Foreword

In 1980, a committee of distinguished members of the American Association of Electromyography and Electrodiagnosis (AAEE) published the first comprehensive collection of terms used in the practice of what was then referred to by the generic name of electromyography. A second such committee, responding to advances and changes in the field, produced a revised glossary in 1987. Many changes, including the name of the organization to the American Association of Electrodiagnostic Medicine (AAEM), have occurred since that time. Some of the changes have been advances in the science of the field, but others have occurred in response to the changing face of medical practice at the turn of the century. For example, we have recognized that our area of special knowledge and skill in medicine is better described as the practice of *electrodiagnostic medicine* rather than the more narrowly defined term *electromyography.* Such changes are not just cosmetic, but they reflect a clearer sense of what makes the activities of the membership of the AAEM unique in the world of medicine. In response to the many changes that have occurred since 1987, a new Nomenclature Committee was formed in 1994 to revise and update the glossary. This document reflects the hard work of that committee. From the work of the committee, it has become clear that the specialty of electrodiagnostic medicine is a growing and changing field. More than 150 new terms have been added, and 15 terms were deleted from the previous glossary. By the time this glossary is in print, additional new terms will likely have come into common usage. It is hoped that this glossary will serve as a stimulus to further growth into the future.

AAEM Nomenclature Committee 1994-2001

Lawrence H. Phillips, II, MD, Chair (1997-2001)
William J. Litchy, MD, Chair (1994-1997)
Raymond G. Auger, MD (1994-2001)
Ernest M. Baran, MD, MSBME (1997-2001)
Francis J. Bonner Jr., MD (1995-1996)
M. E. Brandstater, MBBS, PhD, FRCP (1994-2001)
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Björn Falck, MD, PhD (1994-2001)
Andrew J. Gitter, MD (1996-2001)
Andrew J. Haig, MD (1996-2001)
Mark Hallett, MD (1995-2001)
Charles K. Jablecki, MD (1994-2001)
Dale J. Lange, MD (1996-2001)
Janice M. Massey, MD (1994-1996)
Lawrence R. Robinson, MD (1994-2001)
Margaret A. Turk, MD (1994-1996)
Jacqueline J. Wertsch, MD (1994-2001)
Asa J. Wilbourn, MD (1995-2001)

SECTION I:
ALPHABETIC LIST OF TERMS WITH DEFINITIONS

***A wave** A *compound muscle action potential* that follows the *M wave*, evoked consistently from a muscle by submaximal electric stimuli and frequently abolished by *supramaximal stimuli.* Its *amplitude* is similar to that of an *F wave*, but the *latency* is more constant. Usually occurs before the F wave, but may occur afterwards. Thought to be due to extra *discharges* in the nerve, *ephapses,* or axonal branching. This term is preferred over *axon reflex, axon wave,* or *axon response.* Compare with the *F wave.*

absolute refractory period See *refractory period*.

accommodation In neuronal physiology, a rise in the *threshold* transmembrane *depolarization* required to initiate a *spike,* when depolarization is slow or a subthreshold depolarization is maintained. In the older literature, the observation that the final intensity of current applied in a slowly rising fashion to stimulate a nerve was greater than the intensity of a pulse of current required to stimulate the same nerve. The latter may largely be an *artifact* of the nerve sheath and bears little relation to true accommodation as measured intracellularly.

accommodation curve See *strength-duration curve.*

acoustic myography The recording and analysis of sounds produced by contracting muscle. The muscle *contraction* may be produced by stimulation of the nerve supply to the muscle or by volitional *activation* of the muscle.

action potential (AP) The brief regenerative electric *potential* that propagates along a single axon or muscle fiber membrane. An all-or-none phenomenon; whenever the *stimulus* is at or above *threshold*, the action potential generated has a constant size and configuration. See also *compound action potential, motor unit action potential.*

activation 1) In physiology, a general term for the initiation of a process. 2) The process of *motor unit action potential* firing. The force of muscle *contraction* is determined by the number of *motor units* and their *firing rate.*

activation procedure A technique used to detect defects of neuromuscular transmission during *repetitive nerve stimulation* testing. Most commonly a sustained voluntary *contraction* is performed to elicit *facilitation* or *postactivation depression.* See also *tetanic contraction.*

active electrode Synonymous with *exploring electrode*. See *recording electrode*.

acute inflammatory neuropathy An acute, monophasic *polyneuropathy*. Characterized by a time course of progression to maximum deficit within 4 weeks of onset of symptoms. Most common clinical presentation is an ascending sensory-motor *neuropathy.* Electrodiagnostic studies most commonly reveal evidence for *demyelination*, but *axonal degeneration* also occurs. Distinguish from *chronic inflammatory demyelinating polyradiculoneuropathy (CIDP)*. See also *Guillain-Barré syndrome*.

adaptation A decline in the *frequency* of the *spike discharge* as typically recorded from sensory axons in response to a maintained *stimulus*.

ADEMG Abbreviation for *automatic decomposition electromyography.*

AEP Abbreviation for *auditory evoked potential*.

afterdischarge 1) The continuation of *action potentials* in a neuron, axon or muscle fiber following the termination of an applied *stimulus.* 2) The continuation of firing of *muscle action potentials* after cessation of voluntary *activation,* for example in *myotonia.*

afterpotential The membrane *potential* between the end of the *spike* and the time when the membrane potential is restored to its resting value. The membrane during this period may be depolarized or hyperpolarized at different times.

akinesia Lack or marked *delay* of intended movement, often observed in patients with Parkinson's disease. Often used synonymously with *bradykinesia.*

amplitude With reference to an *action potential*, the maximum *voltage* difference between two points, usually *baseline*-to-peak or peak-to-peak. By convention, the amplitude of *potentials* which have an initial negative deflection from the baseline, such as the *compound muscle action potential* and the *antidromic sensory nerve action potential* are measured from baseline to the most negative peak. In contrast, the amplitude of a *compound sensory nerve action potential, motor unit potential, fibrillation potential, positive sharp wave, fasciculation potential,* and most other action potentials is measured from the most positive peak to the most negative peak.

amplitude decay The percent change in the *amplitude* of the *M wave* or the *compound sensory nerve action potential* between two different stimulation points along the nerve. Decay = 100* (amplitude$_{distal}$ - amplitude$_{proximal}$) / amplitude$_{distal}$. Useful in the evaluation of *conduction block.* Abnormal decay without increased *temporal dispersion* may indicate a conduction block.

anodal block A local block of nerve conduction caused by membrane *hyperpolarization* under a stimulating *anode.* Does not occur in routine clinical studies, since it is possible for the anode to routinely result in nerve *depolarization* if sufficient current intensities are used.

*Illustration in Section II

anode The positive terminal of an electric current source. See *stimulating electrode.*

antidromic Propagation of a nerve impulse in the direction opposite to physiologic conduction; e.g., conduction along *motor nerve* fibers away from the muscle and conduction along sensory fibers away from the spinal cord. Contrast with *orthodromic.*

AP Abbreviation for *action potential.*

artifact (also artefact) A *voltage* change generated by a biologic or nonbiologic source other than the ones of interest. The *stimulus artifact* (or *shock artifact*) represents cutaneous spread of stimulating current to the *recording electrode* and the *delay* in return to *baseline* which is dependent on the ability of filters to respond to high voltage. Stimulus artifacts may precede or overlap the activity of interest. *Movement artifact* refers to a change in the recorded activity caused by movement of the recording electrodes.

asterixis A quick involuntary movement caused by a brief lapse in tonic muscle *activation*. It can be appreciated only during voluntary movement. Is usually irregular, but can be rhythmic and confused with action *tremor.*

ataxia Clumsiness of movement. Specific features include dysmetria (incorrect distance moved) and dysdiadochokinesis (irregularity of attempted rhythmic movements). Most commonly due to a disorder of the cerebellum or proprioceptive sensory system. Referred to, respectively, as cerebellar ataxia or sensory ataxia.

auditory evoked potential (AEP) Electric *waveforms* of biologic origin elicited in response to sound stimuli. Classified by their *latency* as short-latency *brainstem auditory evoked potential (BAEP)* with a latency of up to 10 ms, middle-latency with a latency of 10 to 50 ms, and long-latency with a latency of over 50 ms. See *brainstem auditory evoked potential.*

automatic decomposition EMG (ADEMG) computerized method for extracting individual *motor unit action potentials* from an *interference pattern.*

averager See *signal averager.*

averaging A method for extracting time-locked *potentials* from random background *noise* by sequentially adding traces and dividing by the total number of traces.

axon reflex Use of term discouraged as it is incorrect. No *reflex* is thought to be involved. See preferred term, *A wave.*

axon response See preferred term, *A wave.*

axon wave See *A wave.*

axonal degeneration Degeneration of the segment of a nerve distal to the cell body with preferential distal pathology.

axonotmesis Nerve injury characterized by axon and myelin sheath disruption with supporting connective tissue preservation, resulting in *axonal degeneration* distal to the injury site. Compare *neurapraxia, neurotmesis.*

backaveraging *Averaging* a signal which occurs in a time epoch preceding a triggering event. Often used to extract a time-locked EEG signal preceding voluntary or involuntary movement, usually triggered by the onset of the *EMG* activity of the movement. An example is the *Bereitschaftspotential*.

backfiring *Discharge* of an *antidromically* activated motor neuron.

