One facet of electrocardiography has traditionally dealt with the relationship between body-surface potentials and an equivalent generator that could have produced them. The generator developed here consists of a collection of multipoles whose components can be evaluated by performing appropriate integrations of the potential over the body surface. [The *SCI*® indicates that this paper has been cited in over 115 publications.]

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This paper is part of my PhD dissertation. The topic, theoretical electrocardiography, falls within the domain of biomedical engineering. At the time I did my graduate work there were no biomedical engineering programs; my degree was in electrical engineering. Shortly after I graduated, the University of Pennsylvania, through its Moore School of Electrical Engineering, embarked on a pioneer graduate program in biomedical engineering under H.P. Schwan with support from the National Institutes of Health.

The Moore School had a long history in the area of what might be termed electromedicine. A collaborative effort in electrocardiography involving an electrical engineer and a cardiologist dated back to the 1940s. I was the fourth electrical engineer in this chain.

One of my predecessors was Ernest Frank, who made several outstanding contributions and developed what is still, I believe, the most widely used lead system for recording the vector-cardiogram.[1] The research was continued by one of his students, Robert Okada, who approached me as a possible successor. I did not hesitate long. The topic sounded fascinating and fit in with interests I had in electro-magnetic field theory. Okada did not leave the university as quickly as he had anticipated, and I spent several years engaging him in long discussions that helped crystallize my ideas.

The paper is a theoretical one concerned with the electric sources that give rise to the electrocardiogram and the ways that one might represent these sources, given that what one measures is a set of electric potentials available at the skin. The physics, involving electric current distributions in the body, is known as the volume conductor problem. Schwan's measurements of the electric properties of body tissues provided important experimental data.[2]

The paper is important, I believe, because it is the first one that utilized Green's theorem to develop the fundamental equations of the volume conductor problem in electrocardiography for a general current dipole source and a realistic torso. It also considers the inverse problem, which arises in many other fields. Later, one of my students, W.T. Miller, and I showed how the source dipoles could be related to cardiac cellular electric activity, leading to a model of the electrocardiogram.[3]

The use of Green's theorem is now firmly rooted in theoretical electrocardiography. A number of subsequent workers have used this basic approach to derive other equations of interest. The multipole expansion has continued to interest investigators as a framework for exploring aspects of the electrocardiogram. The interested reader can refer to a collection of papers with added explanatory material.[4] I am particularly intrigued by the relationship of a number of ideas in theoretical electrocardiography to an 1853 paper by H. Helmholtz.[5]

The *Classic* paper played a role in my selection for two awards from the Institute of Electrical and Electronics Engineers. At the time of its publication Okada commented to me that he felt that it would become a *Classic* work. I was dubious. He was right.

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3. Miller W T & Geselowitz D B. Simulation studies of the electrocardiogram. *Circ. Res.* 43:301-23. 1978. (Cited 50 times.)
4. Pilkington T C & Plonsey R, eds. *Engineering contributions to biophysical electrocardiography.* New York: IEEE Press, 1982. 248 p.
5. Helmholtz H. Ueber einige Gesetze der Vertheilung elektrischer Ströme in körperlichen Leitern mit Anwendung auf die thierisch-elektrischen Versuche (Application of laws concerning solid-conductor current-distribution to experiments in animal-tissue electricity). *Poggendorff's Ann.* 89:211-33; 353-77. 1853. (Cited 2 times since 1955.)

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