When completed submit via:
Technology Transfer Office
Sears Building – 6th Floor
(216) 368-6837 • Fax (216) 368-0196

Case Western Reserve University
INVENTION DISCLOSURE

Case No. (this space for TTO use only) [redacted]

Please see the instructions on page 2 for additional information on how to complete this form.

1. TITLE OF INVENTION
NONINVASIVE ELECTROCARDIOGRAPHIC IMAGING (ECGI)

2. **PLEASE ATTACH A DESCRIPTION OF TECHNOLOGY.** See ATTACHED

3. INVENTOR(S)	POSITION	% OF CONTRIBUTION	SCHOOL & DEPARTMENT	EXTENSION
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

4. Was this invention developed with the use of any research grant/contract funds? YES ☑ NO ☐

CONTRACT NO(S).	SPONSOR(S)	O.S.P. PROJECT NO(S).	PRINCIPAL INVESTIGATOR
[redacted]	[redacted]	[redacted]	[redacted]

Please note that accurate and complete sponsorship information is necessary to fulfill CASE obligations under research contracts.

5. If no contract or grant, was there significant use of CASE administered funds or facilities? YES ☐ NO ☐

6. DATES OF CONCEPTION AND PUBLIC DISCLOSURE *(accurate data is essential, as prior disclosure may affect the possibility of obtaining patent rights)*	DATE	REFERENCES / COMMENTS Please include names of periodicals/journals. *(use a separate sheet if necessary)*
A. Date of conception of invention. Has this date been documented? If so, where?	[redacted]	[redacted]
B. First publication containing sufficient description to enable a person skilled in this field to understand and to make or use the invention. (Include theses and the date(s) submitted).	[redacted]	[redacted]
C. First public oral disclosure of invention sufficient to enable a person skilled in this field to understand and to make or use the invention.	[redacted]	
D. If unpublished and undisclosed, provide the anticipated publication or oral disclosure date and any submissions made for potential publication.		

7. Has the invention been reduced to practice? YES ☑ NO ☐ If yes, please give date of first reduction to practice 1992
8. Please attach list of any commercial entities that may be interested in this invention. (Provide as much detail as is possible.) See ATTACHED
9. Please attach the name, department and contact information of up to three peers who would be willing to perform a confidential review of the invention. (optional)
10. I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true.

Per the Intellectual Property Policy, I (we) hereby agree to assign all right, title and interest to this invention to CASE and agree to execute all documents as requested, assigning to CASE our rights in any patent application filed on this invention, and to cooperate with the CASE Technology Transfer Office in the protection of this invention. CASE will share any royalty income derived from the invention with the inventor(s) according to the Intellectual Property Policy.

Inventor [redacted]	Inventor Name:
Inventor's Signature Date	Inventor's Signature Date
Home Address [redacted]	Home Address
Social Security No. (required) Country of Citizenship	Social Security No. (required) Country of Citizenship
Inventor Name:	Inventor Name:
Inventor's Signature Date	Inventor's Signature Date
Home Address	Home Address
Social Security No. (required) Country of Citizenship	Social Security No. (required) Country of Citizenship

Please note that Social Security number and country of citizenship are required; absence of this information may hinder distribution of the inventors' share of any royalties that may result from this technology. If there are more than four inventors, please attach an additional form.

11. Technology disclosed to and understood by: [redacted]

Signature of Non-Inventor Witness [redacted] Date [redacted]

Name and Title of Witness (please type or print) [redacted]

Instructions

1. Please provide a brief title for the invention.

2. Please attach a description of the technology. At a minimum, this should be a one to two page summary description of the invention and why it is unique or represents an improvement over existing technologies. Preferably, the description will include one or more of the following: submissions for publication or published material; lab notes; presentations; diagrams/drawings; results and graphs.

   The description allows our office to conduct a review of patentability and commercial viability. The more complete the description is, the more thoroughly we can conduct such a search. *Please feel free to include as much information as you like – it will help our office evaluate and understand your innovation.*

3. Please list all individuals who contributed to the concept and/or reduction to practice of the invention. For a definition of "reduction to practice" please see the instructions for item 7, below. The % contribution should be decided by and between the inventors and should total 100%.

