EW MOVEMENT NOTATION:
THE SYSTEM OF REFERENCE

Noa Eshkol and John Harries

Abstract

A survey is offered of the structure of the system of reference of Eshkol Wachman Movement Notation. It is not possible in a short space to demonstrate how this “empty” concept is applied in the realm of real movement of real human bodies, and only purely geometrical aspects of the system will be dealt with.

Introduction

The Eshkol Wachman (EW) method is a movement notation, and not necessarily a dance notation. This means that we are not dependent upon dan terminology, and do not think in its concepts. No doubt some more or less logical system could be devised on the basis of dance conventions; but for our .purpose - the analysis of movement - thinking in the usual vocabulary is deliberately avoided and concepts such as flexion, extension, contraction, locomotion and the like are relegated to a secondary level Instead, abstract terms have been found with tie aim of covering all human activity and motion of the skeletal structure of the human body. In this paper we shall deal only with the purely geometrical aspect of the system of reference of EW movement notation. We therefore leave for the present the problems of practical usage, and explain how the abstract model is conceived, so as to be able to return by way of this gate to the domain of human movement, and to see how closely the abstract framework fits contingent reality.

System of reference - sphere of movement

E.W. Movement Notation is designed to express the relations and changes of relation between the parts of the body, and information which car, be derived from these. A part of the body is any limb which either lies between two joints or has a joint and a free extremity. The limbs are imagined as straight lines; in the analysis of movements, we treat the body as a system of articulated axes. See Figure 1.

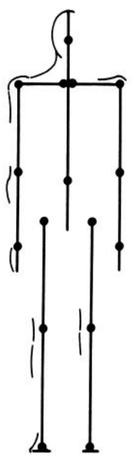


Fig. 1. the body as a system 0f articulated axes

The system of reference used in EW Movement Notation is a sphere.

The movements of a single axis of constant length free to move about one end will all be enclosed by a sphere; the free end will always describe a curved path on the surface of this sphere. Every limb in the body can be regarded as such an axis.

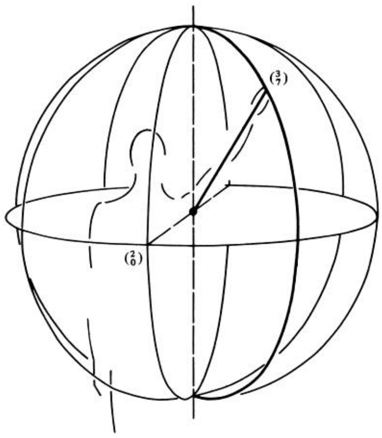


Fig. 2. The system of reference is a sphere

Typically, the curves described on the surface of the sphere will be circles or parts of circles, of various sizes and orientations. In order to define these data, coordinates are ascribed to the sphere. The equatorial plane of the sphere of movement, parallel to the ground, is called the horizontal plane. One direction on the horizontal plane is selected as the starting position for all measurements. This direction is named absolute zero.

Eight directions are obtained on the horizontal plane by measuring off intervals of 45 degrees from this absolute zero. They are numbered in the clockwise direction, looking down on the plane from above. This is the most commonly used scale. Any unit can be chosen and is briefly stated as 1=90 degrees, 1=30 degrees, 1=5 degrees or any other, according to need. (Note that differences of a single degree are imperceptible in movement of the human body, and will only be used in the context of computers or other precision devices.)

Planes perpendicular to the horizontal plane are referred to as vertical planes. They are identifiable inasmuch as they intersect .with the directions which result from the division of the horizontal plane, and each is named according to one of the two horizontal directions with which it coincides. The line in which all vertical planes intersect is the vertical axis of the sphere. See Figure 3, and Table I.

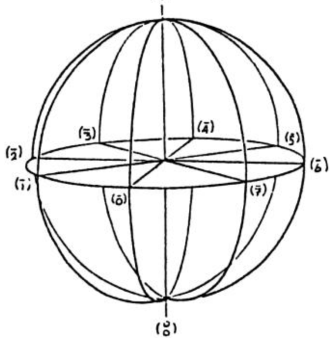


Fig. 3. Horizontal plane and vertical planes in the scale l=45 degrees

The vertical plane is divided according to the sane scale as the horizontal plane. Zero on any vertical plane is the vertically downward ‘south’ pole, and other positions are counted upward in the direction on the horizontal plane by which the vertical plane is identified, as shown in Figure 4.

