Vectorcardiographic Notation

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The method of viewing the frontal, sagittal and transverse vectorcardiographic planes is considered from the standpoint of devising a uniform system of measuring angles on these planes. It is pointed out that care must be taken in the selection of oscilloscopic presentations to prevent inconsistency of the signs of the trigonometric functions of such angles. Two groups of oscilloscopic presentations are suggested, either of which permits angles to be measured in a clockwise direction from a reference axis of uniform position on each plane.

It is highly desirable that universal agreement be reached concerning the use of certain terminology and notation in vectorcardiography. Toward this end, the Committee on Electrocardiography of the American Heart Association has recently recommended standard designations for vectorcardiographic axes and planes and uniform methods of displaying planar vectorcardiograms. Briefly, in accordance with the Committee’s recommendations, the three rectilinear coordinate axes of the body, transverse, longitudinal and sagittal, are to be designated by the symbols x, y and z, respectively. The three planes defined by these rectilinear coordinates, transverse, frontal and sagittal, are to be designated by the symbols xz, xy and yz, respectively. The frontal plane is to be viewed by an observer facing the anterior aspect of the upright subject. The sagittal plane is to be viewed by an observer facing the left lateral aspect of the upright subject. An alternate sagittal view, which the Committee deems less desirable, is from the upright subject’s right side. The transverse plane is to be viewed by an observer facing the head of the prone subject. An alternate, but, in the Committee’s opinion, less desirable transverse view, consists of having an observer face the feet of the supine subject. A diagram of the Committee’s preferred planar displays is illustrated in figure 1.

The Committee devotes considerable space to a consideration of the concept of polarity in that portion of its report dealing with vectorcardiography. Much of the confusion concerning polarity, heretofore apparent in vectorcardiographic literature, can be avoided in the future if this section is carefully read by all investigators in this field. The writer is in full agreement that the movement of the cathode ray during vectorcardiographic recording should be defined by designating the deflection plates of the oscilloscope in accordance with the anatomic aspects of the subject to which they are connected, and that such a definition does not involve consideration of polarity. Nevertheless, as will be pointed out in detail later, the concept of polarity emerges indirectly as the result of the necessity of dealing with the signs of the trigonometric functions of an angle formed by a vector, located in one of the various quadrants of a plane.

To date, the Committee has published no recommendations concerning the manner of measuring and designating angles on the three planes. The method of making such measurements on the frontal or xy plane has been firmly established by Einthoven, and others since, who have measured a positive angle, alpha, by rotating a vector clockwise* about the z axis, the (subject’s) left end of the x axis being designated as 0 degrees. Such a vector may be rotated through 360 degrees to avoid the use of negative angles, or it may be rotated either clockwise or counterclockwise from the

* The conventional mathematical rotation of such a vector is in a counter-clockwise direction. Einthoven reversed this convention in order that the majority of QRS and T vectors might fall in the first rather than in the fourth quadrant. Bayley advocated a return to the conventional notation, but his suggestion has not been generally accepted.
VECTORCARDIOGRAPHIC NOTATION

Fig. 1. Vectorcardiographic views advocated and preferred by the Committee on Electrocardiography and Vectorcardiography of the American Heart Association.

Fig. 2. Clockwise method of measuring angles, first applied by Einthoven to the frontal plane. See text.

left end of the x axis, designated as 0 degrees, to the right end of the x axis, designated as ±180 degrees. These manipulations may be clarified by superimposing figure 2 on the frontal plane view illustrated in figure 1.

Parenthetically, it should be mentioned that the author, with Fowler, devised a method of measuring angles on all three planes in order to study certain vectorcardiographic data statistically. This method, described in detail elsewhere, was chosen because it permitted a separate coordinate axis to be used for the reference or 0 degree axis of each plane. Although this reference notation did not involve inconsistencies of the signs of trigonometric functions, it is the writer’s present opinion that the lack of a uniform position for the reference or 0 degree axis in the three planes is undesirable.

Faced with the problem of designating angles on planes other than the frontal, most vectorcardiographers superimpose figure 2 on such planes whether the latter be viewed from left or right (sagittal) or from head or foot (transverse). Let us consider the Committee’s preferred presentations of the three planes illustrated in figure 1, when figure 2 is superimposed on each. Each plane is then divided into quadrants and, as a result, the spatial coordinate frame is divided into octants involving all possible combinations of the three pairs, right and left, superior and inferior, and anterior and posterior. Let us assume that a vector is directed from the point of intersection of the coordinate axes into each of the octants. These vectors are numbered 1 through 8 in