4. If the invention was conceived or reduced to practice with the use of federal or contract funds, please check the appropriate box and list the grant/contract number(s) in this space. *This information is required for University compliance with Federal law and/or contract obligations.*

5. This refers to the use of University time and/or lab space in the development of the invention. Please check the appropriate box.

6. Please list all dates concerning conception and disclosure or anticipated disclosure of the invention.

7. Please check the appropriate box and fill in the date if applicable. As to the definition of "reduction to practice", there are two types:

   a. *Actual reduction to practice* – the invention physically exists in a functional form; or

   b. *Constructive reduction to practice* – you would be able to explain step by step to an individual of ordinary skill in your field how to build or produce the functional invention.

   If you are able to prepare an invention disclosure, you've very likely reduced the invention to practice.

8. Please attach a list of commercial entities that you think would be interested in licensing this technology to the disclosure. It is ok if you do not have such a list.

9. Optional Peer Review – if you would like a peer review of your work, please attach a list of colleagues who would be willing to perform such a review. Comments from your colleagues will be used to assist the office in its evaluation of your invention.

10. Signature – in order to process the invention disclosure, the signature of **all** named Case inventors and their complete information (social security, address, and citizenship) must be provided. If an inventor is off campus or no longer with the university, a fax signature is acceptable. If an inventor is or was at an institution other than Case during their contribution to the invention, a signature is not required, but please include contact and citizenship information.

11. Witness Signature – this box is to help provide backing to establish a date of conception. It can be signed by a member of your lab or a colleague to whom you have explained the invention in detail, provided that this individual is not also an inventor named on this disclosure.

Case Western Reserve University
Invention Disclosure

Description of Technology

Cardiac arrhythmias claim 400,000 lives in this country alone, but a noninvasive imaging modality or cardiac electrical function does not yet exist. Over the last ten years we have been developing such methodology. Combining body surface potential mapping with heart-torso geometry determination and with mathematical reconstruction methods, we started to evaluate ECGI in patients following demonstrated excellent performance of crucial aspects (i.e., the mathematical reconstruction) in animal studies. Initial results in patients are also very promising.

ECGI will permit noninvasive identification of patients at risk of sudden death before a catastrophic event. Will permit noninvasive diagnosis and localization of an arrhythmogenic focus prior to treatment. Will be a noninvasive tool for evaluating efficacy of therapy.

Description of Invention

Body surface electrocardiographic potentials are recorded every millisecond during the cardiac cycle using a specially designed vest (Figure 1). Using the recorded body surface potentials as input data, potentials are noninvasively computed on the epicardial surface of the heart using a mathematical reconstruction method that we have developed. Geometry information is obtained from CT slices or from bi-plane X-ray tougher with a 3D mechanical digitizer. Once potentials are computed on the heart for the entire cardiac cycle, epicardial electrograms and activation sequences are computed. Examples of ECGI application in patients are provided in Figure 2. In preparatory animal experiments, designed to test the mathematical methodology, single and dual pacing sites were reconstructed with better than 8mm accuracy as evaluated by comparison with direct measurements.

Journal/Publication

Circulation. J. of Cardiovascular Electrophysiology. J. American College of Cardiology. PACE.

Attach list of any commercial entities that may be interested in this invention.

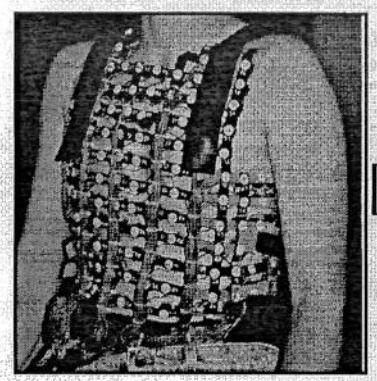
- Biosense (connected with Johnson & Johnson)
- Cordis-Webster (connected with Johnson & Johnson)
- Daig (St. Jude)
- Cardima

- Medtronic
- Siemens
- Prucka

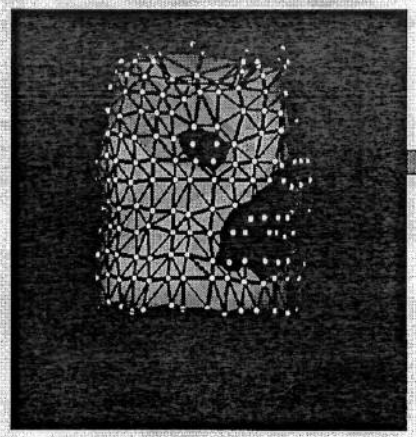
Figure 1A:

The multi-electrode vest for simultaneous recording of potentials (electrocardiograms) over the entire torso surface.