BAEP Abbreviation for *brainstem auditory evoked potential.*

BAER Abbreviation for *brainstem auditory evoked response*. See preferred term, *brain stem auditory evoked potential*.

baseline 1) The *potential* recorded from a biologic system while the system is at rest. 2) A flat trace on the recording instrument; an equivalent term, *isoelectric line,* may be used.

benign fasciculation potential A *firing pattern* of *fasciculation potentials* occurring in association with a clinical syndrome of *fasciculations* in an individual with a nonprogressive neuromuscular disorder. Use of term discouraged.

BER Abbreviation for *brainstem auditory evoked responses.* See preferred term, *brainstem auditory evoked potentials.*

Bereitschaftspotential (BP) A component of the *movement-related cortical potential*. The slowly rising negativity in the EEG preceding voluntary movement. The German term means "readiness potential." Has two *phases* called BP1 and BP2 or BP and NS′ (negative slope). See *backaveraging.*

biphasic action potential An *action potential* with one *baseline* crossing, producing two *phases.*

biphasic end-plate activity See *end-plate activity (biphasic).*

***bipolar needle electrode** *Recording electrode* that measures *voltage* between two insulated wires cemented side-by-side in a steel cannula. The bare tips of the electrodes are flush with the level of the cannula which may serve as a ground.

bipolar stimulating electrode See *stimulating electrode*.

bizarre high-frequency discharge See preferred term, *complex repetitive discharge.*

bizarre repetitive discharge See preferred term, *complex repetitive discharge.*

bizarre repetitive potential See preferred term, *complex repetitive discharge.*

blink reflex See *blink responses.*

***blink responses** *Compound muscle action potentials* evoked from orbicularis oculi muscles as a result of brief electric or mechanical *stimuli* applied to the cutaneous area innervated by the supraorbital (or less commonly, the infraorbital) branch of the trigeminal nerve. Typically, there is an early compound muscle action potential (*R1 wave*) ipsilateral

*Illustration in Section II

to the stimulation site with a *latency* of about 10 ms and a bilateral late compound muscle action potential (*R2 wave*) with a latency of approximately 30 ms. Generally, only the R2 wave is associated with a visible *contraction* of the muscle. The configuration, *amplitude, duration,* and latency of the two components, along with the sites of recording and stimulation, should be specified. The Rl and R2 waves are oligosynaptic and polysynaptic brainstem *reflexes,* respectively. Together they are called the *blink reflex.* The afferent arc is provided by the sensory branches of the trigeminal nerve and the efferent arc is provided by facial nerve motor fibers.

blocking Term used in *single fiber electromyography* to describe dropout of one or more components of the *potential* during sequential firings. If more than one component drops out simultaneously it is described as concomitant blocking. Usually seen when *jitter* values exceed 80 to 100 μs. A sign of abnormal neuromuscular transmission, which may be due to primary *neuromuscular transmission disorders,* such as *myasthenia gravis* and other myasthenic syndromes. Also seen as a result of degeneration and reinnervation in *neuropathies* or *myopathies*. Concomitant blocking may be generated by a split muscle fiber or failure of conduction at an axon branch serving several muscle fibers.

BP Abbreviation for *Bereitschaftspotential.*

brachial plexus An anatomical structure which is formed by the spinal roots from C5 to T1, traverses the shoulder region, and culminates in the named peripheral nerves in the arm. It is composed of roots, trunks, divisions, cords, and terminal nerves.

bradykinesia Slowness of movement, often observed in patients with Parkinson's disease. Often used synonymously with *akinesia.*

***brainstem auditory evoked potential (BAEP)** Electric *waveforms* of biologic origin elicited in response to sound stimuli. Normally consists of a sequence of up to seven waves, designated I to VII, which occur during the first 10 ms after the onset of the *stimulus* and have positive polarity at the vertex of the head.

brainstem auditory evoked response (BAER, BER) See preferred term, *brainstem auditory evoked potentials.*

BSAP Abbreviation for brief, small, abundant potentials. (See *BSAPP*). Use of term is discouraged.

BSAPP Abbreviation for brief, small, abundant, polyphasic *potentials.* Used to describe a *recruitment pattern* of brief *duration*, small *amplitude*, overly abundant, polyphasic *motor unit action potentials*, with respect to the amount of force generated; usually a minimal *contraction.* Use of term discouraged. Quantitative measurements of motor unit action potential duration, amplitude, numbers of *phases,* and *recruitment frequency* are preferred. See *motor unit action potential.*

carpal tunnel syndrome A *mononeuropathy* affecting the median nerve at the wrist. As the nerve passes through the carpal tunnel, a space bounded dorsally by the bones of the wrist, laterally by the forearm flexor tendons, and volarly by the transverse carpal ligament, it is subject to compression by any of these structures. Repetitive hand and wrist movement is thought to contribute to the compression.

C reflex An abnormal *reflex response* representing the electrophysiologic correlate of sensory evoked *myoclonus*. The term "C" was chosen to indicate that the reflex might be mediated in the cerebral cortex. This is sometimes, but not always, true.

c/s (also cps) Abbreviation for *cycles per second.* See preferred term, *Hertz (Hz)*.

cathode The negative terminal of an electric current source. See *stimulating electrode.*

center frequency The mean or median *frequency* of a *waveform* decomposed by *frequency analysis.* Employed in the study of muscle *fatigue.*

central electromyography Use of electrodiagnostic recording techniques to study *reflexes* and the control of movement by the spinal cord and brain. See *electrodiagnosis.*

central motor conduction The time taken for conduction of *action potentials* in the central nervous system from motor cortex to alpha motoneurons in the spinal cord or brainstem. Calculated from the *latencies* of the *motor evoked potentials* produced by *transcranial magnetic stimulation* or *transcranial electrical stimulation,* subtracting the time for peripheral conduction.

chorea Clinical term used to describe irregular, random, brief, abrupt, involuntary movements of the head or limbs due to a disorder of the basal ganglia. Most commonly observed in patients with Huntington's disease and Sydenham's chorea.

chronaxie (also chronaxy) See *strength-duration curve.*

chronic inflammatory demyelinating polyradiculoneuropathy (CIDP) A *polyneuropathy* or *polyradiculoneuropathy* characterized by generalized *demyelination* of the peripheral nervous system. In most cases there is also a component of *axonal degeneration*. Some cases are associated with a monoclonal gammopathy of undetermined significance (MGUS). Distinguish from *acute inflammatory neuropathy*.

clinical electromyography Term used commonly to describe the scientific methods of recording and analysis of biologic electrical *potentials* from human peripheral nerve and muscle. See preferred term, *electrodiagnostic medicine.*

CMAP Abbreviation for *compound muscle action potential*.

coaxial needle electrode See synonym, *concentric needle electrode*.

*Illustration in Section II

collision When used with reference to *nerve conduction studies,* the interaction of two *action potentials* propagated toward each other from opposite directions on the same nerve fiber so that the *refractory periods* of the two potentials prevent propagation past each other.

complex motor unit action potential A *motor unit action potential* that is polyphasic or serrated. See preferred terms, *polyphasic action potential* or *serrated action potential.*

***complex repetitive discharge** A type of *spontaneous* activity. Consists of a regularly repeating series of complex polyphasic or serrated *potentials* that begin abruptly after *needle electrode* movement or spontaneously. The potentials have a uniform shape, *amplitude*, and *discharge frequency* ranging from 5 to 100 *Hz*. The discharge typically terminates abruptly. May be seen in both myopathic and neurogenic disorders, usually chronic. Thought to be due to ephaptic excitation of adjacent muscle fibers in a cyclic fashion. This term is preferred to *bizarre high frequency discharge, bizarre repetitive discharge, bizarre repetitive potential, pseudomyotonic discharge,* and *synchronized fibrillation.* See also *ephapse and ephaptic transmission.*

compound action potential A *potential* or *waveform* resulting from the summation of multiple individual axon or *muscle fiber action potentials.* See *compound mixed nerve action potential, compound motor nerve action potential, compound nerve action potential, compound sensory nerve action potential,* and *compound muscle action potential.*

compound mixed nerve action potential A *compound nerve action potential* recorded from a *mixed nerve* when an electric *stimulus* is applied to a segment of the nerve that contains both afferent and efferent fibers. The *amplitude, latency, duration,* and *phases* should be noted.

