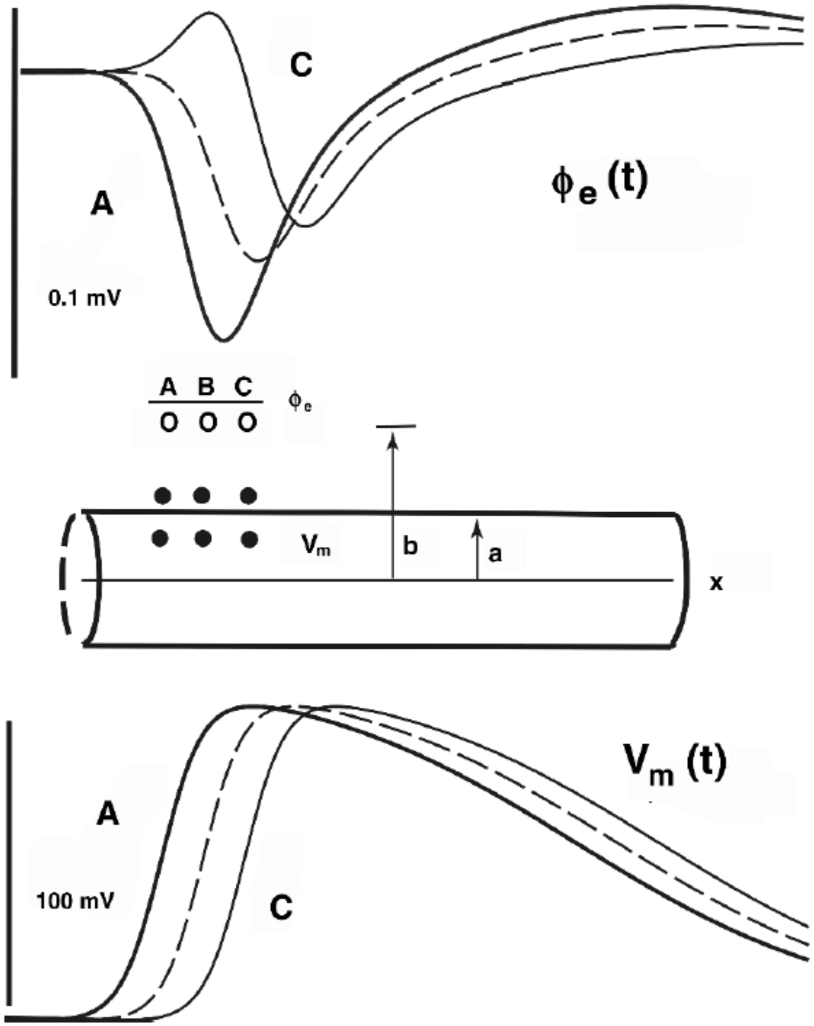
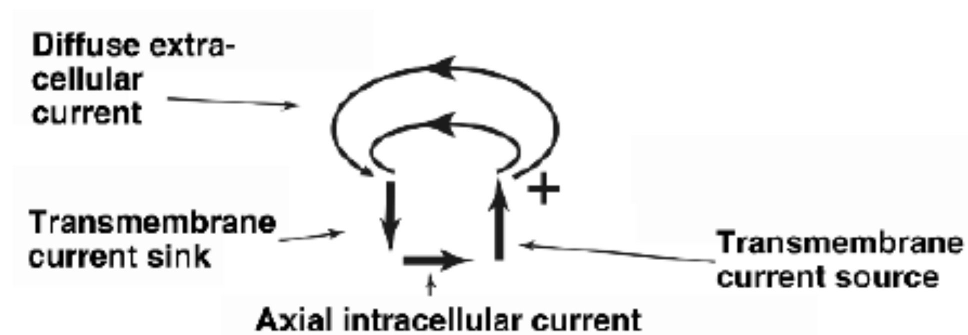
Extracellular Potentials and Recordings

