EVALUATION OF PHYSICAL AND PHYSIOLOGICAL FACTORS AFFECTING ELECTRICAL CONDUCTION FIELDS IN THE HUMAN BODY

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Thesis submitted to the Indian Institute of Technology, Delhi
for the award of the degree of
Doctor of Philosophy

Department of Electrical Engineering
Indian Institute of Technology, Delhi

1975

CERTIFICATE

This is to certify that the thesis entitled "EVALUATION OF PHYSICAL AND PHYSIOLOGICAL FACTORS AFFECTING ELECTRICAL CONDUCTION FIELDS IN THE HUMAN BODY" being submitted by Mr. Shri Nath Tandon to the Indian Institute of Technology, Delhi, for the award of the Degree of Doctor of Philosophy of the Indian Institute of Technology, Delhi, is a record of bonafide research work carried out by him under my supervision and guidance for the last four years and to my knowledge it has reached the standard fulfilling the requirement of the regulations relating to the degree.

The results contained in this thesis have not been submitted in part or in full to any other University or Institute for the award of any degree or diploma.

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ACKNOWLEDGEMENTS

It is with great pleasure and gratitude I acknowledge the constant help, valuable guidance and encouragement of Professor Sujoy K. Guha, throughout the course of this study. It was entirely through his steadfast efforts that I was able to take up this work.

I wish to record my deep sense of gratitude to Professor Sujoy B. Roy and his colleagues, of the Department of Cardiology, All India Institute of Medical Sciences, New Delhi for their help in carrying out clinical studies.

I am highly thankful to Shri M.R. Khan for his constant help and suggestions. Thanks are also due to all my colleagues for their constant help and co-operation.

I am thankful to the authorities of I.I.T., Delhi and A.I.I.M.S, New Delhi, for providing research facilities.

Finally I wish to thank Miss Neelam for efficient typing of the manuscript.

S. Nandon

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SUMMARY

Several techniques in biomedical research, medical diagnosis and medical therapy require an external potential to be applied to the human body. In all such cases where an external voltage is applied, an electrical current field is setup in the body due to finite conductivity of body tissues. Since the body is inhomogeneous and anisotropic, the field patterns will not be uniform and different regions will have different current densities. For research and clinical applications, information regarding the field pattern in specific parts of the body would be of considerable value. The field distribution inside the body cannot be measured readily. A better approach would be to determine field patterns by computation based on a model of the body segment.

Literature survey and main lacuna in the past work on electrical conduction fields in biological systems is reported. The justification for the present work is also brought out. The body segment for the present study was the thorax. An appropriate geometry of thorax has been taken for the present analysis and experimental work. An electrolytic tank model was constructed to simulate the thoracic region. Experiments with the electrolytic tank model led to the conclusion that if information regarding the heart is desired from field distribution studies, the size of the exciting electrodes must be large. Another experiment with electrolytic tank

model has shown that the surface potentials are clearly related to the orientation of the heart.

A theoretical model of the thorax has been established for analysis. Curved boundaries of the thorax and internal organs were approximated by stepped straight lines. Based on tissue properties and boundary conditions the general Maxwell's equation for field distribution has been approximated by the Laplace's equation. Using numerical techniques and digital computer programming, the Laplace's equation has been solved to obtain potential plot over the thoracic region. From a study of the changes in the potential plot due to simulated physiological variations a conclusion is reached that the physiological variations produce measurable changes in the body surface potentials. Studies on animals have shown that the plethysmogram is very well related to the ECG. Heart movements produce considerable change in the plethysmogram and pulmonary circulation has minimal effect. Clinical trials of the technique on normal persons indicate that the plethysmographic wave shapes are reproducible for an individual. Changes in the dimensions of the heart during valsalva manoeuvre are reflected in the plethysmogram. In clinical trials of the technique with cardiac patients, it has been found that in subjects with mitral stenosis, the time phase relationship between ECG and plethysmogram is deviant from those of normals. Monitoring of these patients after valvotomy operation showed that the time phase relationship was the same as that of normals.

The present analysis was extended to obtain equivalent resistance of the thorax. It has been shown that contribution of each organ to the overall resistance measured depends on the field pattern produced by the specific exciting electrode configuration. This aspect has been utilized for assessing heart problems. It has been shown that when subjects with a history of angina pectoris are stressed the total resistance of the lungs and hence the thorax reduces markedly. This measurement therefore provides valuable information which can help in identifying abnormalities in respect of angina pectoris, when the ECG by itself does not give a clear diagnosis.

Finally a critical analysis of the methodology adopted and techniques developed is presented. Suggestion for improvement of the model as well as extending the range of application of the methods developed are given.

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