compound motor nerve action potential (compound motor NAP) A *compound nerve action potential* recorded from efferent fibers of a *motor nerve* or a motor branch of a *mixed nerve.* Elicited by stimulation of a motor nerve, a motor branch of a mixed nerve, or a ventral nerve root. The *amplitude, latency, duration,* and number of *phases* should be noted. Distinguish from *compound muscle action potential.*

compound muscle action potential (CMAP) The summation of nearly synchronous *muscle fiber action potentials* recorded from a muscle, commonly produced by stimulation of the nerve supplying the muscle either directly or indirectly. *Baseline*-to-peak *amplitude, duration,* and *latency* of the negative *phase* should be noted, along with details of the method of stimulation and recording. Use of specific named *potentials* is recommended, e.g., *M wave, F wave, H wave, T wave, A wave,* and *R1 or R2 wave (blink responses).*

compound nerve action potential (compound NAP) The summation of nearly synchronous *nerve fiber action potentials* recorded from a nerve trunk, commonly produced by stimulation of the nerve directly or indirectly. Details of the method of stimulation and recording should be specified, together with the fiber type *(sensory, motor,* or *mixed nerve).*

***compound sensory nerve action potential (compound SNAP)** A *compound nerve action potential* recorded from the afferent fibers of a *sensory nerve,* a sensory branch of a *mixed nerve* or in response to stimulation of a sensory nerve or a dorsal nerve root. May also be elicited when an adequate *stimulus* is applied synchronously to sensory receptors. The *amplitude, latency, duration,* and configuration should be noted. Generally, the amplitude is measured as the maximum peak-to-peak *voltage* when there is an initial positive deflection or from *baseline*-to-peak when there is an initial negative deflection. The latency is measured as either the time to the initial deflection or the negative peak, and the duration as the interval from the first deflection of the *waveform* from the baseline to its final return to the baseline. Also referred to by the less preferred terms *sensory response, sensory potential,* or *SNAP.*

***concentric needle electrode** *Recording electrode* that measures an electric *potential* difference between a centrally insulated wire and the cannula of the needle through which it runs.

conditioning stimulus See *paired stimuli.*

conduction block Failure of an *action potential* to propagate past a particular point in the nervous system whereas conduction is possible below the point of the block. Documented by demonstration of a reduction in the area of a *compound muscle action potential* greater than that normally seen with stimulation at two different points on a nerve trunk; anatomic variations of nerve pathways and technical factors related to nerve stimulation must be excluded as the cause of the reduction in area.

conduction distance The length of nerve or muscle over which conduction is determined, customarily measured in centimeters or millimeters.

conduction time See *conduction velocity.*

conduction velocity (CV) Speed of propagation of an *action potential* along a nerve or muscle fiber. The nerve fibers studied (motor, sensory, autonomic, or *mixed nerve*) should be specified. For a nerve trunk, the maximum conduction velocity is calculated from the *latency* of the *evoked potential* (muscle or nerve) at maximal or supramaximal intensity of stimulation at two different points. The distance between the two points (*conduction distance*) is divided by the difference between the corresponding latencies (*conduction time*). The calculated result is the conduction velocity of the fastest fibers

*Illustration in Section II

and is usually expressed as meters per second (m/s). As commonly used, refers to the *maximum conduction velocity.* By specialized techniques, the conduction velocity of other fibers can also be determined and should be specified, e.g., *minimum conduction velocity.*

congenital myasthenia A heterogeneous group of genetic disorders of the neuromuscular junction manifest by muscle weakness and *fatigue.*

contraction A voluntary or involuntary reversible muscle shortening that may or may not be accompanied by *action potentials* from muscle. Contrast the term *contracture*.

contraction fasciculation Clinical term for visible twitching of a muscle with weak voluntary or postural *contraction* which has the appearance of a *fasciculation.* More likely to occur in neuromuscular disorders in which the *motor unit* territory is enlarged and the tissue covering the muscle is thin, but may also be observed in normal individuals.

contracture 1) Fixed resistance to stretch of a shortened muscle due to fibrous connective tissue changes and loss of sarcomeres in the muscle. Limited movement of a joint may be due to muscle contracture or to fibrous connective tissue changes in the joint. Contrast with *contraction,* which is a rapidly reversible painless shortening of the muscle. 2) The prolonged, painful, electrically silent, and involuntary state of temporary muscle shortening seen in some *myopathies* (e.g. muscle phosphorylase deficiency).

coupled discharge See preferred term, *satellite potential.*

cps (also c/s) Abbreviation for *cycles per second.* See preferred term, *Hertz (Hz)*.

***cramp discharge** Involuntary repetitive firing of *motor unit action potentials* at a high *frequency* (up to 150 *Hz*) in a large area of a muscle usually associated with painful muscle *contraction*. Both *discharge frequency* and number of motor unit action potentials activated increase gradually during development, and both subside gradually with cessation. See *muscle cramp.*

crossed leg palsy Synonym for *peroneal neuropathy at the knee*.

cross talk 1) A general term for abnormal communication between excitable membranes. See *ephapse* and *ephaptic transmission.* 2) Term used in *kinesiologic EMG* for signals picked up from adjacent muscles.

cubital tunnel syndrome A *mononeuropathy* involving the ulnar nerve in the region of the elbow. An *entrapment neuropathy* caused by compression of the nerve as it passes through the aponeurosis (the cubital tunnel) of the two heads of the flexor carpi ulnaris approximately 1.5 to 3.5 cm distal to the medial epicondyle of the elbow. The mechanism of entrapment is presumably narrowing of the cubital tunnel during elbow flexion. See also *tardy ulnar palsy* and *ulnar neuropathy at the elbow*.

cutaneous reflex A *reflex* produced by cutaneous stimulation. There are several *phases* to cutaneous reflexes, and, if the muscle has a background *contraction*, the phases can be seen to be inhibitory as well as excitatory.

CV Abbreviation for *conduction velocity*.

cycles per second (c/s, cps) Unit of *frequency*. See preferred term *hertz* (*Hz*).

decomposition EMG Synonym for *automatic decomposition EMG.*

decremental response See preferred term, *decrementing response*.

***decrementing response** A reproducible decline in the *amplitude* and/or area of the *M wave* of successive *responses* to *repetitive nerve stimulation*. The rate of stimulation and the total number of stimuli should be specified. Decrementing responses with disorders of neuromuscular transmission are most reliably seen with slow rates (2 to 5 *Hz*) of nerve stimulation. A decrementing response with *repetitive nerve stimulation* commonly occurs in disorders of neuromuscular transmission, but can also be seen in some *neuropathies, myopathies,* and *motor neuron disease.* An *artifact* resembling a decrementing response can result from movement of the *stimulating* or *recording electrodes* during *repetitive nerve stimulation* (see *pseudodecrement*). Contrast with *incrementing response*.

delay 1) The time between the beginning of the horizontal sweep of the oscilloscope and the onset of an applied *stimulus.* 2) A synonym for an information storage device *(delay line)* used to display events occurring before a trigger signal.

delay line An information storage device used to display events which occur before a trigger signal. A method for displaying a *waveform* at the same point on a sweep from a free-running *electromyogram.*

demyelination Disease process affecting the myelin sheath of central or peripheral nerve fibers, manifested by *conduction velocity* slowing, *conduction block,* or both.

denervation potential Sometimes used as a synonym for *fibrillation potential.* Use of this term is discouraged, since fibrillation potentials can occur in the absence of denervation. See preferred term, *fibrillation potential.*

depolarization A change in the existing membrane *potential* to a less negative value. Depolarizing an excitable cell from its resting level to *threshold* typically generates an *action potential*.

depolarization block Failure of an excitable cell to respond to a *stimulus* due to pre-existing *depolarization* of the cell membrane.

depth electrodes *Electrodes* which are inserted into the substance of the brain for electrophysiological

*Illustration in Section II

recording. Most often inserted using stereotactic techniques.

dermatomal somatosensory evoked potential (DSEP) Scalp recorded *waveforms* generated from repeated stimulation of a specific dermatome. Different from typical *somatosensory evoked potentials* which are recorded in response to stimulation of a named peripheral nerve.

discharge The firing of one or more excitable elements (neurons, axons, or muscle fibers); as conventionally used, refers to all-or-none *potentials* only. Synonymous with *action potential.*

discharge frequency The rate at which a *potential* discharges repetitively. When potentials occur in groups, the rate of recurrence of the group and rate of repetition of the individual components in the groups should be specified. See also *firing rate.*

discrete activity See *interference pattern.*

distal latency The interval between the delivery of a *stimulus* to the most distal point of stimulation on a nerve and the onset of a *response.* A measure of the conduction properties of the distal most portion of motor or sensory nerves. See *motor latency* and *sensory latency.*

double discharge Two sequential firings of a *motor unit action potential* of the same form and nearly the same *amplitude,* occurring consistently in the same relationship to one another at intervals of 2 to 20 ms. See also *multiple discharge, triple discharge*.

doublet Synonym for the preferred term, *double discharge.*

DSEP Abbreviation for *dermatomal somatosensory evoked potential*.

duration The time during which something exists or acts. 1) The interval from the beginning of the first deflection from the *baseline* to its final return to the baseline of an *action potential* or *waveform,* unless otherwise specified. If only part of the waveform is measured, the points of the measurement should be specified. For example, the duration of the *M wave* may be measured as the negative *phase* duration and refers to the interval from the deflection of the first negative phase from the baseline to its return to the baseline. 2) The interval of the applied current or *voltage* of a single electric *stimulus.* 3) The interval from the beginning to the end of a series of recurring stimuli or action potentials.

dynamic EMG See *kinesiologic EMG.*

dyskinesia An abnormal involuntary movement of a *choreic* or *dystonic* type. The term is nonspecific and is often used in association with a modifier that describes its etiology, e.g. tardive dyskinesia or L-DOPA dyskinesia.

dystonia A disorder characterized by involuntary movements caused by sustained muscle *contraction*, producing prolonged movements or abnormal postures.