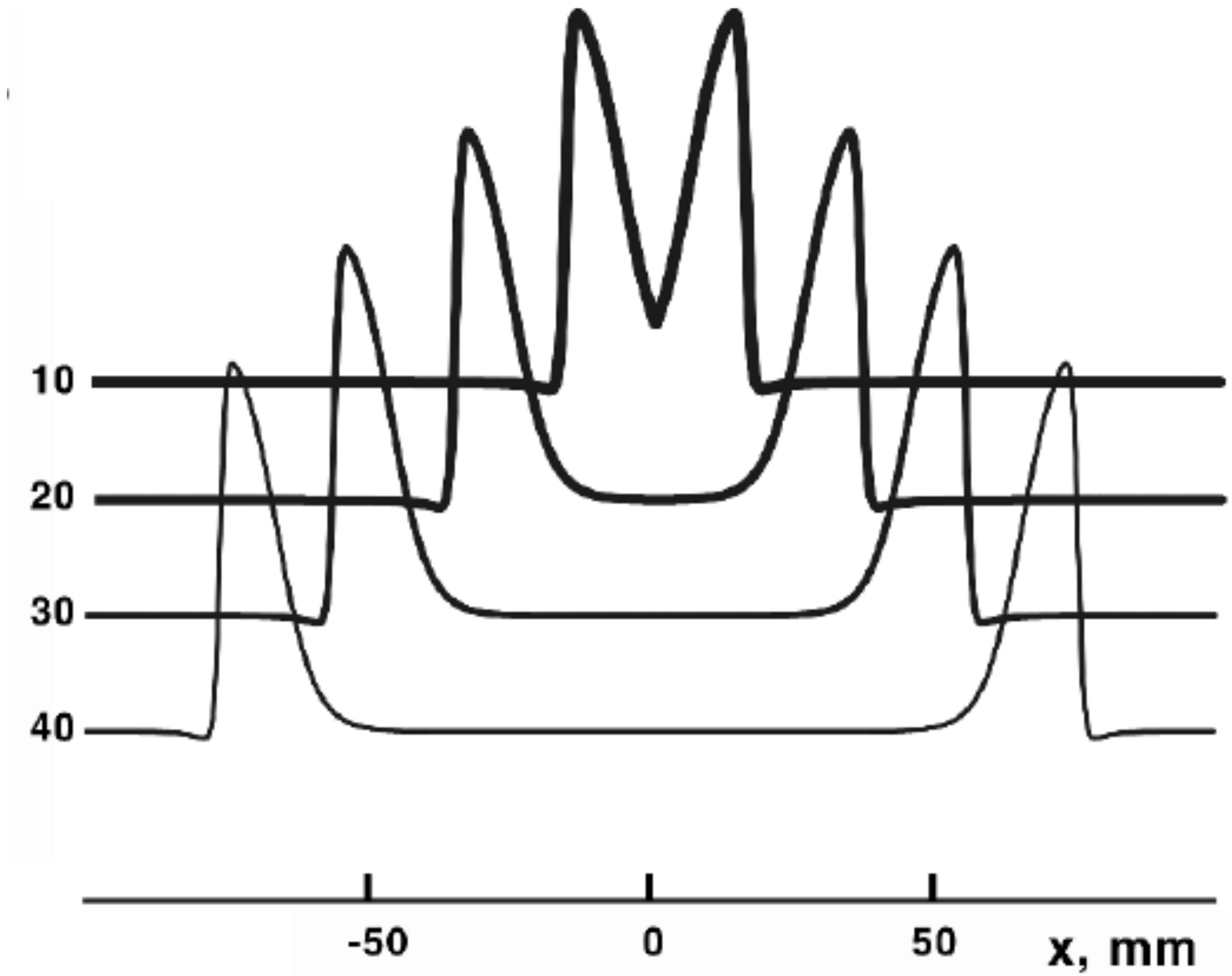
Bioeng 6460
Electrophysiology and Bioelectricity
Derek Dosdall
Derek.Dosdall@carma.utah.edu

Intracellular and Extracellular Waveforms





Transmembrane Potential (x)



Quantitative evaluation of i_m

Remember $i_m = -\frac{\partial I_i}{\partial x}$

and the cable equation … $I_i = -\frac{1}{r_i}\frac{\partial \Phi_i}{\partial x}$