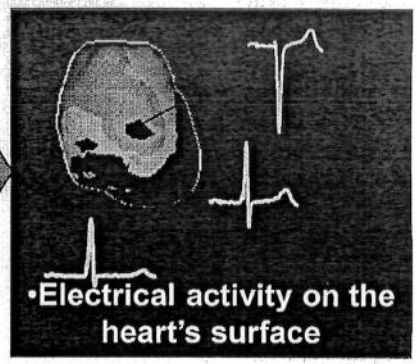
The ECGI Solution



Prototype 224
Lead Vest

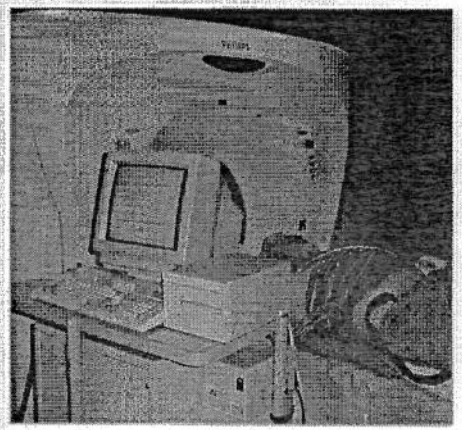


ECGI



Electrical activity on the heart's surface

•Heart
•Geometry



CT Scan

FIGURE 1A

Figure 1B:

An example of a body surface potential map (BSPM) recorded from a patient using the vest of Figure 1A. Colors indicate potential values. The BSPM provides the data for noninvasive ECGI and, together with heart-torso geometry information, is used to noninvasively compute potentials and activation sequences on the surface of the heart.