E-1 Synonymous with *input terminal 1*. See *recording electrode*.

E-2 Synonymous with *input terminal 2*. See *recording electrode*.

E:I ratio In autonomic testing, the ratio of the longest electrocardiographic R-R interval during expiration to the shortest during inspiration. Primarily a measure of parasympathetic control of heart rate.

early recruitment A *recruitment pattern* which occurs in association with a reduction in the number of muscle fibers per *motor unit* or when the force generated by the fibers is reduced. At low levels of muscle *contraction* more *motor unit action potentials* are recorded than expected, and a *full interference pattern* may be recorded at relatively low levels of muscle contraction. Most often encountered in *myopathy*.

earth electrode Synonymous with *ground electrode*.

EDX Abbreviation for *electrodiagnosis*. Can also be used for electrodiagnostic and *electrodiagnostic medicine.*

electric inactivity See preferred term, *electric silence.*

electric silence The absence of measurable electric activity due to biologic or nonbiologic sources. The sensitivity and signal-to-*noise* level of the recording system should be specified.

electrocorticography Electrophysiologic recording directly from the surface of the brain. In the intraoperative setting, recordings are made of ongoing spontaneous electroencephalogram activity, or *potentials* evoked by stimulation of peripheral sensory pathways.

electrode A conducting device used to record an electric *potential* (*recording electrode*) or to deliver an electric current (*stimulating electrode*). In addition to the *ground electrode* used in clinical recordings, two electrodes are always required either to record an electric potential or to deliver a *stimulus.* See *ground electrode, recording electrode,* and *stimulating electrode*. Also see specific *needle electrode* configurations: *monopolar, unipolar, concentric, bifilar recording, bipolar stimulating, multilead, single fiber,* and *macro-EMG needle electrodes*.

electrodiagnosis (EDX) The scientific methods of recording and analyzing biologic electrical *potentials* from the central, peripheral, and autonomic nervous systems and muscles. See also *clinical electromyography, electromyography, electroneurography, electroneuromyography, evoked potentials, electrodiagnostic medicine, electrodiagnostic medicine consultation,* and *electrodiagnostic medicine consultant.*

electrodiagnostic medicine A specific area of medical practice in which a physician integrates information obtained from the clinical history, observations from physical examination, and scientific data acquired by recording electrical *potentials* from the

*Illustration in Section II

nervous system and muscle to diagnose, or diagnose and treat diseases of the central, peripheral, and autonomic nervous systems, neuromuscular junctions, and muscle. See also *electrodiagnosis, electrodiagnostic medicine consultation,* and *electrodiagnostic medicine consultant.*

electrodiagnostic medicine consultant A physician specially trained to obtain a medical history, perform a physical examination, and to record and analyze data acquired by recording electrical *potentials* from the nervous system and muscle to diagnose and/or treat diseases of the central, peripheral, and autonomic nervous systems, neuromuscular junction, and muscle. See also *electrodiagnosis, electrodiagnostic medicine,* and *electrodiagnostic medicine consultation.*

electrodiagnostic medicine consultation The medical evaluation in which a specially trained physician (*electrodiagnostic medicine consultant*) obtains a medical history, performs a physical examination, and integrates scientific data acquired by recording electrical *potentials* from the nervous system and muscle to diagnose and/or treat diseases of the central, peripheral, and autonomic nervous systems, neuromuscular junction, and muscle. See also *electrodiagnosis, electrodiagnostic medicine,* and *electrodiagnostic medicine consultant.*

electromyogram The record obtained by *electromyography.*

electromyograph Equipment used to activate, record, process, and display electrical *potentials* for the purpose of evaluating the function of the central, peripheral, and autonomic nervous systems, neuromuscular junction, and muscles.

electromyographer See preferred term, *electrodiagnostic medicine consultant.*

electromyography (EMG) Strictly defined, the recording and study of *insertion, spontaneous,* and *voluntary activity* of muscle with a *recording electrode* (either a *needle electrode* for invasive *EMG* or a *surface electrode* for kinesiologic studies). The term is also commonly used to refer to an *electrodiagnostic medicine consultation,* but its use in this context is discouraged.

electroneurography (ENG) The recording and study of the *action potentials* of peripheral nerve. Synonymous with *nerve conduction studies.*

electroneuromyography (ENMG) The combined studies of *electromyography* and *electroneurography.* Synonymous with *clinical electromyography.* See preferred term *electrodiagnostic medicine consultation.*

EMG Abbreviation for *electromyography.*

***end-plate activity** Spontaneous electric activity recorded with a *needle electrode* close to muscle end plates. These *potentials* may have several different morphologies.

1. Monophasic: Low-*amplitude* (10 to 20 μV), short-*duration* (0.5 to 1.0 ms), negative potentials occurring in a dense, steady pattern, the exact *frequency* of which cannot be defined. These nonpropagated potentials are probably *miniature end-plate potentials* recorded extracellularly. Referred to as *end-plate noise* or *sea-shell sound (sea shell roar or noise).*
2. Biphasic: Moderate-amplitude (100 to 300 μV), short-duration (2 to 4 ms), initially negative *spike* potentials occurring irregularly in short bursts with a high frequency (50 to 100 *Hz*). These propagated potentials are generated by muscle fibers excited by activity in nerve terminals. These potentials have been referred to as biphasic spike potentials, *end-plate spikes,* and, incorrectly, *nerve potentials.* May also have a biphasic initially positive morphology.
3. Triphasic: Similar to biphasic potentials, but the *waveforms* have three *phases* with an initial positive deflection. Fire in an irregular fashion; contrast with *fibrillation potential*.

end-plate noise See *end-plate activity (monophasic).*

end-plate potential (EPP) The graded nonpropagated membrane potential induced in the postsynaptic membrane of a muscle fiber by release of acetylcholine from the presynaptic axon terminal in response to an *action potential*.

end-plate spike See *end-plate activity (biphasic).*

end-plate zone The region in a muscle where neuromuscular junctions are concentrated.

ENG Abbreviation for *electroneurography.*

ENMG Abbreviation for *electroneuromyography.*

entrapment neuropathy A *mononeuropathy* caused by compression of a nerve as it passes through an area of anatomical narrowing.

ephapse A point of abnormal communication where an *action potential* in one muscle fiber or axon can cause *depolarization* of an adjacent muscle fiber or axon to generate an action potential.

ephaptic transmission The generation of a *nerve fiber action potential* from one muscle fiber or axon to another through an *ephapse.* Postulated to be the basis for *complex repetitive discharges, myokymic discharges,* and *hemifacial spasm.*

EPSP Abbreviation for *excitatory postsynaptic potential.*

Erb's point The site at the anterolateral base of the neck where percutaneous nerve stimulation activates the axons comprising the upper trunk of the *brachial plexus.*

Erb's point stimulation Percutaneous *supraclavicular nerve stimulation* during which the upper trunk of the *brachial plexus* is activated. See the more general and preferred term, *supraclavicular nerve stimulation*.

*Illustration in Section II

evoked potential Electric *waveform* elicited by and temporally related to a *stimulus,* most commonly an electric stimulus delivered to a sensory receptor or nerve, or applied directly to a discrete area of the brain, spinal cord, or muscle. See *auditory evoked potential, brainstem auditory evoked potential, spinal evoked potential, somatosensory evoked potential, visual evoked potential, compound muscle action potential,* and *compound sensory nerve action potential.*

evoked potential studies Recording and analysis of electric *waveforms* of biologic origin elicited in response to electrical, magnetic, or physiological *stimuli.* Stimuli are applied to specific motor or sensory receptors, and the resulting waveforms are recorded along their anatomic pathways in the peripheral and central nervous system. A single motor or sensory modality is typically tested in a study, and the modality studied is used to define the type of study performed. See *auditory evoked potentials, brainstem auditory evoked potentials, visual evoked potentials,* and *somatosensory evoked potentials.*

evoked response Tautology. Use of term discouraged. See preferred term, *evoked potential.*

excitability Capacity to be activated by or react to a *stimulus.*

excitatory postsynaptic potential (EPSP) A local, graded *depolarization* of a neuron in response to *activation* by a nerve terminal. Contrast with *inhibitory postsynaptic potential.*

exploring electrode Synonymous with *active electrode.* See *recording electrode.*

F reflex An incorrect term for *F wave.*

F response Synonymous with *F wave*. See preferred term, *F wave.*

***F wave** An *action potential* evoked intermittently from a muscle by a supramaximal electric *stimulus* to the nerve due to *antidromic activation* of *motor neurons.* When compared with the maximal *amplitude* of the *M wave,* it is smaller (1 to 5% of the M wave) and has a variable configuration. Its *latency* is longer than the M wave and is variable. It can be evoked in many muscles of the upper and lower extremities, and the latency is longer with more distal sites of stimulation. Named "F" wave by Magladery and McDougal in 1950, because it was first recorded from foot muscles. Compare with the *H wave* and the *A wave.* One of the *late responses.*

facial neuropathy Clinical diagnosis of facial weakness or paralysis due to pathology affecting the seventh cranial nerve (facial nerve). Bell's palsy refers to a facial *neuropathy* due to inflammation of the facial nerve.