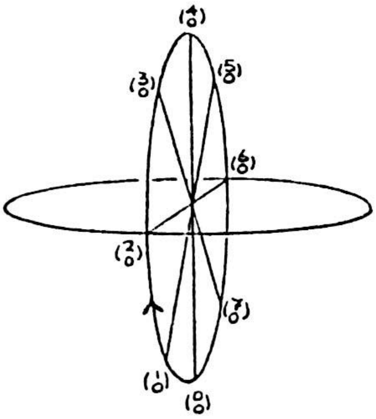


Fig. 4. A vertical plane in the scale 1=45 degrees

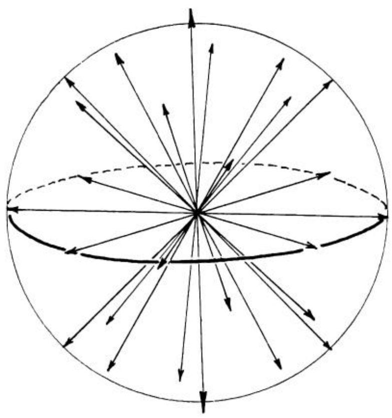


Fig. 5. The Positions in the scale 1=45 degrees

Any position of the moving axis (pivoted at the centre of its sphere of movement - Figure 5) can now be defined by stating (1) the horizontal component: the number designating the plane on which it lies; and (2) the vertical component: the number indicating its deviation from zero on the vertical plane. The two numbers are written in parentheses, the vertical component above and the horizontal component below,

$\binom{v}{h}$ v – vertical

h – horizontal

for exampel: $\binom{2}{0}$

With the scale 1=45 degrees, twenty-six positions are expressible for each and every limb or limb segment: see Figure 6.

