22 to 39, selected for ordinary body size and weight and normal muscle strength in power grip. Their shoes had leather-soles as those of C/A, and the heel height was about 3.5 cm. During the experiments they were standing on a piece of carpet from the aisle of an aircraft. The toes of one foot was in line with the cart and a pace length (65 cm) in front of the other. Both hands gripped the cart handle. The cart was fixed to a strain-gauge registering horizontal forces. In the cabin the cart is usually moved a short distance two to five times per minute. Thus, the subjects were asked to push and pull the cart with the maximum initial force they perceived as "acceptable" under these circumstances. Afterwards their ability to push and pull the cart was tested in slowly increased maximum exertions (Chaffin, 1975). All measurements were repeated three times. Two wide-body carts were studied: a drink-cart and a meal cart. Furthermore, the break-away (start-up) force was measured for the fully-loaded wide-body carts (gross weight: 85 kg) standing on the above-mentioned carpet, with the support inclined 0^o, 2^o, 4^o, 7^o and 10^o. The floor inclination in the DC9 and the A300 was measured from take-off up to cruising level and during return to ground level.

RESULTS AND DISCUSSION

The maximum acceptable initial force for repetitive exertions was, on average, 68 Newtons (N) (S.D.= 15N). The maximum force for a single exertion was, on average, 270 N (S.D.= 44 N). The latter was limited by the friction between the shoes and the carpet for all subjects. No significant differences were found between pushing and pulling or the two investigated carts. As a result of our study the Swedish National Board of Occupational Safety and Health has reduced its recommended limit for repetitive push and pull in this task from 200 N, based on a study of Snook (1978), to 100 N. The break-away force of a fully-loaded cart falls below this limit 13 to 15 minutes after take-off in a DC9 or A300, if the cart wheels are parallel to the pushing/pulling direction(figure 1). The handling of carts is usually initiated a minute after take-off, when the "fasten seatbelt"-sign is switched off. Thus, handling of wide-body carts should be delayed at least 12 to 14 minutes to fulfil the recommendations. This cannot be done on short flights without reducing the service level. Development of a new cart for easier manual handling is in progress.

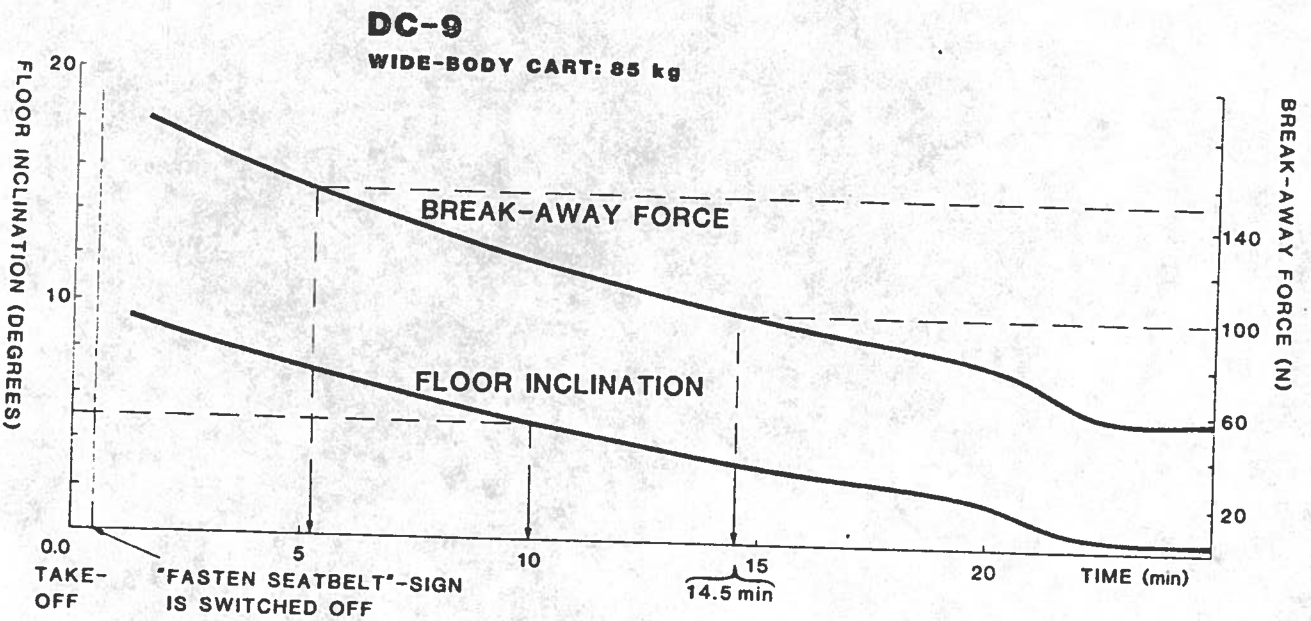

Figure 1: Break-away force for a fully-loaded wide-body cart and floor inclination from take-off (time=o) up to cruising level. According to the company, wide-body carts should not be handled when the floor inclination exceeds 5° or the break-away force exceeds 150 N. These values and the latest recommendation of 100 N are shown in the figure.