***facilitation** An increase in an electrically measured *response* following identical *stimuli.* Occurs in a variety of circumstances: 1) Improvement of neuromuscular transmission resulting in *activation* of previously inactive muscle fibers. May be identified in several ways: *Incrementing response*–a reproducible increase in the *amplitude* and area of successive *M waves* during *repetitive nerve stimulation. Postactivation* or *posttetanic facilitation*– Nerve stimulation studies performed within a few seconds after a brief period (2 to 60 s) of nerve stimulation producing *tetanus* or after a strong voluntary *contraction* may show changes in the configuration of the M wave(s) compared to the results of identical studies of the rested muscle as follows: a) *repair of the decrement*–A diminution of the *decrementing response* with slow rates (2 to 5 *Hz*) of repetitive nerve stimulation; b) increment after exercise– an increase in the amplitude and area of the M wave elicited by a single supramaximal stimulus. Distinguish from *pseudofacilitation,* which occurs in normal individuals in response to repetitive nerve stimulation at high rates (20 to 50 Hz) or after strong volitional contraction. It probably reflects a reduction in the *temporal dispersion* of the summation of a constant number of *muscle fiber action potentials* and is characterized by an increase in the amplitude of the successive M waves with a corresponding decrease in their *duration.* There is no net change in the area of the negative *phase* of successive M waves. 2) An increase in the amplitude of the *motor evoked potential* as a result of background muscle activation.

far-field A region of electrical *potential* where the isopotential *voltage* lines associated with a current source change slowly over a short distance. Some use the term far-field potential to designate a potential that does not change in *latency, amplitude,* or polarity over infinite distances; alternative designations include "boundary potential" and "junctional potential." The terms *near-field* and far-field are arbitrary designations as there are no agreed-upon criteria defining where the near-field ends and the far-field begins. Compare with *near-field.*

fasciculation The random, spontaneous twitching of a group of muscle fibers belonging to a single *motor unit.* The twitch may produce movement of the overlying skin (if in limb or trunk muscles) or mucous membrane (if in the tongue). If the motor unit is sufficiently large, an associated joint movement may be observed. The electric activity associated with the twitch is termed a *fasciculation potential.* See also *myokymia.* Historically, the term *fibrillation* was used incorrectly to describe fine twitching of muscle fibers visible through the skin or mucous membranes. This usage is no longer accepted.

***fasciculation potential** The electric activity associated with a *fasciculation* which has the configuration of a *motor unit activation potential* but which occurs spontaneously. Most commonly occur sporadically and are termed "single fasciculation

*Illustration in Section II

potentials." Occasionally the potentials occur as a *grouped discharge* and are termed a "brief *repetitive discharge*." The repetitive firing of adjacent fasciculation potentials, when numerous, may produce an undulating movement of muscle (see *myokymia*). Use of the terms *benign fasciculation* and *malignant fasciculation* is discouraged. Instead, the configuration of the *potentials,* peak-to-peak *amplitude, duration,* number of *phases,* stability of configuration, and *frequency* of occurrence, should be specified.

fatigue A state of depressed responsiveness resulting from activity. Muscle fatigue is a reduction in *contraction* force following repeated voluntary contraction or electric stimulation.

fiber density 1) Anatomically, a measure of the number of muscle or nerve fibers per unit area. 2) In *single fiber electromyography,* the mean number of *muscle fiber action potentials* fulfilling *amplitude* and *rise time* criteria belonging to one *motor unit* within the recording area of a *single fiber needle electrode* encountered during a systematic search in a weakly, voluntarily contracting muscle. See also *single fiber electromyography, single fiber needle electrode.*

fibrillation The spontaneous *contractions* of individual muscle fibers which are not visible through the skin. This term has been used loosely in *electromyography* for the preferred term, *fibrillation potential.*

***fibrillation potential** The *action potential* of a single muscle fiber occurring spontaneously or after movement of a *needle electrode.* Usually fires at a constant rate. Consists of biphasic or triphasic *spikes* of short *duration* (usually less than 5 ms) with an initial positive *phase* and a peak-to-peak *amplitude* of less than 1 mV. May also have a biphasic, initially negative phase when recorded at the site of initiation. It has an associated high-pitched regular sound described as "rain on a tin roof." In addition to this classic form, *positive sharp waves* may also be recorded from fibrillating muscle fibers when the potential arises from an area immediately adjacent to the needle electrode.

firing pattern Qualitative and quantitative descriptions of the sequence of *discharge* of electric *waveforms* recorded from muscle or nerve.

firing rate *Frequency* of repetition of a *potential.* The relationship of the frequency to the occurrence of other potentials and the force of muscle *contraction* may be described. See also *discharge frequency.*

flexor reflex A *reflex* produced by a noxious cutaneous *stimulus,* or a train of electrical stimuli, that activates the flexor muscles of a limb and thus acts to withdraw it from the stimulus. In humans, it is well-characterized only in the lower extremity.

frequency Number of complete cycles of a repetitive *waveform* in 1 second. Measured in *hertz* (*Hz*) or *cycles per second* (*cps* or c/s).

frequency analysis Determination of the range of *frequencies* composing a *waveform,* with a measurement of the absolute or relative *amplitude* of each component frequency.

full interference pattern See *interference pattern.*

***full wave rectified EMG** The absolute value of a *raw EMG* signal. Involves inverting all the *waveforms* below the *isopotential line* and displaying them with opposite polarity above the line. A technique used to analyze *kinesiologic EMG* signals.

functional refractory period See *refractory period.*

G1, G2 Abbreviation for *grid 1* and *grid 2.*

generator In *volume conduction* theory, the source of electrical activity, such as an *action potential.* See *far-field* and *near-field.*

"giant" motor unit action potential Use of term discouraged. Refers to a *motor unit action potential* with a peak-to-peak *amplitude* and *duration* much greater than the range found in corresponding muscles in normal subjects of similar age. Quantitative measurements of amplitude and duration are preferable.

giant somatosensory evoked potential Enlarged *somatosensory evoked potentials* seen as a characteristic of cortical *reflex myoclonus* and reflecting cortical hyperexcitability.

grid 1 Synonymous with *G1, input terminal 1 (E-1),* or *active* or *exploring electrode.* Use of the term *G1* is discouraged. See *recording electrode.*

grid 2 Synonymous with *G2, input terminal 2 (E-2),* or *reference electrode.* Use of the term *Grid 2* is discouraged. See *recording electrode.*

ground electrode A connection from the patient to earth. Used as a common return for an electric circuit and as an arbitrary zero *potential* reference point.

grouped discharge Term used historically to describe three phenomena: (1) irregular, voluntary grouping of *motor unit action potentials* as seen in a tremulous muscular *contraction,* (2) involuntary grouping of motor unit action potentials as seen in *myokymia,* (3) general term to describe repeated firing of motor unit action potentials. See preferred term, *repetitive discharge.*

Guillain-Barré syndrome Eponym for *acute inflammatory neuropathy*. Also referred to as Landry-Guillain-Barré syndrome or Landry-Guillain-Barré-Strohl syndrome.

H reflex Abbreviation for Hoffmann reflex. See *H wave.*

H response See preferred term *H wave.*

***H wave** A *compound muscle action potential* with a consistent *latency* recorded from muscles after stimulation of the nerve. Regularly found in adults only in a limited group of physiologic extensors, particularly the calf muscles. Compared to the *M*

*Illustration in Section II

wave of the same muscle, has a longer latency and thus is one of the *late responses* (see *A* and *F wave*). Most reliably elicited with a *stimulus* of long *duration* (500 to 1000 μs). A stimulus intensity sufficient to elicit a maximal amplitude M wave reduces or abolishes the H wave. Thought to be due to a spinal *reflex,* with electric stimulation of afferent fibers in the *mixed nerve* and *activation* of motor neurons to the muscle mainly through a monosynaptic connection in the spinal cord. The latency is longer with more distal sites of stimulation. The reflex and *wave* are named in honor of Hoffman's description (l918). Compare the *F wave* and *A wave*.

habituation Decrease in size of a *reflex motor response* to an afferent *stimulus* when the latter is repeated, especially at regular and recurring short intervals.

hemifacial spasm Clinical condition characterized by frequent, repetitive, unilateral, involuntary *contractions* of the facial muscles. Electrodiagnostic studies demonstrate brief *discharges* of groups of *motor unit action potentials* occurring simultaneously in several facial muscles. Occasionally high *frequency* discharges occur.

hertz (Hz) Unit of *frequency.* Synonymous with *cycles per second*.