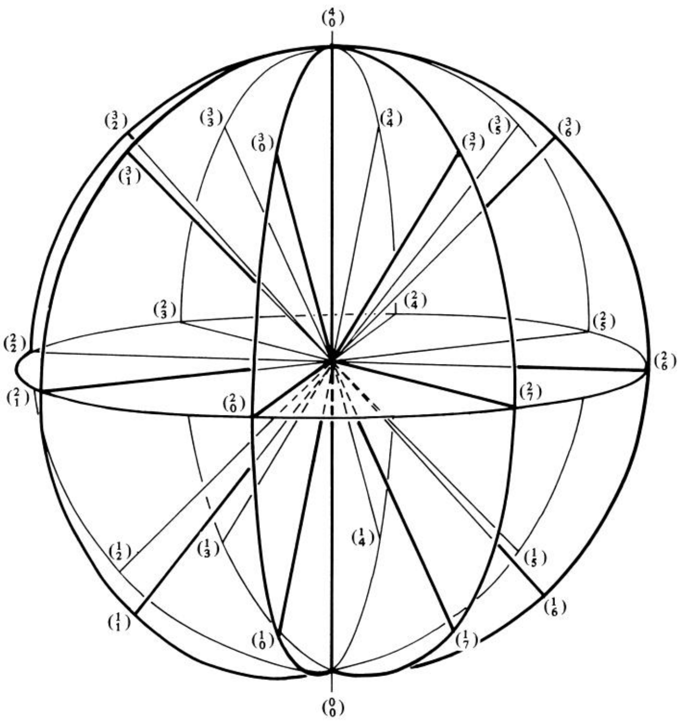


Fig. 6. The system of reference with scale 1=43 degrees

$\binom{0}{-}$			
$\binom{1}{0}=\binom{7}{4}$	$\binom{1}{1}=\binom{7}{5}$	$\binom{1}{2}=\binom{7}{6}$	$\binom{1}{3}=\binom{7}{7}$
$\binom{2}{0}=\binom{6}{4}$	$\binom{2}{1}=\binom{6}{5}$	$\binom{2}{2}=\binom{6}{6}$	$\binom{2}{3}=\binom{6}{7}$
$\binom{3}{0}=\binom{5}{4}$	$\binom{3}{1}=\binom{5}{5}$	$\binom{3}{2}=\binom{5}{6}$	$\binom{3}{3}=\binom{5}{7}$
$\binom{4}{-}$			
$\binom{5}{0}=\binom{3}{4}$	$\binom{5}{1}=\binom{3}{5}$	$\binom{5}{2}=\binom{3}{6}$	$\binom{5}{3}=\binom{3}{7}$
$\binom{6}{0}=\binom{2}{4}$	$\binom{6}{1}=\binom{2}{5}$	$\binom{6}{2}=\binom{2}{6}$	$\binom{6}{3}=\binom{2}{7}$
$\binom{7}{0}=\binom{1}{4}$	$\binom{7}{1}=\binom{1}{5}$	$\binom{7}{2}=\binom{1}{6}$	$\binom{7}{3}=\binom{1}{7}$

Table I. The table, shows the 26 positions (scale 1=45 degrees), each expressed in the two possible ways.

If the scale is made smaller, the number of definable positions in the system of reference increases. For instance, in the scale 1=30 degrees, the system of reference contains 62 positions.

The unit of measurement by which the system of reference is structured is chosen according to the movement data to be analysed. For the movement of the human body, a larger unit than 45 degrees is not feasible. However, whatever the scale chosen, it will always contain two finer grids, expressible by means of three signs:

\+ meaning a third of the unit of the current scale.

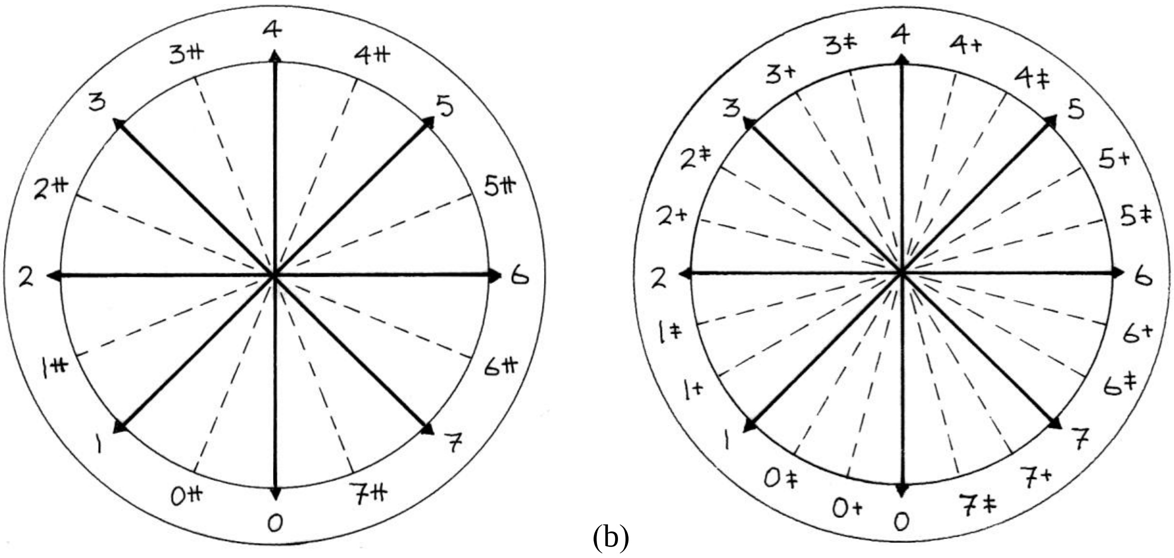
╫ meaning half the unit of the current scale.

╪ meaning two-thirds of the unit of the currentscale.

For example, in a scale of 1=45 degrees, + indicates 15 degrees, ╫ is 22.5 degrees, and ╪ is 30 degrees. This makes available positions which could otherwise only be reached by employing both a scale of 1=15 degrees and a scale of 22.5 degrees.