Take the derivative and substitute… $i_m = \frac{1}{r_i}\frac{\partial^2 \Phi_i}{\partial x^2}$

Remember $r_i = \frac{R_i}{\pi a^2}$ and $\sigma_i = \frac{i}{R_i}$

So $i_m = \frac{\pi a^2}{R_i}\frac{\partial^2 \Phi_i}{\partial x^2} = \pi a^2 \sigma_i \frac{\partial^2 \Phi_i}{\partial x^2}$

i_m related to V_m

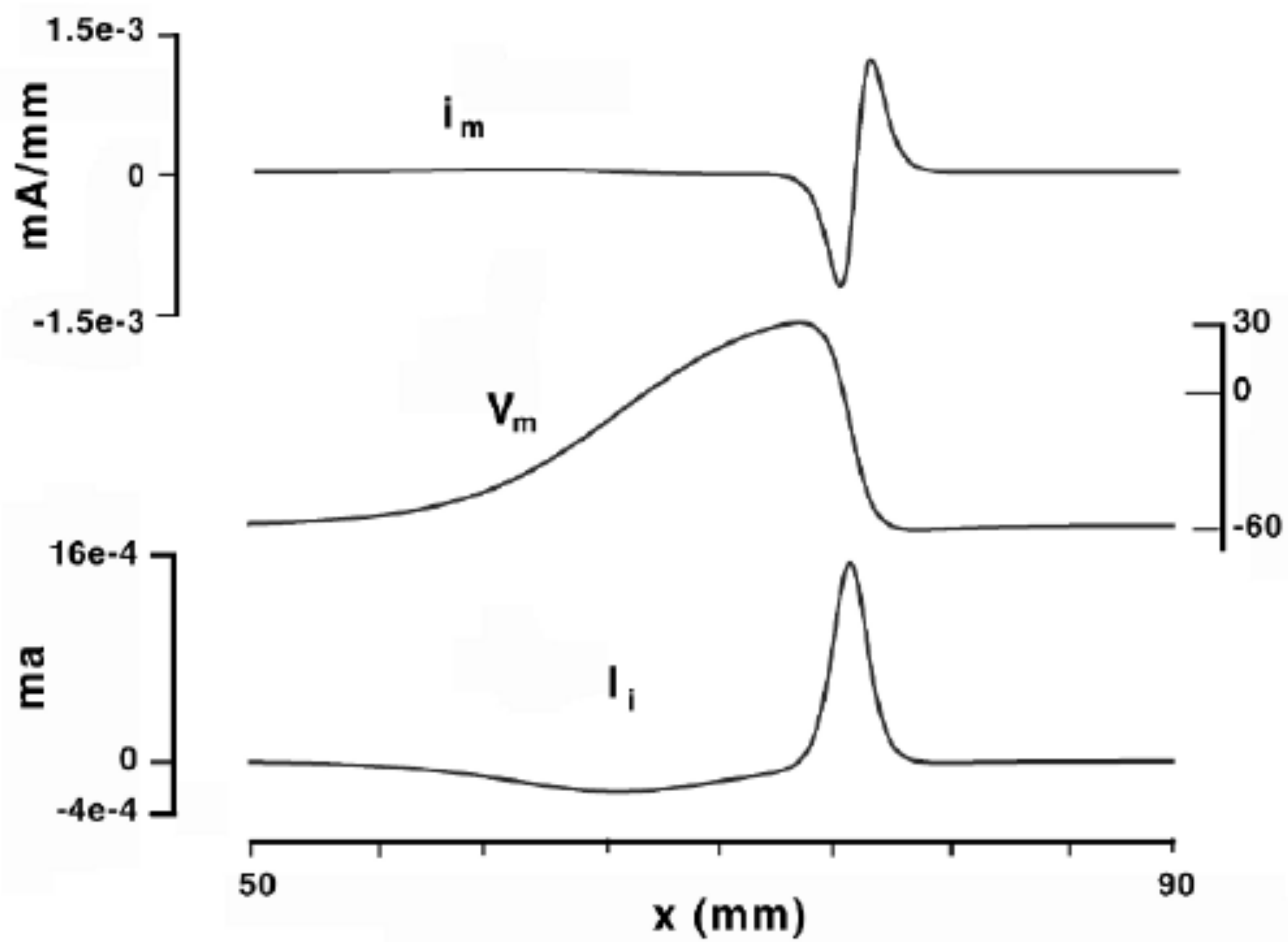
Remember $V_m(x) = \Phi_i(x) - \Phi_e(x)$