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VIIIth INTERNATIONAL CONGRESS OF BIOMECHANICS
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OFFICIAL CONGRESS OF INTERNATIONAL SOCIETY OF BIOMECHANICS

ABSTRACTS

第８回 国際バイオメカニックス学会大会

抄　録　集

VIIIth I.C.B. ORGANIZING COMMITTEE

ERGONOMIC AND MEDICAL FACTORS IN SHOULDER/ARM PAIN AMONG CABIN ATTENDANTS AS A BASIS FOR JOB REDESIGN

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The upswing for airline aviation with increasing cabin factors, along with increasing average employment time for cabin attendats (C/A) may have increased the sum up of physical load on C/A.

In 1979 a questionnaire among 900 C/A in Sweden (SAS) revealed high frequencies of shoulder and arm complaints*. 15 cases were described as serious and the patients associated their disorders with serving coffee in the cabin. Therefore an ergonomic evaulation of this task and a medical examination of patients were carried out as a basis for job redesign.

12 healthy, female subjects (6 C/A and 6 non-C/A) aged 21 to 37 were studied. Each subject served coffee in a mock-up for 15 minutes. The task was repeated three times using *a*) the ordinary pot, *b*) a pot with "better" ergonomic quality of the handle, *c*) another work method excluding the pot, distributing the cups one by one from a service cart. The pot/cut was held in the right hand and the subjects maintained a constant work rate equal to an average used by C/A during ordinary work in the cabin. The physical strain was evaluated by heart rate recordings and subjective ratings of exertion and discomfort. The muscular load and fatigue was evaluated by vocational electromyography.

The mean heart rate was low in all three experimental tasks (about 90/min) and so were the subjective ratings of exertion. Computer analysis of the myoelectric and force signals revealed high static load levels on the upper part of trapezius, the biceps, and the extensor carpi radialis muscle on the right side during work with the pots. No significant differences appeared with the two types of pots. Electromyographic signs of muscular fatigue occurred within a minute while holding a full pot.

The load on the investigated muscles in shoulder and arm was significantly reduced when working without a pot. Furthermore the subjective rating of discomfort in shoulder and arm was reduced for all subjects.

A thorough clinical and laboratory examination of 10 patients (mean employment time: 9.0 years) revealed a dominance of symptoms from the three above mentioned muscles. No concealed, specific medical cause could be found. Sport activities during leisure time might have contributed to the development of the disorders in two of the patients.

The study suggests local physical strain during cabin work as a predominant cause of the reported disorders. The problem would primarily be solved by a change of work methods.

*The results were published April 1981.

IEA'82

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Edited by
Kageyu Noro, Ph.D.

AN ERGONOMIC EVALUATION OF FOOT COMPLAINTS AMONG WAITERS AS A BASIS FOR JOB DESIGN

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25 waiters and 25 workers in occupations not known to cause leg complaints have been studied. Swelling of the left foot and changes of subjective rating of foot discomfort were measured during working days and days off. The left foot of the waiters was examined for abnormalities. The findings suggest that foot complaints among waiters should not be explained by an abnormal increase of foot volume. 16 of the waiters had obvious abnormalities of the left foot. It is suggested that mechanical stress on the foot tissues during prolonged work in an upright position might in the long run deteriorate the form and function of the feet, and thus cause the above mentioned abnormalities.

Introduction:

Several investigations among waiters have shown high frequencies of complaints originating from the locomotor system. A questionnaire answered by 796 waiters showed that the most frequent problem was foot and leg disorders experienced by 53 % (Karlsen & Naess, 1978). Comparable investigations of other occupational groups have shown lower frequencies of complaints from the lower limbs. This suggests the existence of "an occupational factor" causing leg/foot disorder among waiters.

Several investigations indicate that feelings of heaviness in the legs and distension of the feet, which appear during prolonged standing, are due to an increased volume of the lower limbs (e.g. Dupuis & Rieck, 1980).

In the light of these findings an ergonomic evaluation of foot complaints among waiters has been carried out to form part of the basis for job design.

Materials and methods:

The subjects were 25 waiters at two restaurants and a reference group of 25 workers in other occupations not known to cause leg complaints.

The left foot of the waiters was examined for abnormalities. Their subjective rating of foot discomfort was measured before and after a shift. Their working shoes were evaluated.

For 12 of the waiters, 9 females and 3 males, aged 22 to 48 years (mean: 34 y), the volume of the left foot and the subjective rating of foot discomfort were measured three times on working days: when they woke up in the morning at about 11 a.m., and before and after the shift at 6 p.m. and 2 a.m. respectively. For 8 of these subjects the measurements were also carried out on days off, when they got up at about 11 a.m., and before they went to bed at about 11 p.m.

The amount of sitting, standing and walking and the frequency of change from standing or sitting to walking were studied for 8 and 7 waiters respectively.

