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This study was concerned with the application of human anthropometry to the design of office spaces. Pertinent literature, available to the writer, relating to space requirements for people performing office tasks was reviewed and noted.

Information on basic body measurements, spatial requirements for individual work areas, spatial relationships between individuals including physical features of offices, and spatial organization of office areas, was summarized. This information was presented as a slide series with accompanying script.

SPACE REQUIREMENTS FOR PEOPLE PERFORMING OFFICE TASKS

by

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CHAPTER I

INTRODUCTION

From earliest times man has used his instinct or intellect to create tools and inventions for his comfort and safety. More than two million years ago, hominids in Kenya made bone and stone tools to conform with the shape of the thumb and hand. (6)

During the last 100 years, scientific technology has resulted in a machine age. During this revolutionary time the study of man, his limitations and his safety have been neglected. Technologies developed largely according to technical advancements without consideration of the human needs. Dimensions of the human body and the body's functional limitations need to be considered as man adjusts to the technological world.

During World War II a new class of machines evolved that required close integration with man's total abilities. With the evolution of the aviation industries, engineers were faced with the problems of accommodating human beings in aircraft and other confined work places.

Studies were made of human space needs, which were not strictly engineering formulas, but rather human engineering principles developed by anatomists, anthropologists, physiologists, and psychologists. From these studies man has attempted

to derive reliable anthropometric data which could be used in the design of everything from truck-cabs to clothing.

The Importance of Human Spatial Needs in Designing Office Work Areas

In our highly industrialized society, more and more people work at desks. It has been said that urban man spends 88% of his day working at a desk. (44) In 1970 there were 37 million white collar workers - the largest occupational group in the United States. (24:10)

An individual worker seated at his or her desk is the basic unit of the office. In addition, the working area which he or she has is the module or unit upon which space planning is built. (34) Space planning in offices needs to be for people, by people, and with people. The designer should realize that his design is good when it is honestly conceived for the use of people; is comfortable for them to use; is practical for them to use; and is aesthetically pleasing.

Therefore, the study of space requirements in offices, is the study of man's spatial needs for "maximum job performance and job satisfactions within the constraints imposed by available resources." (35:589) The optimum utilization of the working human is the ultimate objective of ergonomics in offices. Since the amount of office work space is a potentially important variable in human performance and comfort, there is a need for studies of human

work spaces in offices. Consideration of work space and arrangement, and the design of personal equipment require attention to human body structure and sizes. These matters are in the domain of human anthropometry. In addition, dynamic anthropometry is important in planning spaces for people in offices.

Scope of the Study

This study reviewed selected research work done in the field of anthropometry and related these basic human measurements to spatial requirements for individual work areas, to the spatial relationships between individuals including physical features of offices, and to the spatial organization of office areas.

From these research findings, a slide series and accompanying script were developed to illustrate and summarize information pertaining to space requirements for people performing office tasks. The purposes of developing the slide/script sequence were to communicate the information in an effective manner, and to increase an awareness for the need of considering human measurements in designing office spaces.

The slide/script sequence was designed for college classes, office space administrators, interior designers, architects, and designers and manufacturers of office furniture.

Purposes of the Study

The purposes of this study were as follows:

1) To compile research findings, based on human measurements, of space needs for people performing office tasks.

2) To present the nucleus of these findings in an attractive, easily assimilated form so that office planners of the future may better meet the space needs of humans.

List of Definitions Used

Anthropometry - The measurement of various physical features of the body, including linear dimensions, circumference and weight.

Dynamic Anthropometry - The measurements of people in the process of performing some function. This includes ranges of speed and strength of body movements.

Ergonomics - The scientific study or relationships of man and his working environment.

Functional Module - The unit of space required to perform a specific office function.

Open-Plan Offices - The layouts of offices without corridors. Based on the subdivision of office floor space into large spaces with smaller separate spaces for senior staff only.

Percentile - The values representing the percentage of people at or below a certain measurement.

CHAPTER II

REVIEW OF LITERATURE

Basic Body Measurements

The basic criterion for accommodating designs to people of different sizes is the knowledge of their body measurements or anthropometry. The dimensions needed for workspaces vary with a person's duties. Most office duties are performed sitting down. In planning a work space for a seated person, the designer must know first the occupant's static dimensions (sitting height, knee length, arm reach, etc.), and then his dynamic dimensions, which include both the distances the person can move and the forces he can exert. Designers, therefore, need to have a complete data bank when their design is to be used by humans. A work area used by many people needs to be designed for the majority.

Unfortunately, good anthropometric surveys are difficult and expensive to perform. Most of the anthropometric data published to date comes from large surveys carried out for a special purpose (often a selected population). (18) Large samplings have been taken by the armed forces to make the man-machine relationship successful in a fighting environment. Although these measurements are accurate and comprehensive, they are limited to a select

group. Civilian surveys have not been as extensive in terms of samples and measurements. Since most of the civilian surveys were performed several years ago, the information needs to be corrected for the growth of people's height (about 0.3 inches per decade) and supplemented by the military information to be most useful today. (6:4) In addition, many civilian surveys were for the purpose of designing clothing and footware. (17)

A good anthropometric survey includes a population of males and females, adults and children. It should be large enough to represent the total population, including people of different localities, ages, and races. Measurements should be taken by highly trained technicians using standardized methods. The body should be measured in various postures and, for accuracy and consistency, without shoes and clothing. (6)

Factors influencing anthropometric surveys

Occupational, racial, age and body type differences, and varying types of measuring devices influence anthropometric surveys.

Occupational. In 1952 Clements and Pickett investigated the stature of Scotsmen. From their studies it was found that the administrative classes were taller than the semi-skilled or labourers - the mean difference amounting to 1.4 inches. (18)

Racial. Corrections in proportional differences in races should be made. Japanese and other Orientals, for example, have about the same sitting height as whites, but their legs tend to be shorter. Blacks have longer legs in proportion to their trunks than whites and Japanese. An average Black male's leg is 3.6 inches longer than an average Japanese male's leg; and it is 1.5 inches longer than the average white male's leg. (6)

Age. Age also appears to be related to most body measurements. E. M. Clements in a 1954 survey of "Body Measurements of the Working Population" contended that, ". . . stature is likely to reach its maximum at about age twenty and to decrease at a rate of about 0.03 inches per ten years." (18:40) In 1967 W. F. F. Kensley made a study in London of "Women's Measurements and Sizes." This study, involving a small sample of women, revealed a height difference of about 1.3 inches between women of an average age of 23 and women of an average age of 55. (18) Clara Ridder, in her 1959 study, Basic Design Measurements of Sitting, suggested that "older people tended to be shorter and heavier for their height." (23:14) Therefore, age was inversely related to all linear measurements and directly related to all width measurements.

Body types. In addition to average body sizes, three other body types could cause discrepancies in anthropometric surveys. Those three types are the rotund

(endomorphic), the muscular (mesomorphic), and the thin (ectomorphic). (6) Measurements of the rotund person, for example, can influence design work such as in the determination of seat width and in the height of a work surface to clear the thigh and abdomen. Also, differences in body sizes and types affect reach and sitting space requirements.

Varying measuring devices. The measuring devices used by researchers varied from study to study. Most anthropometric dimensions were taken with standard instruments - anthropometer, calipers, and tape.

Dempsey, 1953, in his study on the Development of a Workspace Measuring Device for the U. S. Air Force, devised a different method for obtaining functional data.

> With his workspace measuring device the person sits at the center of what resembles a large pin cushion. He is surrounded by slender shafts which can be moved radically toward him until he can touch the tip of each. These points in space describe his work envelope. This device, though very effective, requires a considerable amount of space. (39:151)

Another unique measuring device was an experimental chair designed by Clara Ridder for her research of basic design measurements for sitting.