Hoffmann reflex See *H wave.*

hyperekplexia Clinical condition characterized by exaggerated *startle reflexes.* Startle reflexes can be exaggerated by being more extreme than expected (larger *amplitude* or more widespread) or by lack of normal *habituation* to repeated similar *stimuli.* Can be either genetic or acquired.

hyperpolarization A change in the existing membrane *potential* to a more negative value.

hypertonia See *tone.*

hypotonia See *tone.*

Hz Abbreviation for *hertz.*

impulse blocking See *blocking.*

inching A *nerve conduction study* technique consisting of applying stimuli at multiple short distance increments along the course of a nerve. This technique is used to localize an area of focal slowing or *conduction block.*

incomplete activation *Motor unit action potentials* firing, on requested maximal effort, in decreased numbers at their normal physiological rates, within the basal firing range of 5 to 10 *Hz*. Causes include *upper motor neuron syndrome*, pain on muscle *contraction,* hysteria/conversion reaction and malingering. Contrast with *reduced recruitment*.

increased insertion activity See *insertion activity.*

increment after exercise See *facilitation.*

incremental response See preferred term, *incrementing response.*

***incrementing response** A reproducible increase in *amplitude* and/or area of successive *M waves* to *repetitive nerve stimulation.* The rate of stimulation and the number of *stimuli* should be specified. Commonly seen in two situations. First, in normal subjects the configuration of the M wave may change in response to repetitive nerve stimulation so that the amplitude progressively increases as the *duration* decreases, leaving the area of the M wave unchanged. This phenomenon is termed *pseudofacilitation.* Second, in *neuromuscular transmission disorders,* the configuration of the M wave may change with repetitive nerve stimulation so that the amplitude and the area of the M wave progressively increase. This phenomenon is termed *facilitation.* Contrast with *decrementing response.*

indifferent electrode Synonymous with *reference electrode.* Use of term discouraged. See *recording electrode.*

infraclavicular plexus Segments of the *brachial plexus* inferior to the divisions; includes the three cords and the terminal peripheral nerves. This clinically descriptive term is based on the fact that the clavicle overlies the divisions of the brachial plexus when the arm is in the anatomic position next to the body.

inhibitory postsynaptic potential (IPSP) A local graded *hyperpolarization* of a neuron in response to *activation* at a synapse by a nerve terminal. Contrast with *excitatory postsynaptic potential.*

injury potential 1) The *potential* difference between a normal region of the surface of a nerve or muscle and a membrane region that has been injured; also called a "demarcation," or "killed end" potential. Approximates the potential across the membrane because the injured surface has nearly the same potential as the interior of the cell. 2) In *electrodiagnostic medicine,* the term is also used to refer to the electrical activity associated with *needle electrode* insertion into muscle. See preferred terms *fibrillation potential, insertion activity,* and *positive sharp wave.*

input terminal 1 The input terminal of a differential amplifier at which negativity, relative to the other input terminal, produces an upward deflection. Synonymous with *active* or *exploring electrode, E-1* or less preferred term, *grid 1.* See *recording electrode*.

input terminal 2 The input of a differential amplifier at which negativity, relative to the other input terminal, produces a downward deflection. Synonymous with *reference electrode, E-2* or less preferred term, *grid 2*. See *recording electrode.*

***insertion activity** Electric activity caused by insertion or movement of a *needle electrode* within a muscle. The amount of the activity may be described as normal, reduced, or increased (prolonged), with a description of the *waveform* and repetition rate. See also *fibrillation potential* and *positive sharp wave.*

integrated EMG Mathematical integration of the *full wave rectified EMG* signal. Reflects the cumulative

*Illustration in Section II

EMG activity of a muscle over time. See also *linear envelope EMG.*

interdischarge interval Time between consecutive *discharges* of the same *potential.* Measurements should be made between the corresponding points on each *waveform.*

interference Unwanted electric activity recorded from the surrounding environment.

***interference pattern** Electric activity recorded from a muscle with a *needle electrode* during maximal voluntary effort. A full interference pattern implies that no individual *motor unit action potentials* can be clearly identified. A reduced interference pattern (intermediate pattern) is one in which some of the individual motor unit action potentials may be identified while others cannot due to superimposition of *waveforms.* The term *discrete activity* is used to describe the electric activity recorded when each of several different motor unit action potentials can be identified in an ongoing recording due to limited superimposition of waveforms. The term *single unit pattern* is used to describe a single motor unit action potential, firing at a rapid rate (should be specified) during maximum voluntary effort. The force of *contraction* associated with the interference pattern should be specified. See also *early recruitment, recruitment pattern, reduced recruitment pattern.*

interference pattern analysis Quantitative analysis of the *interference pattern.* This can be done either in the *frequency* domain using fast Fourier transformation (FFT) or in the time domain. Can be done using a fixed load (e.g. 2 kg), at a given proportional strength (e.g. 30% of maximum) or at random strengths. The following are measured in the time domain: a) the number of *turns* per second and b) the *amplitude,* defined as the mean amplitude between peaks.

intermediate interference pattern See *interference pattern.*

international 10-20 system A system of *electrode* placement on the scalp in which electrodes are placed either 10% or 20% of the total distance on a line on the skull between the nasion and inion in the sagittal plane and between the right and left preauricular points in the coronal plane.

interpeak interval Difference between the peak *latencies* of two components of a *waveform.*

interpotential interval Time between two different *potentials.* Measurement should be made between the corresponding parts of each *waveform.*

intraoperative monitoring The use of electrophysiological stimulating and recording techniques in an operating room setting. The term is usually applied to techniques which are used to detect injury to nervous tissue during surgery or to guide the surgical procedure.

involuntary activity *Motor unit action potentials* that are not under volitional control. The condition under which they occur should be described, e.g., spontaneous or *reflex* potentials. If elicited by a *stimulus,* its nature should be described. Contrast with *spontaneous activity.*

IPSP Abbreviation for *inhibitory postsynaptic potential.*

irregular potential See preferred term, *serrated action potential.*

isoelectric line In electrophysiologic recording, the display of zero *potential* difference between the two input terminals of the recording apparatus. See *baseline.*

iterative discharge See preferred term, *repetitive discharge.*

jiggle Shape variability of *motor unit action potentials* recorded with a conventional *EMG needle electrode.* A small amount occurs normally. In conditions of disturbed neuromuscular transmission, including early reinnervation and myasthenic disorders, the variability can be sufficiently large to be easily detectable by eye. Quantitative methods for estimating this variability are not yet widely available.

***jitter** The variability of consecutive *discharges* of the *interpotential interval* between two *muscle fiber action potentials* belonging to the same *motor unit.* Usually expressed quantitatively as the mean value of the difference between the interpotential intervals of successive discharges (the *mean consecutive difference, MCD*). Under certain conditions, it is expressed as the mean value of the difference between interpotential intervals arranged in the order of decreasing interdischarge intervals (the *mean sorted difference, MSD*). See *single fiber electromyography.*

Jolly Test A technique named for Friedrich Jolly, who applied an electric current to excite a *motor nerve* repetitively while recording the force of muscle *contraction.* Use of the term is discouraged. Inappropriately used to describe the technique of *repetitive nerve stimulation.*

kinematics Technique for description of body movement without regard to the underlying forces. See *kinesiologic EMG.*

kinesiologic EMG The muscle electrical activity recorded during movement. Gives information about the timing of muscle activity and its relative intensity. Either *surface electrodes* or intramuscular fine *wire electrodes* are used. Synonymous with *dynamic EMG.*

kinesiology The study of movement. See *kinesiologic EMG.*

kinetics The internal and external forces affecting the moving body. See *kinesiologic EMG.*

late component (of a motor unit action potential) See preferred term, *satellite potential.*

*Illustration in Section II

late response A general term used to describe an *evoked potential* in motor *nerve conduction studies* having a longer *latency* than the *M wave.* Examples include *A wave, F wave,* and *H wave.*

latency Interval between a *stimulus* and a *response.* The *onset latency* is the interval between the onset of a stimulus and the onset of the *evoked potential.* The *peak latency* is the interval between the onset of a stimulus and a specified peak of the evoked potential.

latency of activation The time required for an electric *stimulus* to depolarize a nerve fiber (or bundle of fibers as in a nerve trunk) beyond *threshold* and to initiate an *action potential* in the fiber(s). This time is usually of the order of 0.1 ms or less. An equivalent term, now rarely used, is the "utilization time."