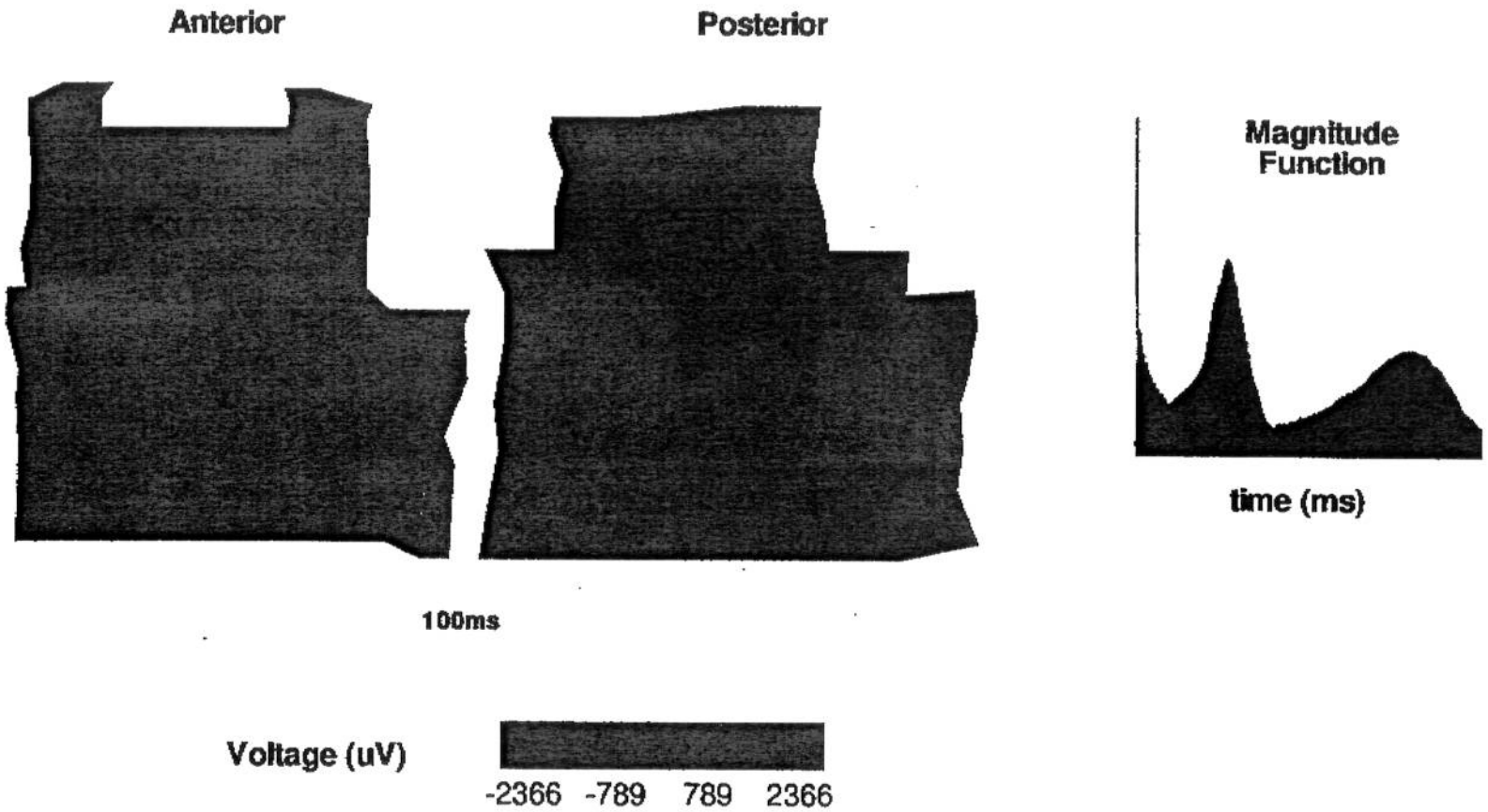
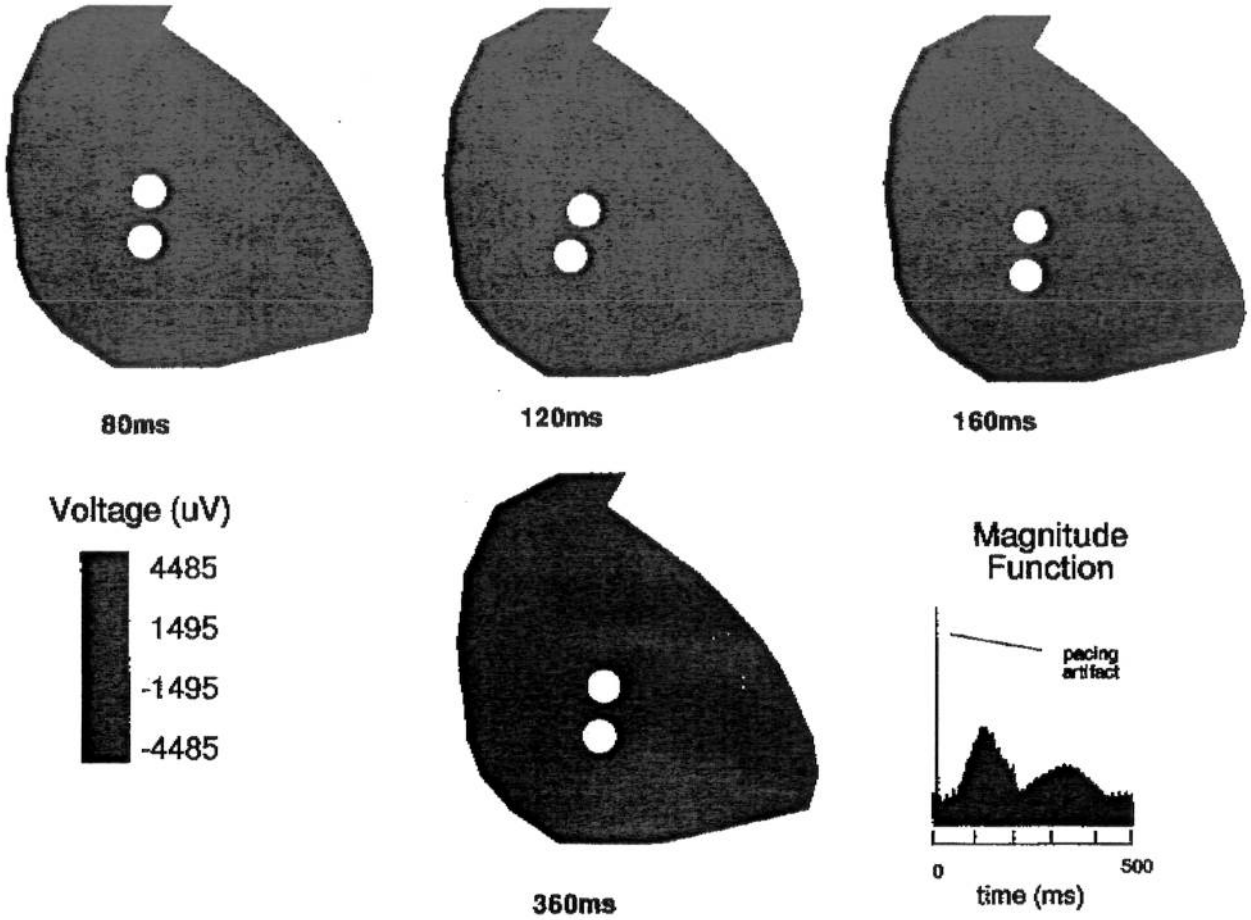