Again, in a scale of 1=30 degrees, + is 10 degrees, ╫ is 15 degrees, and ╪ is 20 degrees. The reason for using these signs rather than numerical fractions is ease of reading.

With these three additional signs, 432 positions can be defined in a system of reference with 1=15 degrees. This :s illustrated :by the division of a plane, shown in Figure 7. In (a) the intermediate values are half the unit; in (b) they are one-third and two-thirds of a unit.



(a) (b)

Fig. 7. Intarmediate values in the scale: 1=45 degrees.

These signs can be used in the complex of a positional sign, attached to the vertical component, the horizontal component, or both. They can also be used with amount of movement (movement measured as an angular interval, irrespective of its spatial orientation), note: an analogy may be drawn between, these signs and the harps and flats in musical notation.

Axis of movement, angle of movement, type of movement

Positions were defined by identifying them with coordinates of the system of reference. The movements 0f limbs - ie. their changing relations - are also defined, oriented and measured according to this system of reference.

The simplest ‘unit’ of movement for a single limb is the circle. When the limb describes a circle, an imaginary line passing through the centre of any such circle and perpendicular to its plane, is said to be the axis about which the limb noves. This axis of movement (AXM) originates at the joint about which the limb pivots, ie. the centre of the individual system of reference of that limb.

Since the axis of movement originates at the joint of the moving limb, its position can be defined according to the system of reference, centred upon that joint. Beginning at any given position, a limb can move about an axis of movement at any defined position in the system ofreference.

A type of movement is determined by the angular relation between the axis of movement and the position of the axis of the limb throughout the movement . The angle between the two axes establishes the shape of the path of movement and its size. by varying the angle between the two axes, a continuous scale of circles of different sizes is obtained. when the angle of movement is 90 degrees, any point on the limb traces a ‘great circle’ in the sphere of movement and the surface which the whole axis sweeps out is a plane, and the movement is called plane movement. In the case where the angle between the axes is zero (ie. their positions coincide), no surface is created by movement of the axis of the limb, which simply rotates about itself. This movement is called rotatory movement. Between those to extremes of 90 degrees and zero degrees lie all the other possible angular relationships of axis of limb, to axis of movement. All of these prduce circles of

Different size and surfaces of conical shape. this type of movement is called conical movement. See Figures 8, 9, 10.

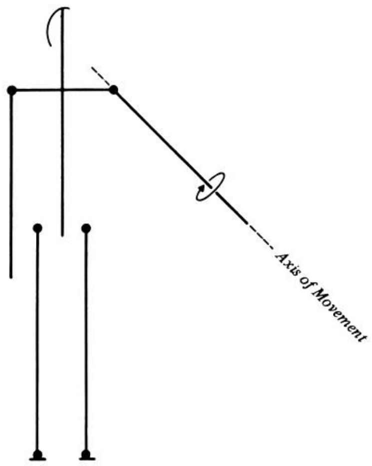


Fig. 8. Rotatory movement

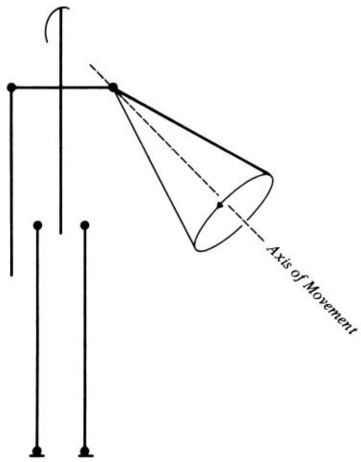
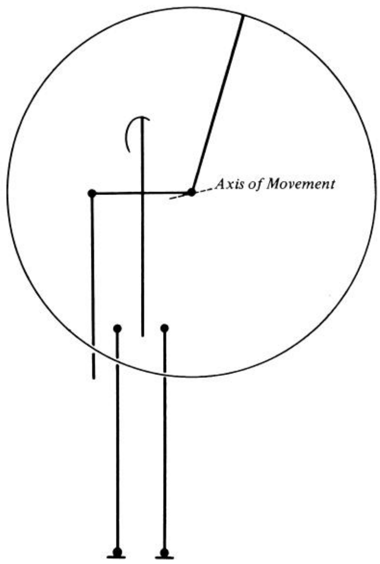


Fig. 9. Conical movement



Fig/ 10. Plane movement

The symbol for plane movement is an arrow ↑; the symbol for rotatory movement is ◠ and the symbol for conical movement is ∧ .