latent period See preferred term, *latency.*

linear envelope EMG Moving average of the *full wave rectified EMG.* Obtained by low pass filtering the full wave rectified EMG. See also *integrated EMG*.

linked potential See preferred term, *satellite potential.*

lipoatrophy Pathologic loss of subcutaneous fat and connective tissues overlying muscle which mimics the clinical appearance of atrophy of the underlying muscle.

long-latency reflex A *reflex* with many synapses (polysynaptic) or a long pathway (long-loop) so that the time to its occurrence is greater than the time of occurrence of *short-latency reflexes.* See also *long-loop reflex.*

long-loop reflex A *reflex* thought to have a circuit that extends above the spinal segment of the sensory input and motor output. May involve the cerebral cortex. Should be differentiated from reflexes arising from stimulation and recording within a single or adjacent spinal segments (i.e., a segmental reflex). See also *long-latency reflex.*

M response See preferred term, *M wave.*

***M wave** A *compound muscle action potential* evoked from a muscle by an electric *stimulus* to its *motor nerve.* By convention, the M wave elicited by a supramaximal *stimulus* is used for motor *nerve conduction studies.* Ideally, the *recording electrodes* should be placed so that the initial deflection of the *evoked potential* from the *baseline* is negative. Common measurements include *latency, amplitude,* and *duration.* Also referred to as the *motor response.* Normally, the configuration is biphasic and stable with repeated stimuli at slow rates (1 to 5 *Hz*). See *repetitive nerve stimulation.*

macro motor unit action potential The average electric activity of that part of an anatomic *motor unit* that is within the recording range of a *macro-EMG electrode.* Characterized by consistent appearance when the small recording surface of the macro-EMG electrode is positioned to record *action potentials* from one muscle fiber. The following characteristics can be specified quantitatively: (1) maximal peak-to-peak *amplitude,* (2) area contained under the *waveform,* (3) number of *phases.*

macro MUAP Abbreviation for *macro motor unit action potential.*

***macroelectromyography (macro-EMG)** General term referring to the technique and conditions that approximate recording of all *muscle fiber action potentials* arising from the same *motor unit.* See *macro motor unit action potential.*

macro-EMG Abbreviation for *macroelectromyography.*

***macro-EMG needle electrode** A modified *single fiber electromyography* electrode insulated to within 15 mm from the tip and with a small recording surface (25 μm in diameter) 7.5 mm from the tip.

malignant fasciculation Used to describe large, polyphasic *fasciculation potentials* firing at a slow rate. This pattern has been seen in progressive *motor neuron disease,* but the relationship is not exclusive. Use of this term is discouraged. See *fasciculation potential.*

maximal stimulus See *stimulus.*

maximum conduction velocity See *conduction velocity.*

MCD Abbreviation for *mean consecutive difference*. See *jitter.*

mean consecutive difference (MCD) See *jitter.*

mean sorted difference (MSD) See *jitter.*

membrane instability Tendency of a cell membrane to depolarize spontaneously in response to mechanical irritation or following voluntary *activation.* May be used to describe the occurrence of spontaneous single *muscle fiber action potentials* such as *fibrillation potentials* during *needle electrode* examination.

MEP Abbreviation for *motor evoked potential.*

MEPP Abbreviation for *miniature end-plate potential*.

microneurography The technique of recording peripheral nerve *action potentials* in humans by means of intraneural *electrodes.*

miniature end-plate potential (MEPP) The postsynaptic muscle fiber *potentials* produced through the spontaneous release of individual acetylcholine quanta from the presynaptic axon terminal. As recorded with *monopolar* or *concentric needle electrodes* inserted in the end-plate region, MEPPs are monophasic, negative, short *duration* (less than 5 ms), and generally less than 20 μV in *amplitude.*

minimum conduction velocity The *nerve conduction velocity* measured from slowly conducting nerve fibers. Special techniques are needed to produce this measurement in *motor* or *sensory nerves.*

mixed nerve A nerve composed of both motor and sensory axons.

MNCV Abbreviation for *motor nerve conduction velocity*. See *conduction velocity.*

mononeuritis multiplex A disorder characterized by axonal injury and/or *demyelination* affecting nerve

*Illustration in Section II

fibers in multiple nerves (multiple *mononeuropathies*). Usually occurs in an asymmetric anatomic distribution and in a temporal sequence which is not patterned or symmetric.

mononeuropathy multiplex A disorder characterized by axonal injury and/or *demyelination* affecting nerve fibers exclusively along the course of one named nerve.

monophasic action potential An *action potential* with the *waveform* entirely on one side of the *baseline.*

monophasic end-plate activity See *end-plate activity (monophasic).*

***monopolar needle electrode** A solid wire *electrode* coated with Teflon™, except at the tip. Despite the term monopolar, a separate surface or subcutaneous reference electrode is required for recording electric signals. May also be used as a *cathode* in *nerve conduction studies* with another electrode serving as an *anode.*

motor evoked potential (MEP) A *compound muscle action potential* produced by either *transcranial magnetic stimulation* or *transcranial electrical stimulation*.

motor latency Interval between the onset of a *stimulus* and the onset of the resultant *compound muscle action potential (M wave)*. The term may be qualified, as proximal motor latency or *distal motor latency,* depending on the relative position of the stimulus.

motor nerve A nerve containing axons which innervate extrafusal and intrafusal muscle fibers. These nerves also contain sensory afferent fibers from muscle and other deep structures.

motor nerve conduction velocity (MNCV) The speed of propagation of *action potentials* along a *motor nerve.* See *conduction velocity.*

motor neuron disease A clinical condition characterized by degeneration of *motor nerve* cells in the brain, brain stem, and spinal cord. The location of degeneration determines the clinical presentation. Primary lateral sclerosis occurs when degeneration affects mainly corticospinal tract motor fibers. Spinal muscular atrophy occurs when degeneration affects lower motor neurons. Amyotrophic lateral sclerosis occurs when degeneration affects both corticospinal tracts and lower motor neurons.

motor point The site over a muscle where its *contraction* may be elicited by a minimal intensity short *duration* electric *stimulus.*

motor response 1) The *compound muscle action potential* (*M wave*) recorded over a muscle in response to stimulation of the nerve to the muscle. 2) The muscle twitch or *contraction* elicited by stimulation of the nerve to a muscle. 3) The muscle twitch elicited by the *muscle stretch reflex.*

motor unit The anatomic element consisting of an anterior horn cell, its axon, the neuromuscular junctions, and all of the muscle fibers innervated by the axon.

***motor unit action potential (MUAP)** The *compound action potential* of a single *motor unit* whose muscle fibers lie within the recording range of an *electrode.* With voluntary muscle *contraction*, it is characterized by its consistent appearance and relationship to the force of the contraction. The following measures may be specified, quantitatively if possible, after the *recording electrode* is placed randomly within the muscle:

1. Configuration
   a. *Amplitude*, peak-to-peak (μV or mV).
   b. *Duration*, total (ms).
   c. Number of *phases* (monophasic, biphasic, triphasic, tetraphasic, polyphasic).
   d. Polarity of each phase (negative, positive).
   e. Number of *turns.*
   f. Variation of shape (*jiggle*), if any, with consecutive *discharges.*
   g. Presence of *satellite (linked) potentials,* if any.
   h. *Spike* duration, including satellites.
2. *Recruitment* characteristics
   a. *Threshold* of *activation* (first recruited, low threshold, high threshold).
   b. *Onset frequency.*
   c. *Recruitment frequency (Hz)* or *recruitment interval* (ms) of individual potentials.

Descriptive terms implying diagnostic significance are not recommended, e.g. *myopathic, neuropathic, regeneration, nascent, giant, BSAP* and *BSAPP.* See *polyphasic action potential, serrated action potential.*

motor unit fraction See *scanning EMG.*

motor unit number counting See the preferred term *motor unit number estimate (MUNE).*

motor unit number estimate (MUNE) A quantitative technique for determining the number of functioning *motor units* in a muscle. A variety of methods, including *spike*-triggered *averaging,* incremental *motor nerve* stimulation, *F-wave* measurement, or a Poisson statistical technique can be used. Synonyms can include *motor unit number estimation* and *motor unit number estimating.*

motor unit number estimating (MUNE) See *motor unit number estimate (MUNE).*

motor unit number estimation (MUNE) See *motor unit number estimate (MUNE).*

motor unit potential (MUP) See synonym, *motor unit action potential.*

motor unit territory The area of a muscle cross-section within which the muscle fibers belonging to an individual *motor unit* are distributed.

movement artifact See *artifact.*

movement-related cortical potential Electroencephalogram activity associated with (before and after) a voluntary movement. There are several components including the *Bereitschaftspotential*

*Illustration in Section II

before the movement and the motor potential at about the time of the movement. See also *Bereitschaftspotential*.