Often $R_e \ll R_i$ and $r \approx 0$ so…

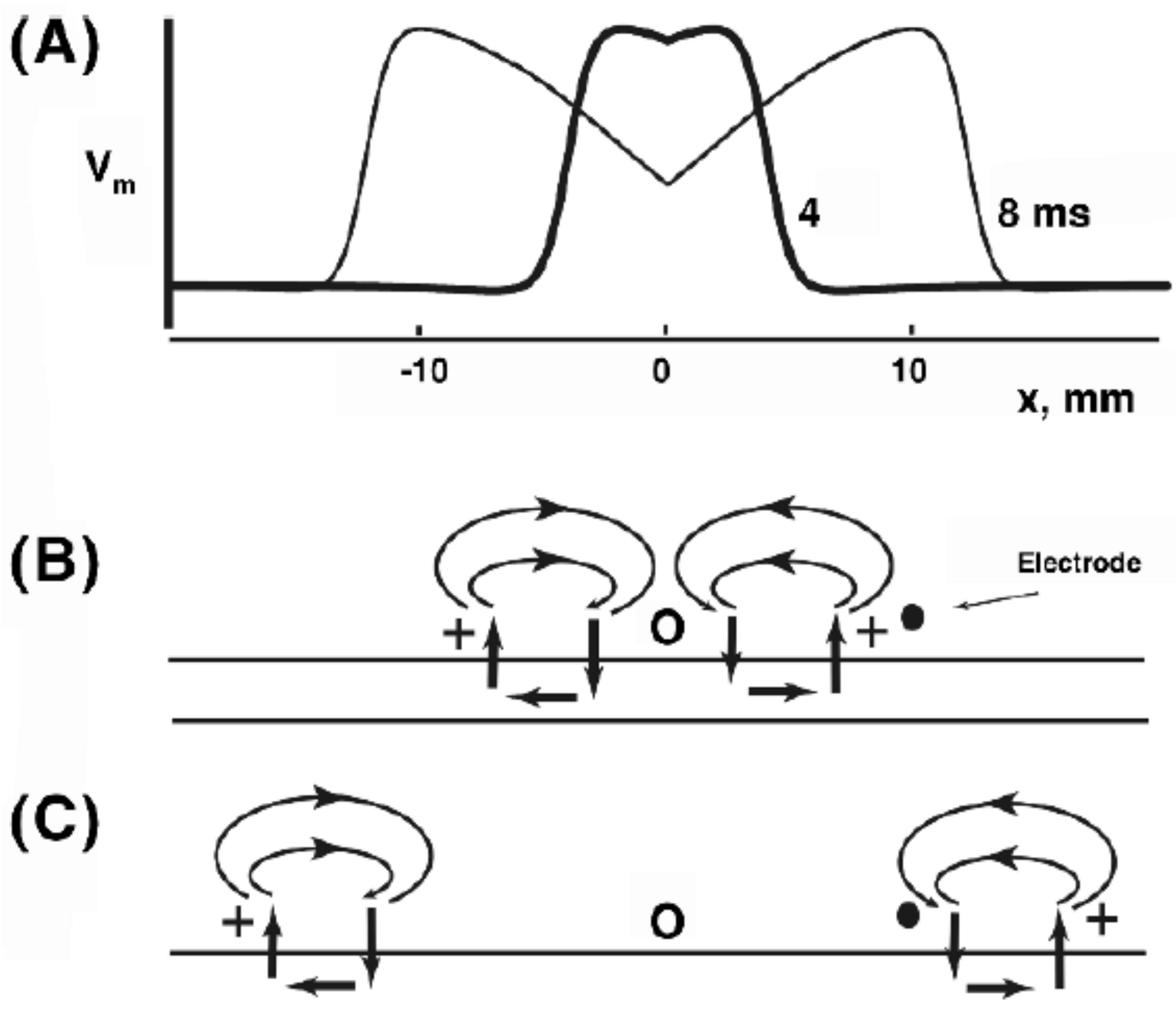
$$V_m(x) = \Phi_i(x) - \Phi_e(x) \approx \Phi_i(x)$$

So $$i_m = \frac{1}{r_i}\frac{\partial^2 \Phi_i}{\partial x^2} \approx \frac{1}{r_i}\frac{\partial^2 V_m}{\partial x^2}$$

Transmembrane and Intracellular Current (x)