There is theoretically an indefinite number of ways of moving from one known position to another. by defining a path of movement, all positions on the path are summarised in one concept and one symbol, which is more economical and less ambiguous. The three types provide a classification by means of which the properties of movements may be identified.

The full exploitation of the system of reference

The classification of movement outlined in the x previous section provides an elegant and economical way of describing movement. Plane, conical or rotatory movement can be defined by means of two positions - of the axis of the limb, and of t!,* axis of movement - and indications of Sense of movement (positive or negative), and amount (movement measured as an angular interval).

However, the number of movement paths definable when description is based on axes of movement, is less than the full number actually latent in any system of reference. To exploit fully the potential of the system of reference, the comprehensive method adopted relates pairs of positions to one another so as to provide ‘milestones’ on circular trajectories.

Using this method, when the trajectories are ‘great circles’ 0f the sphere - that is, when the path of movement 0f the axis of the limb sweeps out a plane – the two positions in the system of reference are used to define a chord which identifies the specific plane. when the circle is smaller – that is, when it represents the base of a cone – the two positions in the system of reference define a diameter of the base (the apex being at the articulation of the axis of the moving limb.)

Asymbol indicates whether the two positions represent a chord or a diameter.

From a starting position $\binom{v}{h}$ ymbol impli $\underset{\longrightarrow}{\binom{v}{h}}$ ord, so that the path of movement is in a plane;

while with the same positions, the folowing symbol $\overset{\wedge}{\binom{v}{h}}$ implies a diameter, and the path of movement is conical.

If the 26 integral positions are taken as the axes of movement available in the system of reference, then 13 distinct great circles (planes) and 34 cones can be defined in relation to these axes.

By adopting the mode of description by means of chords and diameters, the number of definably different sizes and orientations of circle which can be traced by the extremity of a moving limb, becomes 320 (including the 47 obtainable by the method using axis of movement and axis of limb). when the method employed is that using chords and diameters, the axes of movement can only be found by computation. An advantage of this method of description is that mover and observer can use it intuitively, without mathematical computation.

An inventory is given in the pages which follow, characterising the circles obtainable in a system of reference with the scale 1=45 degrees.

The scheme represents an ideal doimain of movement how much of it can be performed by specific limbs in a real human body, depends upon the anatmical structure of the body and its environment .

Plane movement – great circles

The shortest route from one position to another will be part of a ‘great circle’ - ie. a plane. A system of reference with the scale 1=45 degrees provides for the following planes:

(i) horizontal plane. The system of reference ‘contains’ a single horizontal plane, which forms the equator of the sphere.

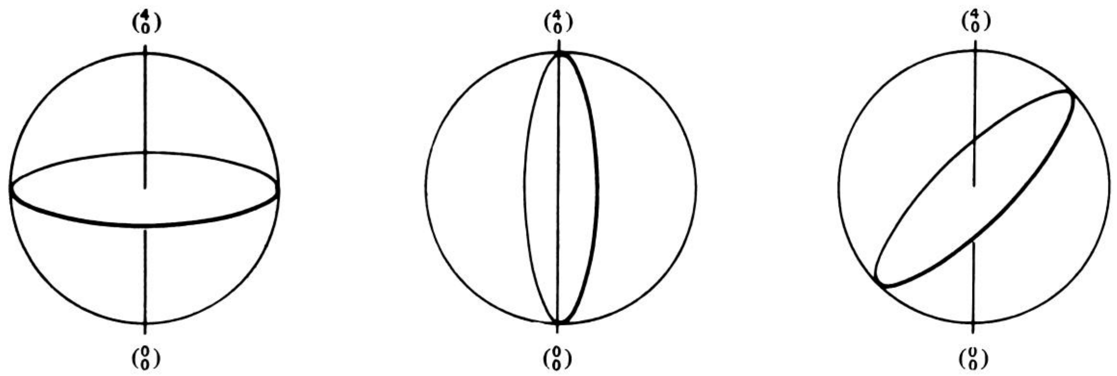
Trajectories on the horizontal plane have a vertical axis of movement $\binom{0}{0}$ or $\binom{4}{0}$.