Anterior
Posterior
Magnitude Function
time (ms)
100ms
Voltage (uV)
-2366 -789 789 2366

FIGURE 1B

Figure 2A:

Example of noninvasive reconstruction of cardiac activation in patients. The white circles on the heart indicate the site of pacing by an implanted device. The intense minimum (dark blue) is correctly constructed noninvasively by ECGI at the site of pacing (accuracy of 10mm) and spreads away from this site in time, indicating the correct sequence of activation. Examples of noninvasively computed electrograms (potentials as a function of time) from selected sites around the heart are shown at the bottom of the figure.


80ms
120ms
160ms
Voltage (uV)
4485
1495
-1495
-4485
360ms
Magnitude Function
pacing artifact
0
500
time (ms)

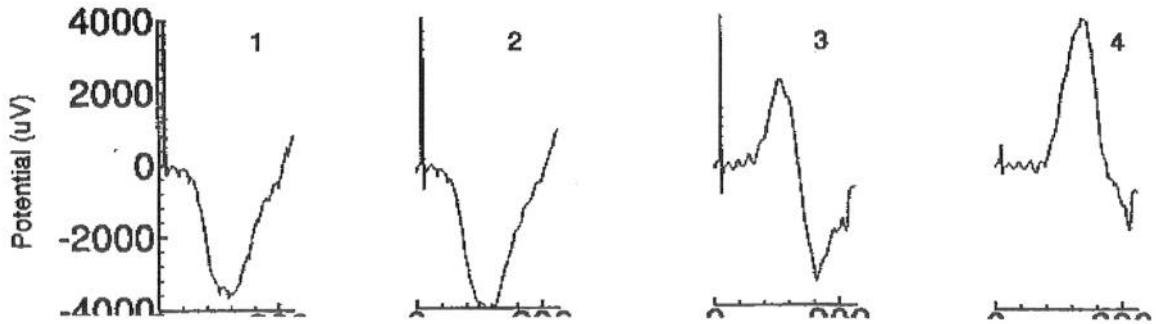

4000
2000
0
-2000
Potential (uV)
1
2
3
4

FIGURE 2A

Figure 2B:

Example of noninvasive reconstruction of cardiac activation in a human volunteer during a normal heart beat. The central minimum (green, 28 ms) that intensifies (32 ms) reflects arrival of activation to the surface of the heart and is consistent with invasive measurements of normal activation. A noninvasively computer electrograms from this region is shown on bottom left.