† The general method of deriving the equations given in that paper are not dependent upon this specific notation. The equations can easily be modified to conform to any notation chosen.
figure 3 and in table 1. The octant into which each of the eight vectors is directed, is designated by the appropriate symbols in the second column of table 1. It should be noted from figure 3 that each quadrant of each plane contains two vector projections. Although up until the present point in the discussion, nothing has been said or implied concerning polarity of the x, y, and z coordinate axes, it is no longer possible to avoid a consideration of polarity. The magnitude and direction of a vector, lying in the first quadrant (0 to 90 degrees) of a plane, is defined in terms of its two rectilinear coordinates, both of which must be positive. Similarly, a vector in the third quadrant (180 to 270 degrees) is defined in terms of coordinates which are both negative. For a vector in the second quadrant (90 to 180 degrees), one coordinate is positive and the other negative, and these conditions are completely reversed for a vector in the fourth quadrant (270 to 360 or 0 degrees). These are inescapable facts based upon well established geometric and trigonometric conventions. In fact, the signs of the trigonometric functions are wholly dependent upon the quadrant occupied by the rotating vector forming the angle. From these considerations the signs of the x, y and z coordinates defining each of the eight vectors, one in each octant, are listed in table 1, based on the quadrants of the frontal and sagittal planes occupied by the vector projections. Finally, in the last two columns of table 1 are listed the signs of the x and z coordinates based on the quadrants of the transverse plane occupied by each of the vector projections. It should be noted that there is a complete discrepancy between the signs of the z coordinates based upon the frontal and sagittal planes on the one hand and upon the transverse plane on the other.

How may this mathematic invalidity be circumvented? If the method of viewing the planes (fig. 1), preferred by the Committee, is to be retained, there is only one general solution. The method of measuring Einthoven's angle alpha, so well established for the frontal plane, must be sacrificed in at least one of the two remaining planes. Thus, either of the changes illustrated in figure 4A or in figure 4B

![Diagram](http://circ.ahajournals.org/)

**Fig. 4.** Modification of method of making angular measurements to prevent inconsistency of trigonometric signs. See text.
would correct the discrepancy of sign noted in table 1.

Although the notations depicted by figures 4A and B are mathematically valid, they are quite objectionable from the standpoint of symmetry of presentation. It would be most desirable to measure all angles in a uniform direction of rotation from a reference axis of uniform position in all three planes. To accomplish this feat in the simplest manner possible, the position of the observer of the sagittal plane in figure 4A may be rotated 180 degrees about the y axis. Similarly, the position of the observer of the transverse plane in figure 4B may be rotated 180 degrees about the x axis. Thus, figure 5A differs from figure 4A in that the sagittal plane is viewed from the upright subject’s right side rather than from his left side. Figure 5B differs from figure 4B in that the transverse plane is viewed from the feet of the supine subject rather than from the head of the prone subject. A table similar to table 1 could be constructed for either figure 5A or B, without encountering any discrepancy of sign.  

* Either group of oscillographic presentations could be chosen as standard without invalidating any of the Committee’s recommendations, for it is obvious that in figures 5A and B, respectively, the Committee’s alternate sagittal and transverse views are utilized. However, one minor alteration of the Committee’s recommendations might be suggested. It would seem desirable to designate the reference or 0 degree axis for measuring angles on a given plane by listing the symbol for that axis initially in the double symbol nomenclature of planes. Thus, in both figure 5A and B (as well as in fig. 4A and B) the frontal, sagittal and transverse planes might preferably be designated respectively as xy, zy and xz, rather than as xy, yz and xz, suggested by the Committee.

**Summary**

In the writer’s opinion, it is highly desirable that angles be measured in a uniform direction of rotation on the frontal, sagittal, and transverse vectorcardiographic planes and that the reference or 0 degree axis be located in a uniform position on each of these planes. Furthermore, it would be most desirable to retain Einthoven’s well-established frontal plane convention of a clockwise direction of rotation for a positive angle with the reference or 0 degree axis corresponding to the (subject’s) left end of the x axis, i.e., lead I in Einthoven’s scheme. It is pointed out that the oscillographic views advocated and preferred by the Committee on Electrocardiography and Vectorcardiography of the American Heart Association

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* Unlike the notation previously used, the axes of the oscillographic presentations illustrated in figures 5A and B (as well as in figs. 4A and B) do not consistently form either a right-handed or a left-handed frame (see Braunstein, fig. 1). However, the author can envisage no practical difficulty arising from this discrepancy and considers that the convenience of a uniform position of the reference axis, and of a uniform direction of angular measurement, greatly outweighs any theoretic objection to it.
are mathematically incompatible with the extension of Einthoven's frontal plane convention to both the sagittal and transverse planes. (See fig. 3 and table 1.) However, if an alternate sagittal or transverse plane presentation, either of which is permitted but not preferred according to the recommendations of the Committee, is selected, Einthoven's frontal plane convention may be applied to these planes without any discrepancy of trigonometric sign. For this reason, it is suggested that one or the other of the groups of oscilloscopic presentations illustrated in figure 5A or B be considered for universal adoption. If either is chosen, it is further suggested that the frontal, sagittal and transverse planes be represented respectively by the symbols xy, zy and zx, in order that the first term of the paired symbols might designate the reference axis of the respective plane.

SUMMARIO IN INTERLINGUA
Le methodo de visualisar le planos vectocardiographic frontal, sagittal, e transverse es considerate in connexion con le problema de elaborar un systema uniforme pro le mesuration de angulos in le planos mentionate. Es signalate le necessitate de grande attention in seliger presentationes oscilloscopic, a fin de prevenir inconsequente signos in le functiones trigonometric de tal angulos. Nos propone duo gruppys de presentationes oscilloscopic. Ambes permite le mesuration de angulos in un direction dextrorse ab un axe de base con position uniforme in omne planos.

REFERENCES
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