They can be performed only from starting positions which are parallel to the ground. There are eight integral positions on the horizontal plane.

(ii) Vertical planes. The system of reference contains eight vertical planes, which coincide with the eight positions (radius vectors) on the horizontal plane. If opposite radius vectors are paired, these reduce to four vertical planes coinciding with four diameters on the horizontal plane. Each of these four planes can, therefore be labelled according to either one :0f its radii. (See Table 1). Trajectories on vertical planes have axes of movement on the horizontal plane.

From the vertical positions it is possible to move in any vertical plane. From any other position, it is possible to move in one vertical plane only. There are eight integral positions on each vertical plane.

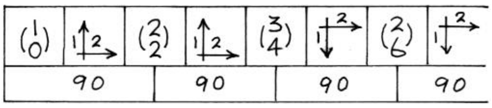
(iii) Intermediate planes. The system of reference contains 32 intermediate planes. These are of four different inclinations, and there are four of each type. All intermediate planes have oblique axes of movement; eight of them have axes of movement identifiable in the system of reference as integral positions. From any position in the system except the two vertical ones, it is possible to nove in a known intermediate plane. In intermediate planes, positions identifiable in the system of reference occur at intervals which vary according to the slope of the plane. See Figure 11.



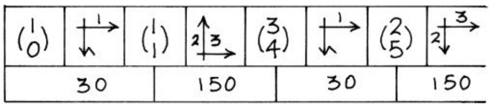
(i) Horizontal plane *(ii) Vertical plane* *(iii) Intermidiate plane*

Fig. 11.

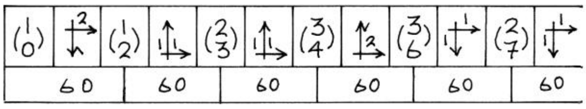
The following table (Table II), representing the intemediate planes in a system of reference with the scale 1=45 degrees, classified according to the four inclinations. The upper line shows transitions from one known position to another; and between them, the amounts of horizontal shift (→) and vertical shift (↑) entailed by the movement. The lower line represents the size of the arc, indegrees.



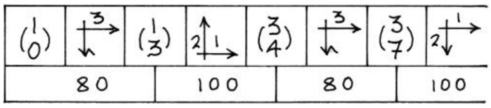
a.



b.



c.



d.

Table II.

As already described, a conical movement may at expressed either by means of the angular relation between the axis of the limb and the axis of movement or, alternatively, by specifyig any diameter definable in the system of reference. Using the latter method, we are able to identify cones which do not necessarily have arcs at integral positions in the system of reference. We can, however, know the size of their diameters by deriving then from the chords of planes :n which the defining positions of the cones Iie. Nine intervals can be distinguished on the intermediate planes in the scale of 1=45 degrees, and these can be used to distinguish nine different angular sizes of cone. We shall state. the size :i the cones by referring then to the corresponding arc chords; a cone with (for example) an angle of movement of 45 degrees will be called a 90 degree cone, which is the arc on a plane the chord of which is equivalent to the diameter of the cone. See Figures 12 and 13.

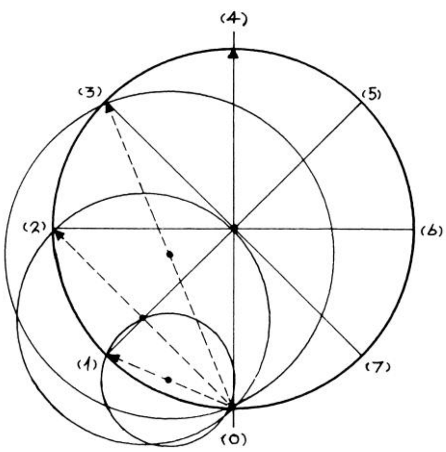


Fig. 12.