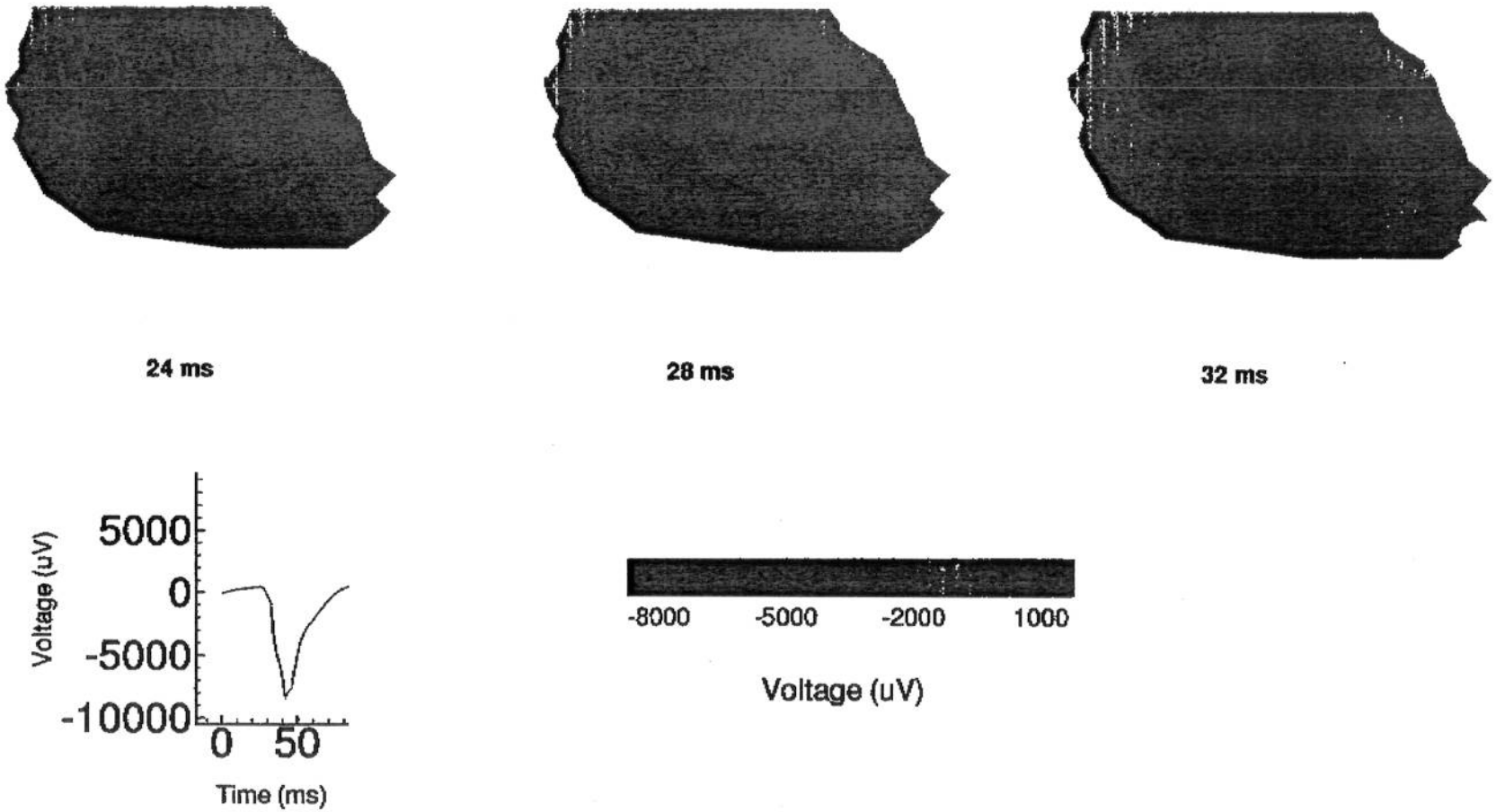

24 ms
28 ms
32 ms
5000
0
-5000
-10000
Voltage (uV)
0
50
Time (ms)
-8000
-5000
-2000
1000
Voltage (uV)

FIGURE 2B