Transmembrane Current



Sampling Rate Considerations

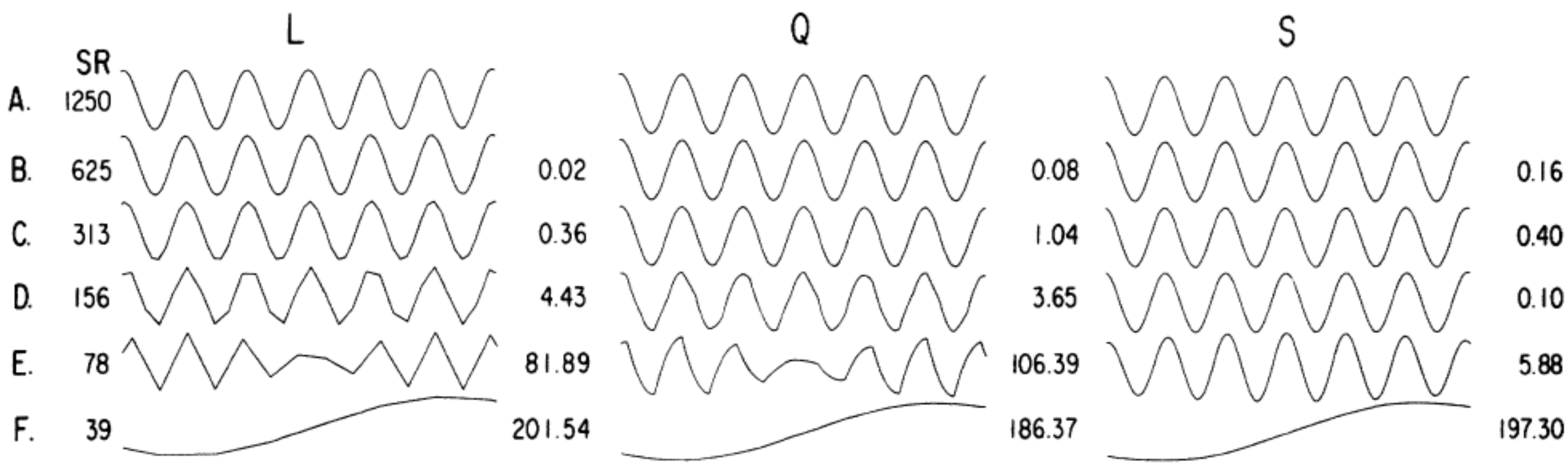
Sampling Rates Required for Digital Recording of Intracellular and Extracellular Cardiac Potentials

ROGER C. BARR, PH.D., AND MADISON S. SPACH, M.D.

SUMMARY Electrocardiograms and cardiac electrograms now frequently are measured for both clinical and experimental purposes by direct digital sampling, with no recording of the signal in analog form. This study examined the question of what sampling rates were required to measure accurately the continuous waveforms from the digital samples. Body surface waveforms and intracellular and extracellular waveforms measured directly from cardiac tissues were evaluated. Cardiac measurements included waveforms from the atrium, ventricle, atrioventricular transmission system and individual Purkinje strands. Sampling rates as high as 15,000 samples/sec were required to record accurately extracellular waveforms of the ventricular conduction system. Decreasing sampling rates were required as the recording site shifted through the ventricle to the body surface, where sampling rates as high as 1500 samples/sec were necessary.

Sine Wave Reconstruction

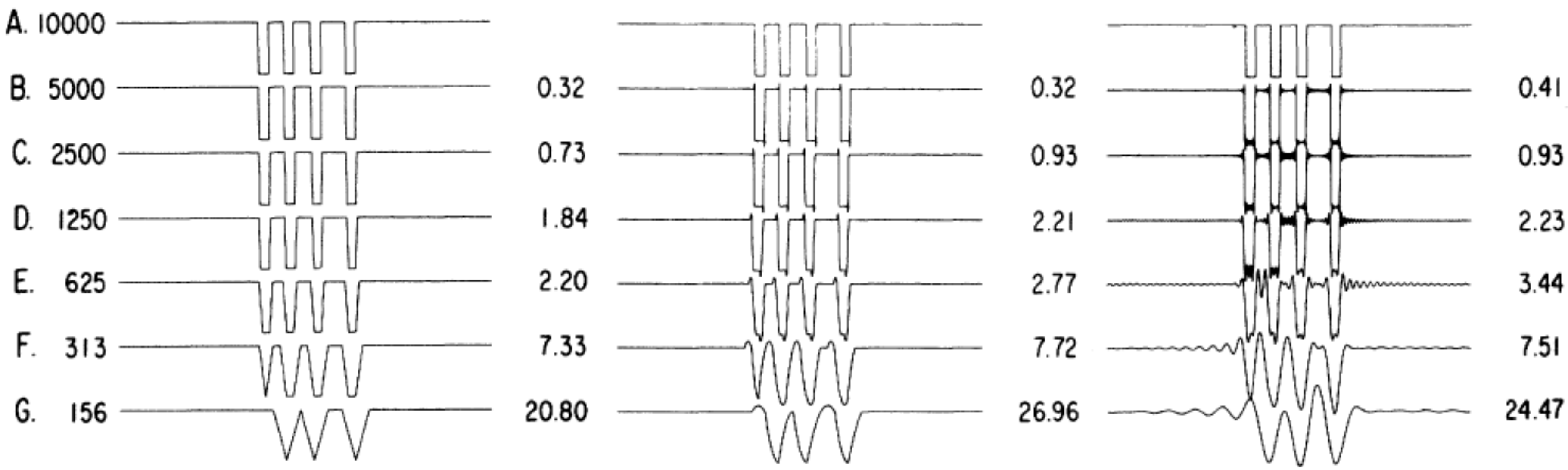
35 Hz sine wave
Linear, quadratic, sine x/x reconstruction