> The seat and back of the experimental chair were made of aluminum plungers inserted into calibrated holes drilled in a wooden base. The plungers were capped with circular rubber tips. A steel spring of 5 pounds strength was inserted between the wooden base and the cap so that plungers adjusted to the shape of the individual sitting on them. Each row of plungers could be quickly locked and unlocked. The seat was adjustable in height

> by means of 2 hydraulic jacks that were placed at the corners of the front of the seat and by a third jack that was centered back of the seat. Therefore, varying heights, slants and shapes of seats were possible. Also, the chair back and arm rests were adjustable. (23:6-8)

This chair, which allowed for the greatest possible variations in heights, depths, slants, and shapes of seats, backs and arm rests, was significant in that any combination of measurements could be made.

Photography has been used by some researchers as an effective means of recording workspace data. Probably the most complete of such systems was that of Morant who photographed a man sitting in the corner of a room with his back touching one wall and his side the other wall. The photographs were taken from both front and side. Grid scales on the wall provided a means of measuring the dimensions. (38)

Anthropometric studies to establish the "average" man

Numerous anthropometric studies, conducted for the purpose of establishing body measurements of the average man, have been done. The armed forces and the clothing industry have performed many of these studies. To date, most of the studies were aimed at establishing average dimensions for men only.

In most of the literature of human factors engineering, an U. S. Air Force study of 1950 by H. T. E. Hertzberg

and G. S. Daniels on the Anthropometry of Flying Personnel was mentioned as one of the most complete and accurate anthropometric studies in this country. (1) (15) In this study 132 different dimensions were measured of 4000 Air Force flying personnel. Data from measurements were used in the design of seating arrangements, tables, passageways and other workspace features. The method of arriving at the dimensions for the average man was most difficult. For computation Hertzberg and Daniels used an arithmetic mean; yet there were no men who fell within the average range in all series of measurements. (15)

Some years ago, Daniels and Churchill made a study to test the assumptions of the concept of the "average" man. They examined body sizes data on more than 4000 U. S. Air Force flying personnel to see how many men would be considered average in 10 dimensions useful to clothing design. Instead of using the exact average, the authors made a very generous allowance of plus and minus 15% from the exact average. This was the middle 30% for each dimension. This they called the "approximate average." Even this approximate average for all 10 measurements was relatively uncommon. Less than 8 in 100 men possessed the average in 2 dimensions; and none for 4 of the 10 dimensions. (38)

A study by Kellermann, Van Wely and Willems of body dimensions of factory employees in the Netherlands

merely established a mean average of body measurements and arbitrarily set a range (plus or minus a figure) in which 90% of the employees fell. (13) The methodologies of this survey were not recorded so the writer of this paper could not evaluate the research results of this study.

Henry Dreyfuss in his publication, The Measure of Man and Designing for People, used the results of several anthropometric surveys to establish averages of human measurements. Even though his work is accepted by many people in the design profession, from the surveys used there was no mention of research methodology, sample size, or techniques of measurement.

The latest work of Henry Dreyfuss and Associates, Human Scale, is a compilation of thirty years work in human dimensions. The editors of the work stated, ". . . that special emphasis was placed on the important surveys, giving due consideration to their accuracy, sampling and recency." (6:4) Percentiles were used in establishing figures for dimensions. The percentiles were to represent the small (2.5 percentile), the average (50 percentile), and the large person (97.5 percentile). Even though no mention was made of the exact research methods, the writer feels that this recently published study could be helpful to designers for information of basic human anthropometry.

Since people vary from the "average" dimensions, equipment, ideally, should be made adjustable to suit a predetermined proportion of the population. When equipment has to be non-adjustable, the designer should choose dimensions suitable for a pre-determined user. This is sometimes called the "range of accommodation" system. In other words, it is taking relevant dimensions on an adequate sample of the using population; reducing the data statistically; then, from these data choosing the dimensions for workspace according to the percentage of the population that the product is intended to accommodate. (38)

The designer needs to know when to use the maximum or the minimum values of a dimension. For example, in designing a work surface and chair combination for a maximum value of knee height, the height of the bottom edge of the kneewell needs to be designed to accommodate the largest user. If women are to use the chair, the minimal height should be the lowest value for women. (38)

Dynamic anthropometry

In recent years greater attention has been given to the developing field of dynamic anthropometry, or the measurements of people while they are in the process of performing some function.

A central postulate of dynamic anthropometry is that the individual body members, performing various

physical functions, do not operate independently, but rather in concert. The practical limit of arm reach, for example, is not the sole consequence of arm length; it is also affected in part by shoulder movement, partial trunk rotation, possible bending of the back, and by the function that is to be performed by the hand. Therefore, all space and dimensions problems can not be resolved on the basis of anthropometric data from static measurement alone. (15)

It is beyond the scope of this paper to deal with dynamic anthropometry extensively. The domain of dynamic anthropometry is concerned with skeletal structure, joint systems, leverages, ranges of movement, centers of rotation, mass, center of gravity, mechanical analysis of movements, pattern of body movement, and other considerations. (15)

Spatial Requirements for Individual Work Areas

Determing space allotments needed according to tasks is the beginning of the determination of space standards for the total office. Office planning systems need to be based on space needs for individuals.

Office tasks

Robert Propst, of the Herman Miller Research Division, found from his studies that the primary activities of an individual in an office were involved with the handling

of information, people and materials. (35) The following are primary tasks involved in performing these activities:

> Based upon information received via some medium (telephone, letter, visitors, etc.) an individual determines that a decision must be made.
>
> The individual then identifies the relevant information which must be brought to bear in order to make an effective decision.
>
> He then retrieves this information by various means from a multiplicity of sources; files, books, reports, people, etc.
>
> He stores the information temporarily until he has accumulated all pertinent facts.
>
> Next, he processes the information. The processing can take several forms; discussion with associates, reading, recording, reducing, modifying, consolidating, comparing, mathematical manipulation, etc.
>
> The preceding is an iterative process sometimes extending over a long period of time, thereby requiring temporary storage and subsequent retrieval of the information.
>
> The process is continued until the information is transformed into a suitable form for making a decision.
>
> Once a decision is made, the individual takes the appropriate action; communicate, document, store, implement, etc. (35:595)

In the same study, Propst interviewed a selected group of office personnel and asked them what percentage of time they devoted to various management activities. Then he observed their activities and calculated actual time percentages for various activities. The following were activities performed: reading, writing, conferring, visiting, phoning, retrieving and storing, dictation, and

non-work personal tasks. The following table illustrates the findings of his study: (35)

Table 1
Percentage of Time Devoted to Various Office Activities

Activities	Estimated % of Time	Actual % of Time
Reading	25	13.1
Writing	20	45.7
Conferring	35	28.3
Visiting	5	0.3
Phoning	5	7.2
Retrieving & Storing	2	1.1
Dictating	0	0.0
Personal	8	4.3
Total Time	100	100.0

The design of office seating

Since most office work is sedentary, the chair is essentially the most important physical facility. It is important, therefore, that seating be properly designed for comfort and efficiency. George Terry, in his book, Office Management and Control, stated,

> "The principal blind spot which seems to affect those responsible for furnishing the office is that most indispensable article - the chair. It is safe to judge the degree of progress an organization has made toward modernizing its office by the kind of chair it furnishes for clerical workers." (28:130)

Principles of good seating design. Sitting can be tiring and painful on a poorly designed seat. A good seat needs to allow for freedom of body movement or a change in the sitting posture. For this reason, a fairly flat seat is preferable to a contoured or bucket seat.

A seat needs to give rigid support, but not rigid confinement. It needs to support the thorax and pelvis and help to maintain the angle of the spine between. (5) Therefore, the design of back rests is important.