For the reference group, aged 19 to 59 years (mean: 35 y), the volume of the left foot and the subjective rating of foot discomfort were measured before and after their 8 hour working day. Thus reference levels were obtained for changes in foot volume and discomfort.

The subjects tested for foot swelling had no obvious circulatory defects.

The procedure used for measuring swelling of the foot was as previously described for measuring swelling of the lower leg (Winkel, 1981). For statistical inference the swelling was normalized to 8 hours, assuming a linear change of foot volume over the period. The subjects expressed their discomfort level in the left foot by drawing a mark on a seven-point scale. For analysis the values were rounded to the nearest half interval. To facilitate the rating the subjects were asked to compare their perception of discomfort with previous assessments.

Statistics:

Foot swelling. Parametric tests were used. In the comparison between the waiters and the reference group two-sample t-tests were used. The effect of the different treatments of the waiters was studied using a paired comparison design.(AOV and t-tests)

Rating of foot discomfort. Non-parametric tests were used. The Mann-Whitney test was used when comparing the waiters and the reference group. The effect of the different treatments was studied using a Friedman rank test. A simultaneous significance level greater than 0.05 (two-tailed) was rejected. The difference in distribution of discomfort between waiters with and without abnormalities of the left foot was tested using Fisher´s exact test (one-tailed).

Results and discussion:

For the waiters a highly significant increase in the discomfort leve of the left foot developed during the shift. (The mean values, shown in figure 1, were not used for statistical inference). Furthermore, the increase was significantly higher compared to the increase in discomfort level for the reference group. During the leisure periods no significant changes were observed.

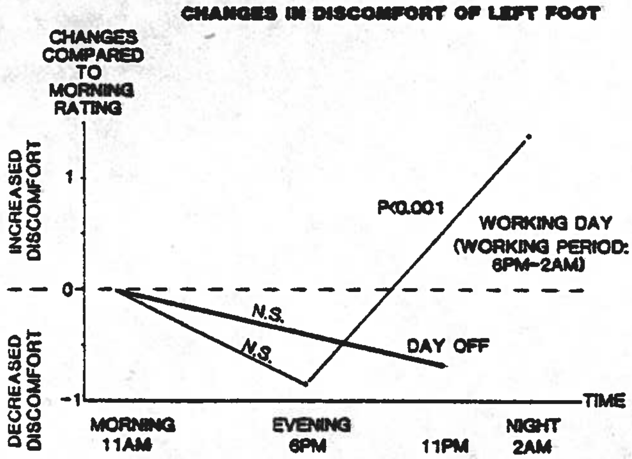

Figure 1.

The mean foot swelling for the various periods are given in table I. No significant difference could be found between the working period for the waiters and the reference group. However, during the leisure periods the swelling was significantly reduced compared to the working periods.

Table I: Normalized foot swelling (%)

Waiters	Mean	S.E.
Leisure period of working day (N = 12)	0.4	0.3
Working period of working day (N = 12)	1.3	0.3
Day off (N = 8)	0.4	0.2
Reference group (N = 25)	1.4	0.2

The activity studies indicated that on average the waiters were standing 56 % (s = 5), walking 35 % (s = 5) and sitting 9 % (s = 7) of the working hours. The low rate of swelling in spite of the long duration of standing might be explained by the frequent interruption of the standing/sitting position by walking (mean: 2.3 times/min, s = 0.7) thus activating the musculo-venous pump.

These findings suggest that foot complaints among waiters should not be explained by an abnormal increase of foot volume.

16 waiters had obvious foot abnormalities, e.g. pes transversoplanus. The location of foot discomfort developed during the working hours seemed to be correlated to the foot abnormalities for 13 of these. But the difference in distribution of discomfort for waiters with and without abnormalities was not significant, probably because of the small number of subjects (figure 2).

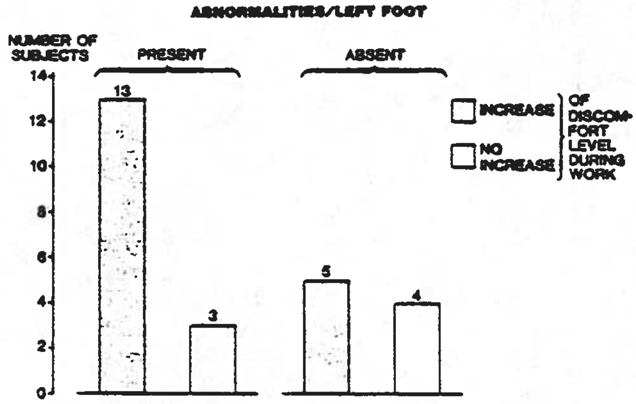

Figure 2.

According to several authors the mechanical stress on the foot tissues during prolonged work in an upright position might in the long run deteriorate the form and function of the feet, e.g. by elongation of ligaments, and thus cause the above mentioned abnormalities.

The examination of the working shoes did not indicate that these might be of significant importance for the development of foot discomfort, according to the author's assessment.

It is suggested that foot complaints among waiters might be reduced by a job enlargement which reduces the time spent in an upright position.

References:

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