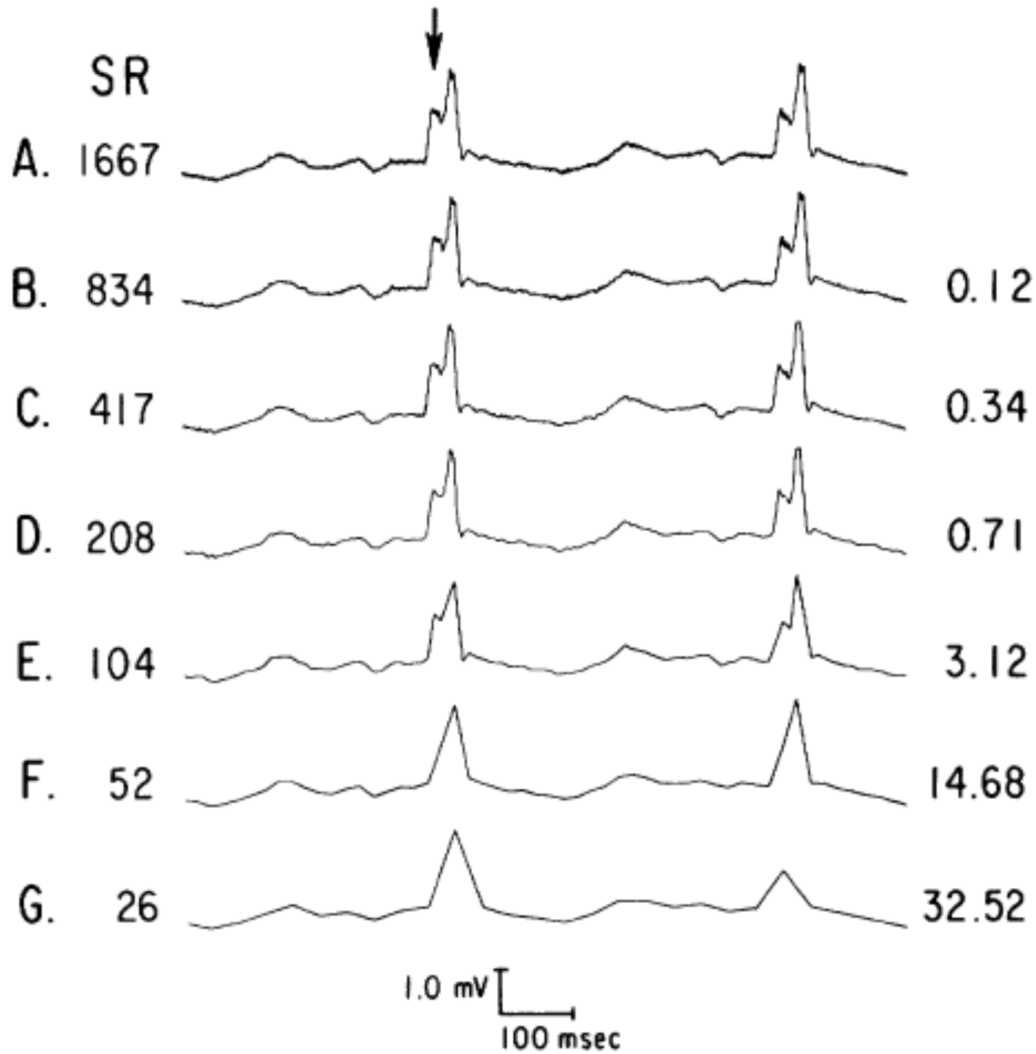
35 Hz sine wave
Linear, quadratic, sine x/x reconstruction

Square Wave Reconstruction

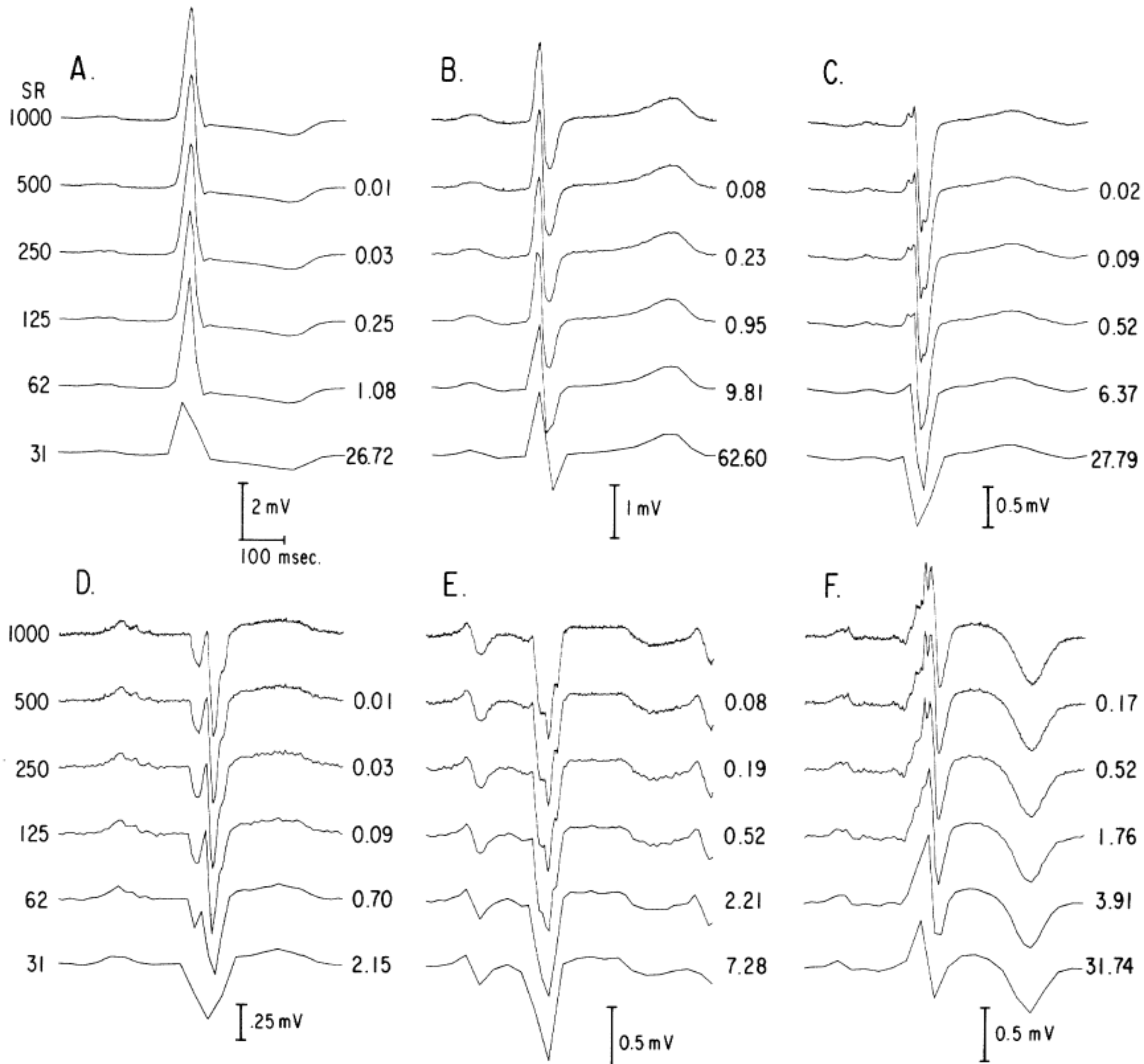
Burst of 100 Hz square waves
Linear, quadratic, sine x/x reconstruction