Correct seat height is important in chair design. A seat which is too high will cause unnecessary pressure under the front of the thighs. The undersides of the thighs are poorly constructed to support body weight. (5)

Most of the weight of the seated body is borne by the ischial tuberosities (bony protrusions on the underside of the pelvis). However, the ischial area becomes uncomfortable and painful in prolonged sitting. Cushioning should, therefore, be provided. (5)

Applying anthropometric measurements to seating. In designing a chair to fit a majority of the people these measurements need to be considered: the seat (height, depth, width, angle, padding, and seat front edge); the back (height, width, and angle); and the arm rests (height, length, and spacing).

Seat height - front edge. The seat height has been considered one of the most important dimensions of a chair.

A person sitting in a chair that is too high will often feel pressure on the underside of the thigh with a resulting numbness in the legs. If pressure is to be avoided on the underside of the thigh, the seat height

needs to be somewhat less than the length of the lower leg from the underside of the knee to the heel (the popliteal height). (18)

In general, if a seat is too high a person will slide forward and any special planning for the depth of a seat or a back rest will be lost. A good test for height is to see if it is possible to slip the fingers readily between the front edge of the seat and the thighs with the legs vertical. If this can be done, the seat is the correct height. (18)

For office work the height of a desk chair should be adjustable to allow for a large range of people and varying work heights. For an adjustable chair intended for women, Murrell recommended a height range between 14 and 17.5 inches. For men he recommended a range covering 15 to 18.5 inches. (18:146) Ridder found a seat height preference to range from 15.2 inches for short people to 17.1 for tall people. (23.24) A range of 13.6 to 20.6 inches for adjustable chair heights would include 100% of the population. (6:19)

Seat depth. The depth of the seat is the distance from the back of the seat (buttocks), when the individual is sitting erect in a chair, to the back of the leg just below the knee when legs are placed squarely on the floor. (4) The depth of a seat should be sufficient to allow

the buttocks to move permitting changes of posture, but should not be so great that the seat cuts into the back of the knee. (18) Seat depths less than 13 inches do not give adequate seat support under the thighs; and the load on other tissues is consequently increased. The resulting discomfort is reflected in a shorter sitting time. (6)

Seat depths greater than 16 inches do not accommodate the small female. If the front edge of the seat comes in contact with the back of the leg, she is forced to sit toward the front or to slide forward away from the backrest which results in a poor sitting posture. (6)

The British Standards Institution's publication, Anthropometric Recommendations of Non-Adjustable Office Chairs, suggested that the depth of a seat should not exceed 15 inches. (3:5) Ridder recommended that the single best depth of seat for the majority and for general use was 16.5 inches. (23:39) For a seated worker the maximum seat depth to accommodate 90% of males and females should be in the range of 15 to 16 inches. (18:147)

Seat width. The seat width should be sufficient to allow a certain amount of movement and adequately support the buttocks. Since hip breath varies from 12.5 inches to 18 inches, a range of 17.5 to 18 inches for seat widths would be adaptable to 100% of the

population. (4:338) Ridder's research recommended 17 inches as a minimum width. (23:39)

Seat angle. Several researchers agree that for chairs to be used at tables or desks, seat surface angles, measured from the front to the back of the seat, need to range from 3 to 5 degrees. (3:4) (6:20) (8:148)

Seat padding. Sitting on hard, flat seats for long periods of time can be uncomfortable. The pressure on the tissue under the ischia impedes the blood flow, creating fatigue and pain. Seat surfaces must be able to exert counter-pressure and support the body's weight. (4) A depression of 0.5 inch in a padded seat is adequate. (6)

Seat front edge. The front edge of the seat needs to be considered. Hard edges at the front of the seat will compress the tissue against the thigh bone and slow down blood circulation in the legs. This compression can cause severe pain or make the legs fall asleep. A softly padded front edge with a radius of about 1 to 2 inches reduces tissue pressure to near zero. In a good chair the sitter is not conscious of the front edge. (6:20)

Back height. A back rest helps to maintain the natural curvature of the hollow in the back (the lumbar region). (15) The back height, width, and angle are important measurements to be considered in designing a good chair.

The upper limit of the back rest needs to be below the shoulder blades so that movement of the shoulders and the arms is permitted. A lumbar support, measuring 5 to 7.5 inches from the seat surface to the bottom of the back rest, accommodates a large population. (5:147) A height of 4 to 6 inches for the lumbar support itself will fit a majority. (5:147) Research indicated that people desired a chair back height of 17.5 inches from the seat to the top of the chair back. (23:28)

Back width. The minimum back width which would provide adequate support at the shoulder level for a majority of the population is 13.5 inches. (23:29) (18:148) (6:20) (3:6) This minimum width allows freedom of arm, elbow and shoulder movement.

Back angle. Most human factors engineering people recommend the use of a continuous back rest, especially if padding can be used to allow for a wide variability of the shape of the back. The angle of such a back rest to the horizontal surface should be between 95 and 110 degrees. (18:149) (6:20) The back rest to seat angle should not create hip angles less than 90 degrees since they cause flattening of the lumbar curve by tilting the pelvis. (5) This may lead to abnormal muscle tension and cramping.

Arm rest height. Arm rests are needed as bases for arm leverage in working positions. In addition to

supporting the weight of the arms, arm rests are useful aids in getting in and out of chairs. (13)

A minimum and maximum range of arm rest heights is from 7 to 10 inches above the seat height. (6:21) An average value of 8.5 inches satisfies most people. (6:21) (18:148) (3:5) High arm rests elevate the shoulders, causing stiffness or pain in shoulder and neck muscles. Low arm rests are conducive to excessive body slump and leaning to one side.

Arm rest length. The most comfortable arm rests are long enough to support the full arm and the base of the hand. The minimum dimension for accomplishing this is 12 inches, measured from the back rest. Short arm rests, 8.3 inches, permit a close approach to tables and desks. Very short arm rests, 6 inches long, which support only the elbows, may be used for typists' chairs. (6:21) A finger clearance of 1.5 inches is needed for arm rests that pass under a table or desk to prevent possible injury in pulling the chair into position. (6:21) In addition, if the chair is to be used with a desk having a shallow center drawer, 7.5 inches should be left free back from the front of the chair seat to the front of the arm rests. (23:40)

Arm rest spacing. Arm rests must be separated only enough to permit seat entry of the largest sitter. If they are too far apart, slender people have to either

hang their elbows inside or use only one arm rest. The minimum space between the insides of the arm rests is 19 inches; and the maximum space is 22 inches. (6:21) (18:148) (23:40)

Application of anthropometric data to the manufacture of office chairs. In 1961, Dancer and Hearner, Ltd., an English company which makes large quantities of inexpensive office chairs, undertook a project of designing a chair that would follow closely the anthropometric measurements of the British Standards Institution (BSI). The dimensions of the final chair mock-up and the comparative BSI sizes are given in the table below: (46)

Table 2
Comparison of Chair Dimensions of Mock-up with BSI

	Mock-up	BSI
Seat height	17"	17"
Seat width	17"	16" (min.)
Effective seat depth	14"	13-15" (14" recommended)
Slope of seat	3°	3°-5°

Dancer and Hearner made two prototypes - one with a short back rest and the other with a longer back rest. The main lumbar support occurred at the same place on both long and short back rests (between 8 and 13 inches above the seat height). Both chairs were tested in an office building for two weeks. At the end of this period a substantial majority favored the longer back version. This

chair has been considered to be one of the best designed British office chairs which meet the needs of people's sizes. (46)

In 1966, the British government took a representative sample of 234 soundly constructed desks and chairs. After checking measurements of chairs and desks, their findings indicated that most of the furniture was ergonomically incorrect. (43)

In 95% of the men in Great Britain, the popliteal area (area under the thigh in back of the knee to the bottom of the floor) measured less than 17.75 inches. In 95% of women, the popliteal area was less than 16.75 inches. It is hardly surprising that an 18-inch chair was too high for most people. (43)

In addition, this British study noted that the seating depth of most office chairs was much too large. Ergonomists recommended 15 to 16 inches as maximum seating depth. Of the chairs studied, 90% had 16.5 to 18.5-inch seat depths. (43:41) Nearly everyone can sit on a 15-inch chair without pressure on the back of the calves, though the long-legged individual will find the seat too shallow. At 18.5 inches, over 25% of men and over 50% of women will feel some calf pressure. (43:41)

Out of 35 non-adjustable office chairs studied, only 3 conformed exactly to the anthropometric recommendations

of the British Standards Institution. Of the remaining 32, 23 were higher than 17 inches. (43:42)

Of the 36 adjustable office chairs studied, only one conformed exactly to the anthropometric recommendations. None of the chairs adjusted below 16.5 inches; and 13 chairs would not adjust as low as 17 inches. Many of the chairs had fixed backs which were too high for comfortable support. (43:42)

The design of work surfaces - tables and desks

The correct relationship between the work surface and seat is important for human comfort and efficiency.