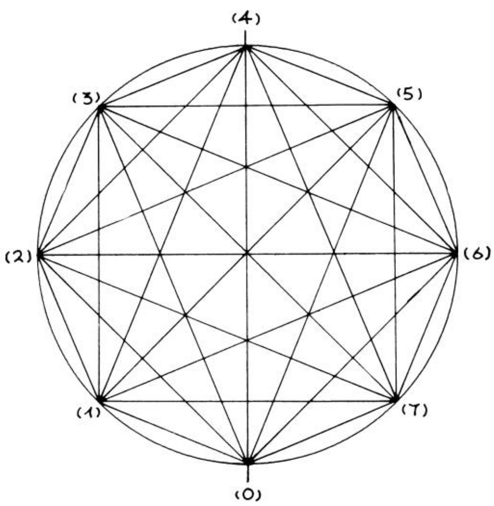


Fig. 13.

Figure 14 illustrates the proportional sizes of the bases of the nine cones avaliable in scale 1=45 degrees, together with a ‘great circle’ (plane) for the sake of comparison: this is seen as the outer circle. Here, all of these are placed concentrically about a common axis of movement.

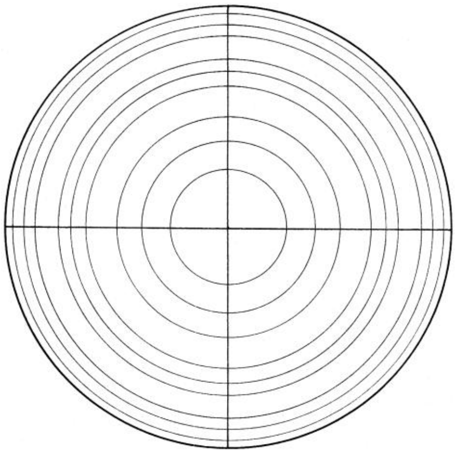


Fig.14. The ten sizes of circle is the scale 1=45 degrees

The following characteristics of cones are worth noting:

(1) All cones with vertical axes nave horizontal bases, and their trajectories are lines of latitude on the movement sphere.

(2) All cones with horizontal aces have bases parallel to vertical planes in the system of reference.

(3) All cones with oblique axes have oblique bases.

(4) The base of a 90 degree cone may be parallel to a horizontal, vertical or oblique (intermediate) plane.

(5) The base of a 120 degree cone say be vertical or oblique.

(6) All other cones have oblique oases only.

Conclusion

This rather dry, almost mathematical, exposition ,of aspects of the geometrical basis of EW notation will have raised questions as to the relation of the human body to all that has been said. It may be felt that one would have to be God-like or at least computer-like to be able to discern the data implied; how can an ordinary flesh-and-blood moving person or observer make distinctions sucs as the system offers? Critics may denide us, pointing out that there is no physical significance in the distinction between a 100-degree interval and one of 120 degrees. While we are aware of such possible objections, nevertheless by establishing a theoretical dialectic of the phenomena, a coherent and logical system is created; and in our view such a system makes the study of the body and its constraints more profitable than if we were to begin from the limitations of the anatomical structure (joints, range of movement) or from the verbal descriptions of ordinary language. The latter approach makes of Every movement a unique phenomenon, implying a unique symbolisation. The more abstract and generalised approach reveals how seemingly disparate phenomena can be described by the same means, a possibility which is obscured by the use of everyday and professional languages. Other aspects of human movement not covered in this paper are the crucial one of time and duration; distribution of the body's weight; contact of its parts with the environment and with each other, and more. The solutions to these problems form other chapters in EW Movement Notation. We have chosen to present at the Conference this abstract aspect of the method, because we believe that without a radical change in our way of thinking about human movement it will not be possible to establish the universal movement notation we all hope for.