Infant Surface-lead ECG

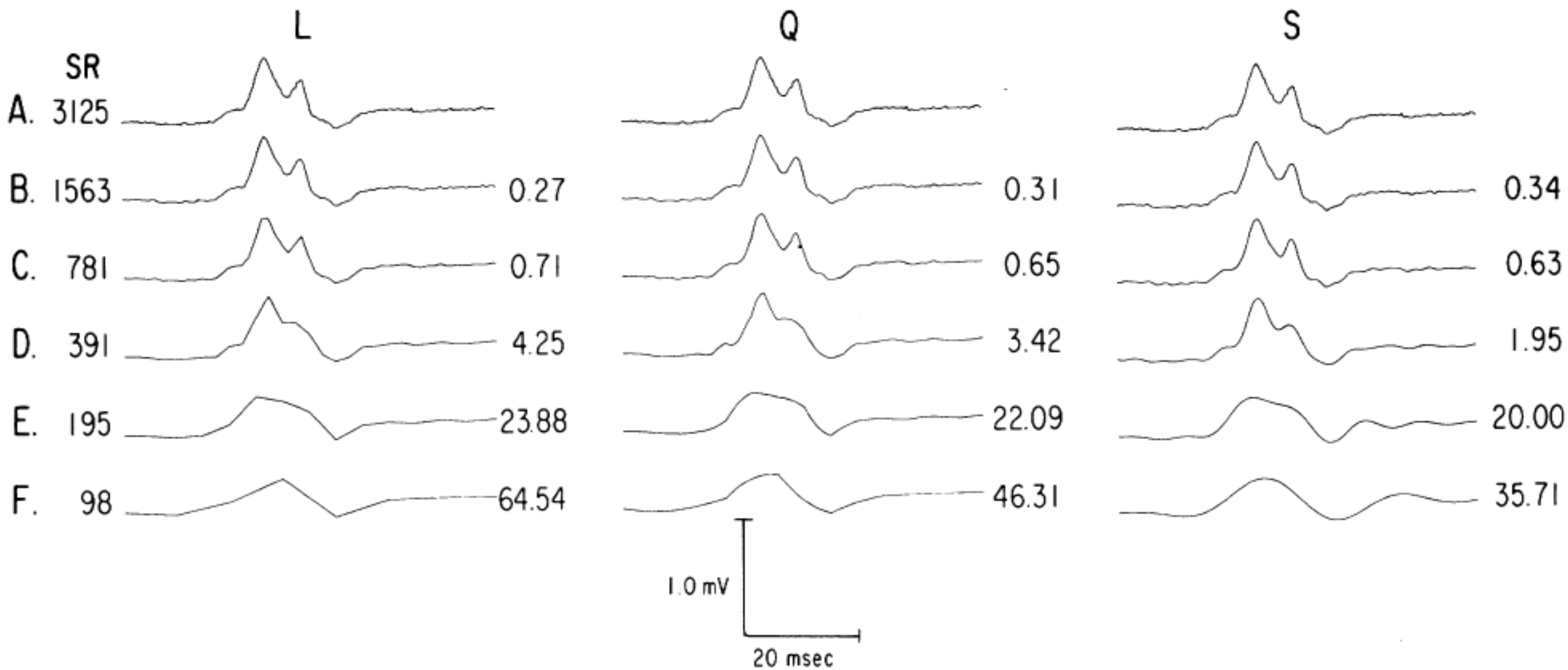


ECG in Various Conditions



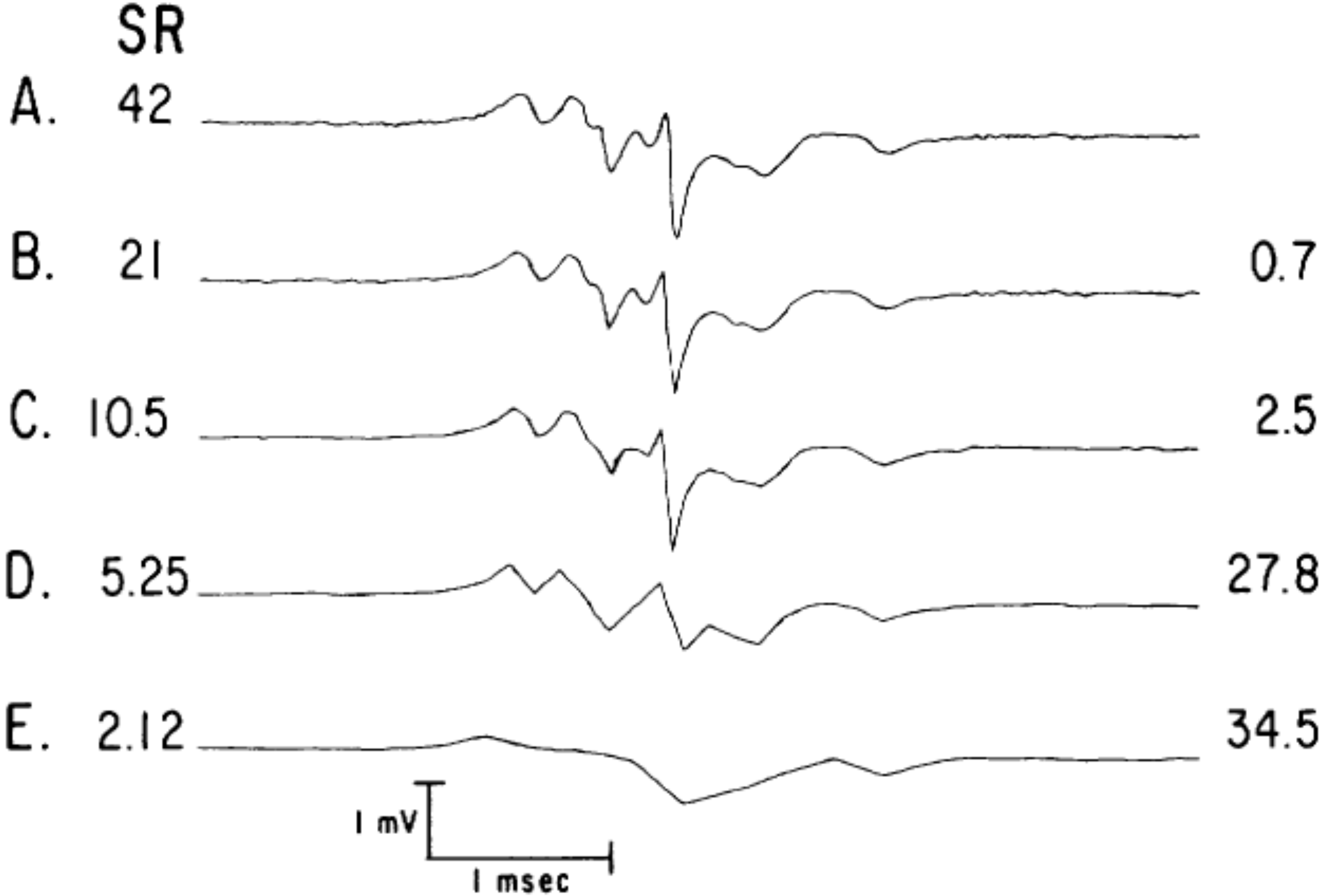
A = Aortic Stenosis
B = Normal
C = Normal
D = Anterior lateral infarct
E = Diaphragmatic infarct
F = Anterior infarct