Applying anthropometric measurements to the design of tables and desks. The working heights, optimum manual space for working, and adequate leg and foot clearances need to be considered in designing work surfaces to fit human dimensions.

Working heights. The desk or table height is very important to the comfort of a seated worker. Table heights are significantly related to the heights of people and to all of their other truly linear body measurements. (23)

If a fixed table and seat height are to accommodate both sexes, most studies recommended 28 inches as an optimum measurement for the distance from tabletop to the floor. (6:22) (3:6) (33:69) (17:383) (28:134) Ridder's subjects preferred table heights ranging from 24.3 to 28.2 inches. (23:32)

When both table and desk are adjustable, a table or desk height which adjust to a range of 26.5 to 31.0 inches and a seat height adjusting to a range of 13.6 to 20.6 inches accommodated nearly all adults of both sexes. (6:23)

Typing tables and desks are generally lower in height than standard office desks. For fixed typing tables, a height of 25 inches is recommended. (3:6) (6:23) When typing table heights are adjustable, a range of 20.5 to 26.5 inches accommodates most adults. (6:23)

In a study for the Institute of Occupational Health in Helsinki, Finland, A. Koskela surveyed the working conditions of 300 office workers. The reason for the investigation was rather common complaints of pain and aches in back, neck, shoulders and arms of the office workers. The investigator interviewed workers and made his own observations. Attention was directed at the relationship of desk and chair dimensions to the posture and muscular pains of the workers. (40)

Of almost 100% of the secretaries interviewed in this study, the typewriter desk was too high. On the newer electric typewriter the keyboard was higher than that of a manual typewriter. This presented problems of shoulder pains. To remedy this problem the legs of the typewriter desk were made adjustable in order to fit the varying heights of secretaries. (40)

Optimum manual space for working. The depth and width of a work surface, which are dependent upon the dimensions of human reach, need to be considered in designing optimum manual space for working.

Work surfaces need to be designed to eliminate unnecessary shoulder and trunk movements. Researchers refer to the area that can be reached without contortion of the shoulder, head or trunk as the maximum working area. The area that can be reached conveniently with a sweep of the forearm with the upper arm hanging in a natural position is called the normal working area. (4) (15)

In 1944 R. M. Barnes conducted a study based on the maximum and minimum arm reach of 30 men. He concluded that a 20-inch radius fell in the area of maximum reach and a radius of 15.5 inches fell in the area of normal reach. (4:341)

In a 1958 paper for the American Psychology Association, T. L. Stoddard and W. K. Carter studied the optimum manual workspace for the seated operator. This study, consisting of a sample size of only 10 men, was designed to measure arm reach in various directions. From this study the average maximum reach was a 24-inch radius; and the average normal reach was an 18-inch radius. The results of this study concluded that the manual work surface needs to be considerably closer to the body than is ordinarily assumed. These findings suggested that an

optimum work surface should tend to be narrower (front to back) and wider (side to side) than the typical work surface in common use (which measures 60 inches long by 30 inches wide). (15)

Since most people can easily reach an 18-inch width, the British Standards Institution and Humanscale agreed that the minimum depth of an office desk or table should be 18 inches from front to back. When a desk is placed flush against a wall, a minimum depth of 24 inches is recommended so as to allow space for the feet. The maximum reach diminished as the arm was extended to the side. (3) (6)

Adequate leg and foot clearance. There must be room for stretching legs and moving them around under a desk.

The British Standards Institution recommended a minimum of 24 inches clearance from the underside of the table or desk to the floor (3:6) To accommodate 95% of adult males 25 inches is the minimum leg clearance; for 95% of adult females 24 inches is the minimum. (8) For these spaces, center drawers should be eliminated. In order to have clearance under a table for crossing legs, Ridder recommended an average of 26 inches. (23:33)

In designing the knee well width of desks, the ease of movement from desk and the ability to move a chair partially under a desk are functional considerations

to be made. British Standards Institution recommended 24 inches for knee well widths. (3)

Application of anthropometric data to the manufact- of work surfaces. Until recently very little innovation had been done in industry to make office work surfaces meet human spatial needs. Mr. Jay Doblin, Director of the Institute of Design at the Illinois Institute of Technology, had this to say about designers of office furniture, "In my lifetime, I have known dozens of furniture designers and have yet to meet one who conscientiously tests his products for human use." (35:590) Confirmation of the preceeding is in evidence throughout most offices.

In 1962, Interiors International, Ltd., a British design firm, began work on a new idea for office desks. The developmental work began by emphasizing that more adequate office storage and work space needed to be provided simultaneously. The research team conducted a number of special surveys to determine human dimensions and to find worker preference to desk layout. From their findings a system of modular office furniture was developed. Within the desk shell, four-inch units could be fitted together to form a variety of compartments to suit individual needs. The ratio of storage space to work surface was infinitely varied. (36)

In the 1966 British government study of office furniture, out of a sample of 131 office desks evaluated,

only 18 conformed to the anthropometric recommendations of the British Standards Institution. (43) Most of the remaining 113 were higher than 28 inches; 18 of the 28-inch desks had less than 26 inches clearance below the desk top. The study indicated also that 16 desks had horizontal bars within the kneewell space. The bars were too high for use as foot rests, yet too low to give enough leg clearance. Four of the desks had kneewell widths of less than 23 inches. (43)

One of the first real innovations in work surface design was the office system, Action Office, developed by Herman Miller, Inc. of Zeeland, Michigan. Based on the German idea of the landscaped office, the Action Office was developed after many years of research by Robert Propst of the Herman Miller Research Division. Its final design was executed by George Nelson. This system provided both a sit-down and a stand-up work surface as a relief from the sedentary seated position. The objectives of this system were to enhance health, creativity, and performance, and to provide secondary work or conference surface. File wells at the rear of desks, flip-up display panels and other surfaces provided constant visual and physical access to relevant information. Such features also facilitated storage and retrieval of information. A communications center was provided to accommodate a telephone, phone book, dictation equipment, and a display and writing

surface in a sound protected booth, thus freeing an individual's valuable work surface. (35) (37) (32)

In addition to the Action Office, many American and European manufacturers have designed similar office systems.

Spatial Relationships Between Individuals Including Physical Features of Offices

To date, research in applying anthropometric measurements to spatial relationships between individuals and physical features of the office has been insignificant. Yet, ". . . spatial organization (of an office) is measured in terms of physical and functional distances between individuals and activities." (10:97)

Distances between individuals

To date, standards for spatial relationships between individuals have been based on measurements of available furniture, equipment and clearances. Literature mentions many measurements that have been used in planning distances between individuals, but these measurements are often given without indicating the research basis.

Memoli and Terry, office space administrators, have set a minimum space standard for the distance from the back of one work station to the back of another station as 72 inches. (16) (28)

A net distance of 42 inches between work stations has been used by office space planners. Anatomy for Interior Designers recommended a minimum distance of 30 inches between work surfaces. (20) Edward Rausch in his book, Principles of Office Administration, stated, "There should be 3 feet minimum, but no more than 4 feet of space between each desk." (22:91)

Clerical workers often use a typewriting return unit to one side of their primary work surface. In open office areas, work stations are often butted close to conserve floor space. The net distance between units is the length of the return unit. (16)

Preferences to spatial arrangements

Robert Propst stated in his book, The Office - A Facility Based on Change, that, ". . . proximity has an effect on office workers." (21:23) People with too much distance across a surface area are orally alienated. People sitting side-by-side, shoulder-to-shoulder are bothered by too close a proximity and the physical stress of twisting necks and torsos to talk. Those who sit across corners will converse with the most ease. (21)

Robert Gutman has stated that,

> "Interior architectural space has an influence on social interaction; for buildings have the capacity to serve as communication networks. The arrangement of walls, rooms, doors, and partitions affects the opportunity people have to see and hear each other and,

> thus, to respond to one another. The location of barriers, apertures, and paths can provide opportunities for communications or hinder them." (10)

The Pilkington Research Unit at the University of Liverpool studied the differences between people's attitudes and behaviors in large and small office areas. (41) (10) In this study, 300 office clerks, supervisors and managers in the CIS building in Manchester, England were asked questions designed to explore their attitudes to open plan offices. In the case of clerks, questions were asked to see how their friendship patterns varied between large open plan areas and smaller semi-enclosed areas. It was found that managers preferred large open offices and clerks preferred small offices. Supervisors preferred small areas.

Differences were also found in friendship patterns in different type of offices. Clerks in large offices made more friendship choices outside their section than those in small offices. Small offices tended to generate more socially cohesive sections, whereas larger offices encouraged more contact between sections and even departments. (10)

David Canter, a psychologist, was interested in the effects of office size. In his studies he attempted to see if office size had any influence on people's performance. Two standard clerical tests, developed for staff selection purposes, were used to study performance

in large and small offices. The results showed some decrease in performance as room size increased. Canter believed that this was partly due to increased distraction in larger offices. (34)

Axel Boje, a foremost German consultant concerned with the open-plan office technique, found from his research that, ". . . subdivision of the available interior space into small individual offices is preferred." (2:14)

Ripen found in his studies of office space administration that, "Desks separated from, rather than abutting on each other, give each worker more of a sense of pride and prestige in his job, less of a feeling of being part of an assembly line." (24:25)

With the random arrangement of work stations, people feel more unique. This helps them to create their own subjective space. In rectilinear arrangements which have a directional basis, working groups may be more easily defined, but the individual becomes merely a part of the grid. (24)

Henry Skolimowski, in writing about the effect of technology on human space suggested that,

> ". . . the more technology develops, the denser becomes human space. The denser the human space, the more matrices man is involved in and dominated by. The more matrices he is involved in, the greater is the part of his behavior which is determined.

> The more determined his behavior is, the more acute is the feeling of loss of identity." (34:238)

Aisle space

Aisle space is very important in determining spatial organization of an office. Assuming no passage is required, a minimum distance of 30 inches from behind a desk to the nearest wall or obstruction is regarded as standard by many office space planners. (12) (20) (6) Allowing passage for one person behind a seated worker, 36 inches is minimum. (20) (12) Some office space planners have recommended a passage of 54 inches for two people to pass each other; and a passage width of 72 inches for two people to pass one other person. (30) (6)

More space for aisles and passageways would be required if bulky equipment, such as roll-away files, were moved through these spaces. Due to sharp corners often found on office furniture and equipment, Panero recommended a 40 inch passageway between movable equipment. (20)

Office administrators have set varying standards for aisle space. Office Systems Procedures Association stated, "Where screening cannot be provided between desks and aisles, a minimum standard of five feet for major aisles and three feet for minor aisles should be used." (27:5-7) Another source recommended that, ". . . main

aisles should be 7 to 8 feet wide, and secondary aisles 4 to 5 feet wide." (22:91) Terry suggested the following:

> "Main corridors should be from 5 to 8 feet wide depending upon the amount of traffic handled. A five foot aisle can normally accommodate around 850 people in five minutes. Main aisles in an office area should be from 4 to 5 feet wide, and the range of secondary aisles should be from 3 to 4 feet wide. Cross aisles should be provided about every fifty feet." (28:234-235)

Space for office equipment

In addition to chairs and work surfaces, side chairs, tables, filing cabinets, and storage shelves, are equipment common to most offices.

Side chairs. To provide a side chair in close proximity to a work station, the width and aisle space of the working unit would be affected. With no passage allowed, a minimum space of 24 to 30 inches from desk to wall or obstruction is needed for a side chair. (20) If passage is to be allowed, a minimum of 52 to 54 inches should be allowed from desk to obstruction. (20)

Tables. The table provides a supplementary work surface in an office. Assuming the same size as the primary work surface, the table is often placed behind the desk. This allows a worker immediate access to an additional work surface.

As a variation, a similarly-sized table is often placed to the side of the work surface. Tables of 18

and 24 inch widths are used effectively to the side of the primary work surface. These smaller tables help to conserve total floor space. An 18-inch wide typing return is made by many office furniture manufacturers.

Filing cabinets. Many sizes and types of filing cabinets are available today. The type of filing equipment needed depends upon the size and quantity of what is to be filed, the frequency of use, and the total size of the file area.

Conventional files. A standard legal size filing cabinet, which measures 28 1/2 inches deep and 17 7/8 inches wide, has been used for many years in offices. In this type cabinet, materials are filed front to back.

In placing a conventional file behind a seated worker, Panero recommended a minimum of 40 to 50 inches between the back of the desk and the front of the file. (20) This allowed for full extension of the file drawer when the worker is seated. To allow passage for one person between a seated worker and an open file drawer, Panero recommened 72 inches as the distance from the front of the file to the back of the desk. (20)

When one is standing directly in front of a conventional filing cabinet, a total space of 80.5 inches is needed. Of this, 28.5 inches are needed for the depth of the filing cabinet; 26 inches for the full extension

of the drawer; and 26 inches for the person. Less floor space is needed if the person stands to the side of the file to work.

If files are banked facing each other, there must be ample space for full extension of both drawers and space for the person. To provide this, there needs to be 78 inches clearance between facing files. (20)

Lateral files. Lateral filing cabinets use less depth of floor space than conventional cabinets, but use greater length of wall space. Lateral cabinets generally measure 18 inches deep and are manufactured in 30, 36, and 42 inch widths. Materials are filed side to side instead of front to back, as in conventional files. To allow full extension of a drawer in a lateral filing cabinet, 59 inches are needed. Of this, 18 inches are needed for the depth of the filing cabinet; 15 inches for the full extension of the file drawer; and 26 inches for the person.

Storage shelves. The dimensions of depth, width and height of shelves need to be designed according to the type of materials shelved. A critical dimension in offices, where shelves are used for active materials, is the height of the top shelf. To allow for the reach of the typical office girl, "The top shelf should not be more than 5 feet 8 inches above the floor." (20:82) To allow for finger space, 7/8 inch clearance is needed between

the maximum height of the material shelved and the bottom of the next shelf. (31:21) A minimum of three feet for rump room is needed between shelving units. When open shelves are facing, 6 feet passage should be allowed. (20)

Spatial Organization of Office Areas

To create well organized office areas, office planners need to consider the layout of the office spaces, the space needs for functional areas, and the location of functional areas.

Objectives of layout design

Office layout can be defined as, ". . . the determination of space requirements and of detailed utilization of this space in order to provide a practical arrangement of physical features considered necessary for the execution of office work within reasonable costs." (28:218) A theoretical ideal of office layout is, ". . . to arrange work stations throughout offices so that all personnel and equipment can function at maximum efficiency. This goal creates a need for considering space, frequency and distance of movement, and aesthetic appeal." (27:87)

Good layout contributes to more efficient work. Too much space is a waste of energy and cost. Crowded conditions interfere with work output and employee morale. The inefficient use of office space is a continuous liability. (28)

The layout of an office is directly affected by the type of building and by the facilities that are installed to control the office environment. In the core-type arrangement in older buildings, all the utilities are in the central core or shaft. This results is shared elevators and restrooms. In the newer block-type arrangements, the utilities are in block or strip patterns in floor or ceiling conduits.