Puppy ECG

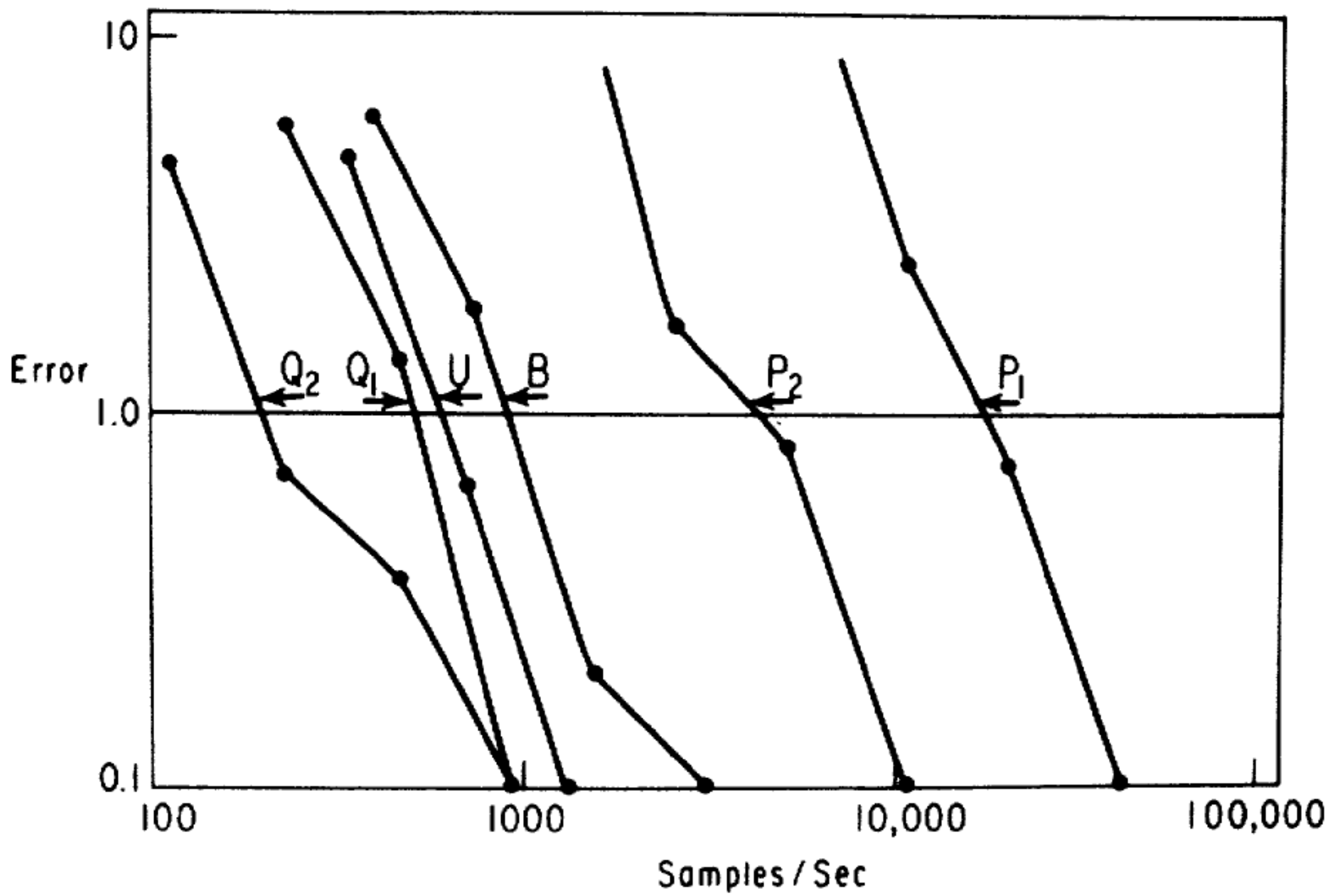


L
Q
S
SR
A. 3125
B. 1563
C. 781
D. 391
E. 195
F. 98
0.27
0.71
4.25
23.88
64.54
0.31
0.65
3.42
22.09
46.31
0.34
0.63
1.95
20.00
35.71
1.0 mV
20 msec

Dog Conduction System

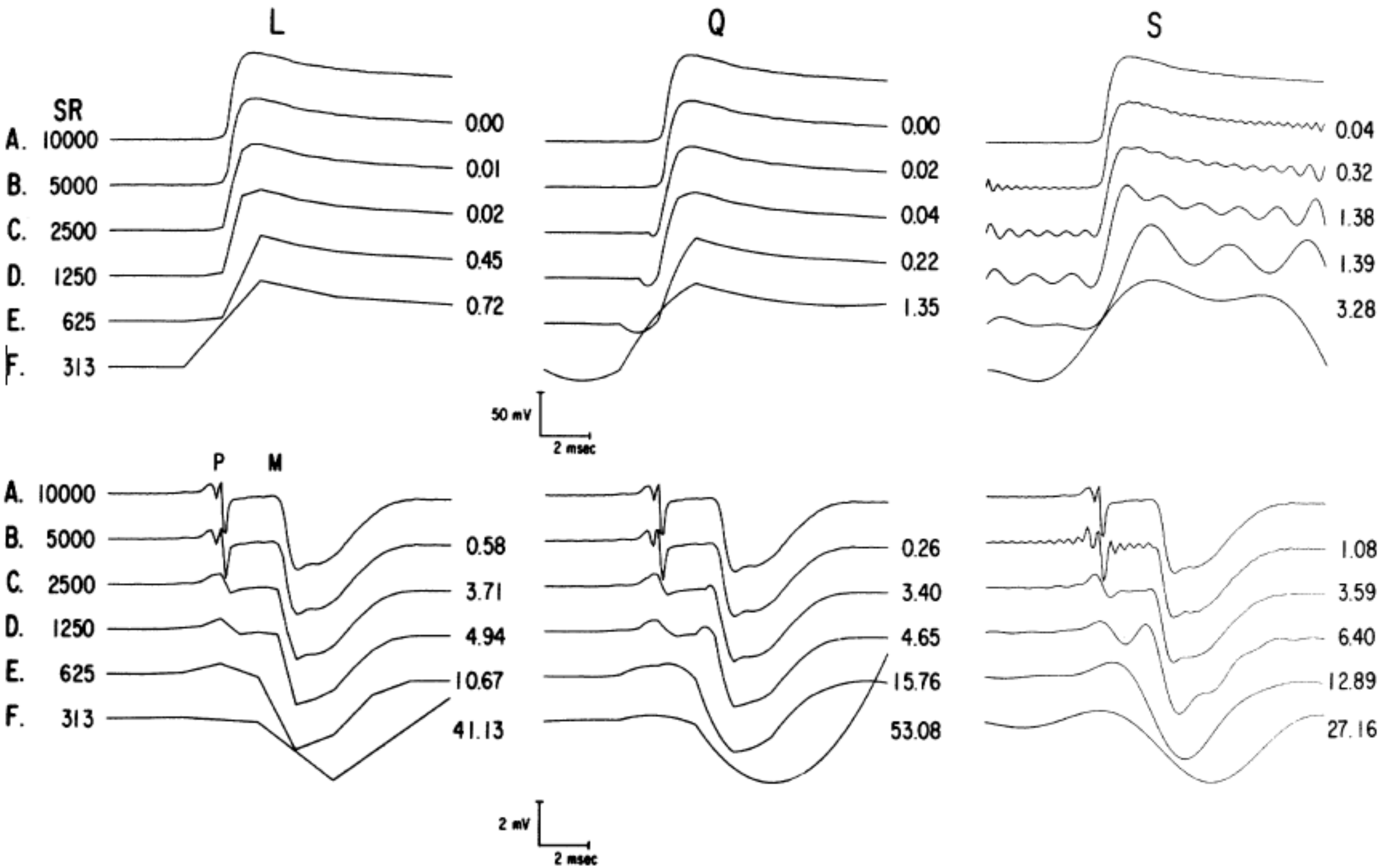


Sample Rates vs Error



Q1, Q2 = Human ECGs. U = Unipolar and Bipolar dog myocardium.
P1 and P2 are dog conduction system recordings

Intracellular and Extracellular Signals



Proceedings of the 28th IEEE
EMBS Annual International Conference
New York City, USA, Aug 30-Sept 3, 2006

FrEP6.7

Guidelines for Plunge Needle Recording for Effective Detection of Purkinje Activation

Derek J. Dosdall, *Member, IEEE*, Jian Huang, William M. Smith, *Fellow, IEEE*, J. Scott Allison, James D. Allred, and Raymond E. Ideker, *Fellow, IEEE*

Extracellular Purkinje System