Business objectives in designing an office layout, which are based on the principles of motion economy, are the following:

1) To reduce the time necessary to do work by eliminating all the unnecessary movement of staff.

2) To obtain an ordered flow of paper and people through the office.

3) To provide working conditions which increase efficiency and reduce strain and fatigue.

4) To conserve space without cramping operation. (17:380)

Rectilinear and random layouts. There are many ways of designing office layouts. The rectilinear grid and the random plan are layouts commonly used in today's offices.

Until the early 1960's the rectilinear grid or compartmented arrangement was used most extensively by office planners. (24) With this arrangement more work

stations could be fitted into a given floor space. A disadvantage is that people often feel regimented or compartmentalized.

The random or landscape plan was developed in Germany in the early 1960's. (2) The identifying characteristic of the landscaped office is the arrangement of work stations in groups rather than in rows or grids. The landscape concept allows greater internal flexibility permitting many arrangements of work positions and frequent changes as needed. People generally have a feeling of spaciousness. This type of arrangement is not advisable when there is a security problem or when floor space is limited. (2)

Space needs for functional areas

Very little research has been conducted for establishing space standards for the functional areas of offices. Office administrators, business efficiency experts, and architects have attempted to establish minimum and maximum space allotments for various areas. The number of people working in a single area; the way they are supervised; the kind, number and type of equipment used; and the types of tasks performed affect the space needs.

The general office, private office, conference room, and reception area are functional areas common to most offices.

General office areas. Ripen has assigned liberal and economical space allotments for general office areas. For general office workers, occupying a standard 60 by 30 inch desk, 65 square feet per person was considered economical and 80 square feet per person was considered liberal. (24) Some office administrators have allowed 50 to 60 square feet of office space per general office employee. (16) (18) (26)

Private office areas. Due to the amount of floor space needed for private offices, most office administrators presently try to keep the number to a minimum. Neuner stated that with private offices, ". . . there is only 50% efficient use of space." (19:98) The amount of space alloted for private offices depends on the total floor space, the center to center distance between building columns, and the location of windows. The National Office Management Association's publication, Office Standards - Space Assignments, designated space allowances for private offices ranging from 500 square feet per person for top executives to 80 square feet per person for supervisors. (19) (24) (27)

Conference rooms. Conference rooms house the work conferences of businesses. The amount of floor space required depends on the number of people to be accommodated at any one time; the physical facilities such as audiovisual aids which may be needed; and the type and frequency of meetings. Neuner recommended an allowance of 25 square

feet per person in a room accommodating up to 30 people, and 8 square feet per person in a room housing 30 to 200 people. (19)

Tables and chairs are basic equipment in conference rooms. Tables which are oval-shaped, boat shaped, or round provide the best visual arrangment. Space planners have recommended that each individual seated at a table be allowed a 27-inch minimum width. (31) So that people are able to move their chairs back from a table, a minimum clearance of 30 inches is needed between table and wall or nearest obstruction.

Reception areas. Reception rooms express the image of businesses. Planners need to allow 10 square feet per person for a maximum number of people expected at any one time. (30) In addition, there should be space planned for a receptionist.

Location of functional areas

To make the best use of the location of functional areas, a study of specific office systems and routines, and the arrangement of equipment needs to be made. Those individuals or areas that have constant or frequent contact with the outside public should be located near the reception room, or have direct access to the corridors in order to minimize the traffic through open working areas. (25) There is a need to know the interactions among job functions

within spaces to be designed. The frequency and importance of contact with others is essential. (47)

An office must be planned so that its departments, though broken down into separate units, still functions as a cohesive whole. It must also be planned so that its space is flexible, and so that the size and groupings of these units can be changed to meet varying needs. (24)

CHAPTER III

METHODOLOGY

Review of Research

Pertinent literature relating to space requirements for people performing office tasks was reviewed and noted. For this study, the literature from a variety of fields including human factors engineering, bio-mechanics, architecture, psychology, interior design, and business management was searched. The Jackson Library of the University of North Carolina at Greensboro, the D. H. Hill and the School of Design Libraries at the North Carolina State University at Raleigh were searched for information. A limited amount of information was found in manufacturers' publications.

After the literature and research was noted, it was compiled into four major divisions which were: basic body measurements, spatial requirements for individual work areas, spatial relationships between individual including physical features of offices, and spatial organization of office areas.

The pertinent findings from the review of literature were summarized. These findings were developed into a slide series and accompanying script.

Development of Slide Series

Using the suggested methods of slide making found in the Eastman Kodak Company's publication, Slides with a Purpose, and Jerrod E. Kemp's book, Planning and Producing Audiovisual Materials, the slide series and script were made. The pertinent information from the review of literature was simplified and illustrated by drawings, cartoons and photographs. All drawings, cartoons and photographs were made by the writer. Using "story-board cards," ideas for slide frames were recorded in visual form. (14) (26) They followed the same basic outline as the review of literature. In addition to the illustrations on each card, a suggested commentary was included. Cards were then organized and edited.

Copies of the visuals were made with a 35mm camera, which was mounted on a copy stand. The photographs were taken indoors with a lighting setup which used two reflective floodlights on either side of the material. The lights were of equal intensity and were placed at 45-degree angles to the copy material. The exposed film was developed into slides by a reputable film processor. Slides and script were re-edited.

CHAPTER IV

FINDINGS

In order to fulfill one of the purposes of this study, the slide series and script, developed from information recorded in the review of literature, served as a summary of the major findings from research on space requirements for people performing office tasks.

The script was numbered to parallel the slide presentation. The following is the commentary developed to accompany the slides.

Office Spaces

Frame #1 - Office Spaces

Frame #2 - By Ellen Goode. Based on thesis presented to the Graduate Faculty of the University of North Carolina at Greensboro. 1975.

Frame #3 - From earliest times, man has designed tools to fit his needs. Cave man made tools such as mallets to conform with the shape of his hands.

Frame #4 - Even the great Leonardo da Vinci, jack-of-all trades in the 15th century, recognized man as the module for all things.

Frame #5 - But somewhere in the progress of mankind, technology has forgotten man and his space needs for work.

Frame #6 - Man has moved from farms and villages to urban areas. In these areas, the office is the working place. It has been said that modern man spends 88% of his day working at a desk. Since urban man is tied to this artificial environment, the office needs

to be made more comfortable and an extension of his body dimensions.

Frame #7 - The purpose of this slide series is to increase an awareness of the need for considering human measurements in designing office spaces. The four sections of the film are: basic body measurements, spatial requirements for individual work areas, spatial relationships between individuals including physical features of offices, and organization of office areas.

Frame #8 - Now, the first section - Basic Body Measurements.

Frame #9 - Body measurements of people vary in all dimensions. There are short people, tall people, round people and thin people. Average human dimensions are hard to establish, because who is average? Yet, specific body measurements can be applied to designing office spaces that will conform to a large population.

Frame #10 - Spatial Requirements for Individual Work Areas.

Frame #11 - The Chair.

Frame #12 - The person sitting at his or her work station is the unit for all office space planning. Since most office tasks are performed sitting down, the spatial relationship of seating is of great importance.

Frame #13 - In designing a chair to best fit human measurements, the seat depth, arm rest height, seat height, back height, and seat width need to be considered.

Frame #14 - If the seat is too high, over 17 1/2 inches, the office worker may find the front edge of the seat surface cutting into the underside of the thighs, as shown in the drawing at the left. Additionally, a seat which is too high may contribute to poor posture, as shown in the drawing on the right.

Frame #15 - To fit a large proportion of the population, office chairs need to adjust to a range in height of 15 to 17 1/2 inches.

Frame #16 - The depth of the seat should be related to the length of the thigh and give adequate seat support under the thigh. A depth of 16 1/2 inches would suit a majority of people.

Frame #17 - The width of the seat needs to be sufficient to allow movement and adequately support the buttocks. Eighteen inches for seat widths would be sufficient for a majority of office workers.

Frame #18 - The back is an important part of the office chair. Proper back support aids in the prevention of fatigue. A back rest, 17 1/2 inches above the chair seat, is comfortable to most office workers.

Frame #19 - Arm rests are needed for supporting the weight of the arms. In addition, arm rests aid in getting in and out of chairs. As shown here, arm rests, which are too high, elevate the sitter out of the chair and cause shoulder strain.

Frame #20 - An 8 1/2 inch height of arm rests above the seat accommodates most people.

Frame #21 - As shown in this drawing, an office chair which would conform correctly to human measurements would have a seat depth of 16 1/2 inches, an arm rest height of 8 1/2 inches, a seat height of 15 to 17 1/2 inches, a back height of 17 1/2 inches above the seat, and a seat width of 18 inches.

Frame #22 - The Work Surface.

Frame #23 - The other piece of equipment that all office workers need is a work surface - a place for machines, paper, and other items. The surface can be as utilitarian as this small work area for a clerk,

Frame #24 - or as luxurious as this executive area.

Frame #25 - Minimum measurements for all work surfaces need to be considered. These include: the depth and width of a manual work surface, the working height, and adequate leg clearance.

Frame #26 - The table or desk height needs to be related to the seat height. If a person is sitting in a higher seat, he will need a higher work surface. And, if one is sitting in a lower seat he will need a lower work surface. Generally, a 28-inch high desk is an optimum height for a seat height of 16 inches.

Frame #27 - There needs to be adequate clearance under a work surface. To accommodate a large population, a minimum of 26 inches clearance, measured from the underside of the table or desk to the floor, is

needed. It is recommended that center drawers under desks or tables be eliminated, as they hamper leg movement. In addition, a minimum of 24 inches for the kneewell width is considered adequate.

Frame #28 - For shoulder and arm comfort when typing, a typist needs a typing table lower than a conventional desk. When typing, a typist can not have space for crossing the legs. Most people prefer a 25-inch height for typing.

Frame #29 - The depth and width of manual work surfaces depend on the human horizontal reach. The area that can be reached by extending the arm without bending is called the normal area. The area that can be reached by bending forward and extending the hand is called the maximum area. Since most people can easily reach an 18-inch width, this width could serve as a minimum work top depth. A 24 to 30-inch maximum depth would be suitable for work surfaces for most people.

Frame #30 - Important dimensions to be remembered in the design of a desk or table are: the working width - 72 inches maximum, the working depth - 30 inches maximum, the working height - 28 inches, leg clearance under a work surface - 26 inches, and kneewell width - 24 inches.

Frame #31 - Spatial Relationships Between Individuals Including Physical Features of Offices.

Frame #32 - Distances Between Individuals.

Frame #33 - Spaces between individuals in offices need to be considered. When people are too far apart, they can not hear each other.

Frame #34 - People sitting shoulder-to-shoulder are bothered by too close a proximity and the physical stress of twisting necks and torsos to talk.

Frame #35 - There are many ways of placing people in office spaces. Though research is limited, many office space planners advocate a minimum of 42 inches between individual work stations, or a distance of 72 inches from fronts of desks.

Frame #36 - Aisle Space.

Frame #37 - The proper design of aisles and passageways insures the smooth flow of people and equipment in offices. When proper consideration is given to the over-all dimensions and directions of traffic, bottlenecks and accidents will be avoided.

Frame #38 - A major aisle needs to be planned to allow passage for two people when they are carrying supplies. A minimum major aisle width of 5 feet is generally considered adequate. For secondary aisles, which allow for the passage of one person, a minimum width of 3 feet is recommended.

Frame #39 - Space for Office Equipment.

Frame #40 - All offices need storage space. Filing cabinets, storage cabinets and open shelves are common types of storage equipment.

Frame #41 - Here is a quick way to reduce, but not a very comfortable solution to the arrangement of filing cabinets.

Frame #42 - When one is standing directly in front of a conventional filing cabinet, a total floor space of 80 1/2 inches is needed. Of this - 28 1/2 inches are needed for the depth of the filing cabinet; 26 inches are needed for the extension of a drawer; and 26 inches are needed for the person. This does seem like alot of floor space for working with a filing cabinet. Less space is needed if the person stands to the side of a file to work.

Frame #43 - In a lateral filing cabinet, materials are filed side to side instead of front to back, as in a conventional file.

Frame #44 - When one is working directly in front of a lateral file, a total of 59 inches of floor space is needed. Of this - 18 inches are needed for the depth of the filing cabinet; 15 inches for the extension of a drawer; and 26 inches for the person.

Frame #45 - When planning file space, office planners need to work carefully to make the best use of wall and floor space. A conventional filing cabinet occupies less length of wall space than a lateral file; but a lateral file needs less depth of floor space. The type of materials to be filed, the total file area,

and the frequency of use needs to be considered in making the best use of filing space.

Frame #46 - Floor to ceiling shelves provide a maximum amount of storage space. To reach the upper shelves a ladder may be needed.

Frame #47 - The depth, width and height of shelves should be designed according to the materials that are to be stored.

Frame #48 - To accommodate short people who shelve active materials, the top shelf should be no more than 68 inches above the floor. A finger clearance of 7/8 inch is needed between the top of the maximum height of the materials shelved and the bottom of the next shelf. In addition, allow 36 inches for stooping.

Frame #49 - Spatial Organization of Office Areas.

Frame #50 - Layouts.

Frame #51 - Good layout of work areas in offices contributes to more efficient work. In order to plan an efficient layout, work stations need to be arranged in accordance to group communications and inter-departmental work flow.

Frame #52 - Offices can be arranged in many different ways. One of the most common types of arrangements is the rectilinear grid pattern as shown in this drawing. Work stations are arranged in rows.

Frame #53 - The rectilinear layout allows for the most people in the least amount of floor space. This arrangement also permits easier clean-up by maintenance people. A disadvantage of the grid pattern is that people often feel regimented or compartmentalized.

Frame #54 - The landscape or random arrangement, as shown in this drawing, is another type of office layout. Work stations are placed randomly throughout spaces.

Frame #55 - The landscape plan offers a more mobile and flexible arrangement of work stations. With this arrangement people generally have a feeling of spaciousness. The landscape plan is not advisable when floor space is limited.

Frame #56 - Random and rectilinear grid arrangements can be compared by the location of authority. In random

arrangements the boss is often located at the hub or nucleus of operations. Using the rectilinear arrangement, the boss often occupies a secluded position within the area.

Frame #57 - Space Requirements for Functional Areas.

Frame #58 - The functional areas of most offices include general offices, private offices, conference rooms and reception areas. The amount of space allotted to each of these areas will depend on the type of job, the number of people working in the area, and the type of equipment used.

Frame #59 - Conference rooms are designed to house all those company meetings. Tables and chairs are basic equipment.

Frame #60 - Space planners have recommended that each individual seated at a table be allowed a 27-inch minimum width. Thirty inches is the minimum amount of space required between the table and wall or obstruction.

Frame #61 - A reception area expresses the image of a business. Space needs to be provided for a receptionist who may greet visitors as well as perform other office tasks.

Frame #62 - In addition, space needs to be provided for waiting. Office planners need to allow ten square feet per person for a maximum number of people expected at any one time.

Frame #63 - Human measurements need to be considered in designing office spaces. An office should be built for people and the tasks they perform. In this complex world, people are still the basic measure of all spaces. To make them safer, more comfortable, more efficient, or just plain happier is the ultimate goal of all office space planning.

CHAPTER V

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

In this era of technological phenomena, man's spatial needs have often been overlooked in designing his work area - the office. This study was concerned with the application of human anthropometry to the design of office spaces.

Studies, which have been conducted to find the normal or average dimensions of the human body, were cited in this paper. These anthropometric measurements were applied to the design of individual work areas, spatial relationships between individuals including physical features of offices, and spatial organization of office areas.

Even though a great deal of research has been done in the design of office seats, most people are still sitting in chairs which do not conform to body dimensions. Chair manufacturers have not heeded the advice of ergonomists. Since the comfort and well-being of people using office furniture are key factors in office efficiency, those who purchase office furniture should influence designers and manufacturers to incorporate recommended anthropometric measurements into their designs.

To date, standards for spatial relationships between individuals have been based upon measurements of available

furniture, equipment and clearances. Literature mentions measurements that have been used in planning distances between individuals, but these measurements are often given without indicating any research basis.

Office planners and administrators have arbitrarily set space allotments for functional areas of offices. Very little research has been conducted for establishing space standards for the various work areas of offices.

However, the available information on office space planning, based on available research on human measurements, was summarized by means of a slide series and accompanying script. The slide series and script were developed to provide a more effective means of communicating this information to students, office planners, manufacturers, interior designers and architects.

There are a number of human anthropometric studies from which data can be related to office space planning. It is generally difficult to relate the information of one study to that of another because of the differing methods and techniques used in the studies. There is a need for evaluating the anthropometric data from the studies.

People do not work in static positions. All tasks require body movements. Further research in the application of dynamic anthropometry to office spaces would be helpful in planning future office environments.

With increased concern for conserving office space, further studies need to be conducted in applying anthropometric measurements to spatial relationships between individuals working in close proximity.

In addition, it is recommended that more research in the design of work surface areas for changing tasks be conducted. With new types of office equipment for new tasks, there is a need for more research in the design of machines to fit human dimensions.

The idea of compiling and presenting spatial requirements for people working in offices could be used for presenting space requirements for other areas used by people.

Today's communications are instantaneous world-wide and much clerical data is processed electronically. With all these advancements human space needs have been neglected. The individual worker seated at his or her work station is the basic unit of the office. Office space planning needs to be based on space needs for individual work areas, communications between people, passages between individuals, and clearances between equipment.

In studying the spatial needs of office workers of the future, office planners and designers may need to know about the body movements involved in performing office tasks; people's feelings about the space in which they work; and the physical conditions that contribute to creative thinking.

BIBLIOGRAPHY

Books

1. Beakley, George C., and Chilton, Ernest G. Design: Serving the Needs of Man. New York: Macmillan Publishing Company, Inc., 1964.

2. Boje, Axel. Open Plan Offices. London: Business Books, Ltd., 1971.

3. British Standards Institution. Anthropometric Recommendations of Non-Adjustable Office Chairs, Desks and Tables. London: British Standards House, 1959.

4. Chapanis, Alphonse; Garner, Wenell R.; and Morgan, Clifford T. Applied Experimental Psychology: Human Factors in Engineering Design. New York: John Wiley and Sons, Inc., 1949.

5. Croney, John. Anthropometrics for Designers. London: B. T. Batsford, Ltd., 1971.

6. Diffrient, Niels; Tilley, Alvin; and Bardagjy, Joan. Human Scale. Cambridge, Mass.: MIT Press, 1974.

7. Dreyfuss, Henry. Designing for People. New York: Simon and Schuster, 1955.

8. Dreyfuss, Henry. The Measure of Man. New York: Whitney Publishers, 1960.

9. Fogel, Lawrence J. Biotechnology: Concepts and Applications. Englewood Cliffs, N. J.: Prentice - Hall Company, 1963.

10. Gutman, Robert. People and Buildings. New York: Basic Books, Inc., 1972.

11. Hohl, Reinhold. Office Buildings: An International Survey. New York: Frederick A. Praeger, Publishers, 1968.

12. Joedicke, Jurgen. Office Buildings. New York: Frederick A. Praeger, Publishers, 1959.

13. Kellermann, F. T.; van Wely, P. A.; and Willems, P. J. Vademecum Ergonomics in Industry. London: Cleaver-Hume Press, Ltd., 1963.

14. Kemp, Jerrold E. Planning and Producing Audiovisual Materials. San Francisco: Chandler Publishing Company, 1968.

15. McCormick, Ernest J. Human Factors Engineering. New York: McGraw-Hill Book Company, 1964.

16. Memoli, Frank. Time-Saver Standards for Building Types. New York: McGraw-Hill Book Company, 1973.

17. Milward, G. E. Organization and Methods. London: MacMillan and Company, Ltd., 1962.

18. Murrell, K. F. H. Human Performance in Industry. New York: Reinhold Publishing Company, 1965.

19. Neuner, John. Office Management: Principles and Practices. Cincinnati, Ohio: South Western Publishing Company, 1959.

20. Panero, Julius. Anatomy for Interior Designers. 3rd ed. New York: Whitney Library of Design, 1973.

21. Propst, Robert. The Office - A Facility Based on Change. Elmhurst, Illinois: The Business Press, 1968.

22. Rausch, Edward N. Principles of Office Administration. Columbus, Ohio: Charles E. Merrill Books, Inc., 1964.

23. Ridder, Clara A. Basic Design Measurements for Sitting. Fayetteville, Arkansas: University of Arkansas, Agriculture Experiment Station, Bulletin 616, 1959.

24. Ripen, Kenneth H. Open Space Administration. New York: McGraw-Hill Book Company, 1974.

25. Saphier, Michael, Office Planning and Design. New York: McGraw-Hill Book Company, 1968.

26. Slides with a Purpose. Eastman Kodak Company, 1973.

27. Systems and Procedures Association. Business Systems. Cleveland, Ohio: Systems and Procedures Association, 1966.

28. Terry, George R. Office Management and Control. Homewood, Illinois: Richard D. Irwin Company, 1953.

29. Walker, L. C. The Office and Tomorrow's Business. New York: The Century Company, 1930.

30. Wood Office Furniture Institute. Office Planning and Layout. Washington, D. C.: Wood Office Furniture Institute, 1957.

31. Woodson, Wesley E. Human Engineering Guide for Equipment Design. Berkeley: The University of California Press, 1954.

Periodicals

32. "Action Office - New Concepts in Office Furniture." Architectural Record 137 (January 1965): 187.

33. "Anthropometric Desk." Design 144 (December 1960): 69.

34. Cantacuzino, Sherban. "Offices." Architectural Review 148 (October 1970): 203-4, 219-50.

35. Fucigna, J. T. "The Ergonomics of Offices." Ergonomics 10 (September 1967): 589-604.

36. "Furniture to Suit the Office Worker." Design 221 (May 1967): 74-5.

37. "Herman Miller in Action." Industrial Design 12 (January 1965): 26-33.

38. Hertzberg, H. T. E. "Dynamic Anthropometry of Working Positions." Human Factors (1960): 147-51.

39. "Human Factors of Seating." Industrial Design 9 (November 1962): 52.

40. Koskela, A. "Ergonomics Applied to Office Work." Ergonomics 2 (1962): 263-65.

41. Manning, Peter. "Environment." RIBA Journal 72 (August 1965): 392-98.

42. Meade, Dorothy. "Sitting at a Table." Design 158 (February 1962): 65.

43. Meade, Dorothy. "The Odd Ergonomic Inch and Why it Matters in the Office." Design 208 (April 1966): 38-44.

44. "Measure: Factors Affecting Design." Architectural Forum 110 (November 1948): 103-60.

45. "Please be Seated." Industrial Design 18 (June 1971): 19-39.

46. "Seating Dimensions: Theory and Practice." Design 145 (January 1961): 31-3.

47. Wheeler, Lawrence, and Miller, Ewing H. "Comprehensive Architectural Practice: Human Factors Analysis." AIA Journal XL (December 1963): 43.