MSD Abbreviation for *mean sorted difference.* See *jitter.*

MUAP Abbreviation for *motor unit action potential.*

multi MUP analysis A *template matching, decomposition EMG* method used for *MUAP* analysis.

multielectrode See *multilead electrode.*

multifocal motor neuropathy A disease characterized by selective focal block of *motor nerve* conduction in multiple nerves. Motor *nerve conduction studies* may permit identification and localization of the segments of nerve affected by the underlying pathology.

multilead electrode Three or more insulated wires inserted through apertures in a common metal cannula with their bared tips flush with the cannula's outer circumference. The arrangement of the bare tips relative to the axis of the cannula and the distance between each tip should be specified. See *electrode.*

multiple discharge Four or more *motor unit action potentials* of the same form and nearly the same *amplitude* occurring consistently in the same relationship to one another and generated by the same axon. See *double* and *triple discharge.*

multiplet See *multiple discharge.*

MUNE Abbreviation for *motor unit number estimate, motor unit number estimation,* and *motor unit number estimating*.

MUP Abbreviation for *motor unit potential.* See preferred term, *motor unit action potential.*

muscle action potential Term commonly used to refer to a *compound muscle action potential.*

muscle atrophy Decrease in size of a muscle that may be due to disease of nerve or muscle, or to disuse.

muscle cramp An involuntary, painful muscle *contraction* associated with electrical activity. *Cramp discharges* are most common, but other types of *repetitive discharges* can also be seen.

muscle fiber action potential *Action potential* recorded from a single muscle fiber.

muscle fiber conduction velocity The speed of propagation of a single *muscle fiber action potential,* usually expressed as meters per second. Usually less than most *nerve conduction velocities,* varies with the rate of *discharge* of the muscle fiber, and requires special techniques for measurement.

muscle hypertrophy Increase in the size of a muscle due to an increase in the size of the muscle fibers or replacement or displacement of muscle fibers by other tissues. The latter is also referred to by the term *pseudohypertrophy*, because the muscle is enlarged but weak. Muscle fibers increase in size as a physiologic *response* to repetitive and forceful voluntary *contraction* or as a pathologic response to involuntary electric activity in a muscle, for example, *myotonic discharges* or *complex repetitive discharges.*

muscle stretch reflex *Activation* of a muscle which follows stretch of the muscle, e.g. by percussion of a muscle tendon. See *stretch reflex, T wave.*

muscle tone See *tone.*

myasthenia gravis A disease characterized by muscle weakness which increases with repetitive muscle *activation.* Most commonly, an autoimmune disease caused by the presence of antibodies to the acetylcholine receptors at the neuromuscular junction.

myoclonus A quick jerk of a body part produced by a brief muscle *contraction* typically originating from activity in the central nervous system. Based on the anatomic location of the pathology, may be classified as spinal, segmental, brainstem, or cortical.

myoedema Focal muscle *contraction* produced by muscle percussion. Not associated with propagated electric activity. May be seen in hypothyroidism (myxedema) and chronic malnutrition.

myokymia Continuous quivering or undulating movement of surface and overlying skin and mucous membrane associated with spontaneous, *repetitive discharge* of *motor unit action potentials.* See *myokymic discharge, fasciculation,* and *fasciculation potential.*

***myokymic discharge** A form of *involuntary activity* in which *motor unit action potentials* fire repetitively and may be associated with clinical *myokymia.* Two firing patterns have been described: (1) Commonly, the *discharge* is a brief, repetitive firing of single motor unit action potentials for a short period (up to a few seconds) at a uniform rate (2 to 60 *Hz*) followed by a short period (up to a few seconds) of silence, with repetition of the same sequence for a particular potential at regular intervals. (2) Rarely, the potential recurs continuously at a fairly uniform *firing rate* (1 to 5 Hz). Myokymic discharges are a subclass of *grouped discharges* and *repetitive discharges.* See also *ephapse* and *ephaptic transmission.*

myopathic motor unit potential Low *amplitude*, short *duration*, polyphasic *motor unit action potentials.* Use of term discouraged. It incorrectly implies specific diagnostic significance of a motor unit action potential configuration. See *motor unit action potential.*

myopathic recruitment Used to describe an increase in the number and *firing rate* of *motor unit action potentials* compared with normal for the strength of muscle *contraction*. Use of term discouraged.

myopathy Disorder affecting the structure and/or function of muscle fibers. Etiologies include hereditary, congenital, mitochondrial, inflammatory, metabolic, infectious, neoplastic, vascular, and traumatic diseases. Most, but not all of these disorders, show abnormalities on needle *electromyography.*

*Illustration in Section II

myotonia Delayed relaxation of a muscle after voluntary *contraction* or percussion. Associated with propagated electric activity, such as *myotonic discharges, complex repetitive discharges* or *neuromyotonic discharges.*

***myotonic discharge** *Repetitive discharge* which occurs at rates of 20 to 80 *Hz*. There are two types: 1) biphasic (positive-negative) *spike potentials* less than 5 ms in *duration* resembling *fibrillation potentials.* 2) *positive waves* of 5 to 20 ms duration resembling *positive sharp waves.* Both potential forms are recorded after *needle electrode* insertion, after voluntary muscle *contraction* or after muscle percussion, and are due to independent, repetitive discharges of single muscle fibers. The *amplitude* and *frequency* of the potentials must both wax and wane. This change produces a characteristic musical sound in the audio output of the *electromyograph* due to the corresponding change in pitch, which has been likened to the sound of a "dive bomber." Contrast with *waning discharge.*

myotonic potential See preferred term, *myotonic discharge.*

NAP Abbreviation for *nerve action potential*. See *compound nerve action potential.*

nascent motor unit potential From the Latin nascens, "to be born." Refers to very low *amplitude*, short *duration*, highly polyphasic *motor unit action potentials* observed during early states of reinnervation. Use of term is discouraged, as it incorrectly implies diagnostic significance of a motor unit action potential configuration. See *motor unit action potential.*

NCS Abbreviation for *nerve conduction study.*

NCV Abbreviation for *nerve conduction velocity*. See *conduction velocity.*

near-field A region of electrical activity where the isopotential *voltage* lines associated with a current source change rapidly over a short distance. The terms near-field and *far-field* are arbitrary designations, as there are no agreed-upon criteria defining where the near-field ends and the far-field begins. Compare with *far-field.*

***needle electrode** An electrical device used for recording or stimulating that is positioned near the tissue of interest by penetration of the skin. See specific electrodes: *bifilar (bipolar) needle recording electrode, concentric needle electrode, macro-EMG needle electrode, monopolar needle electrode, multilead electrode, single fiber needle electrode,* and *stimulating electrode.*

nerve action potential (NAP) Strictly defined, refers to an *action potential* recorded from a single nerve fiber. The term is commonly used to refer to the *compound nerve action potential.* See *compound nerve action potential.*

nerve conduction study (NCS) Recording and analysis of electric *waveforms* of biologic origin elicited in response to electric or physiologic *stimuli.* The waveforms are *compound sensory nerve action potentials, compound muscle action potentials,* or *mixed nerve action potentials.* The compound muscle action potentials are generally referred to by letters which have historical origin: *M wave, F wave, H wave, T wave, A wave,* and *R1, R2 waves.* It is possible under standardized conditions to establish normal ranges for *amplitude, duration,* and *latency* of the waveforms and to calculate the maximum *conduction velocity* of *sensory* and *motor nerves.* The term generally refers to studies of waveforms generated in the peripheral nervous system, whereas *evoked potential studies* refers to studies of waveforms generated in both the peripheral and central nervous systems. Synonymous with *electroneurography.*

nerve conduction velocity (NCV) The speed of *action potential* propagation along a nerve fiber or nerve trunk. Generally assumed to refer to the maximum speed of propagation unless otherwise specified. See *conduction velocity.*

nerve fiber action potential *Action potential* recorded from a single axon.

nerve potential Equivalent to *nerve action potential*. Also commonly, but inaccurately, used to refer to the biphasic form of *end-plate activity* observed during *needle electrode* examination of muscle. The latter use is incorrect, because muscle fibers, not nerve fibers, are the source of these *potentials.*

nerve trunk action potential See preferred term, *compound nerve action potential.*

neurapraxia Clinical term used to describe the reversible motor and sensory deficits produced by focal compressive or traction lesions of large myelinated nerve fibers. It is due to *conduction block,* most often caused by focal *demyelination,* but, when very short lived, presumably caused by focal ischemia. The axon is not injured at the lesion site. Compare with *axonotmesis* and *neurotmesis.*

neuromuscular transmission disorder Clinical disorder associated with pathology affecting the structure and function of the neuromuscular junction and interfering with synaptic transmission at that site. Specific diseases include *myasthenia gravis,* Lambert-Eaton myasthenic syndrome, and botulism.

neuromyopathy Clinical disorder associated with pathology affecting both nerve and muscle fibers.

neuromyotonia Clinical syndrome of continuous muscle fiber activity manifested as continuous muscle rippling and stiffness. It may be associated with delayed relaxation following voluntary muscle *contraction.* The accompanying electric activity may be intermittent or continuous. Terms used to describe related clinical syndromes are continuous muscle fiber activity syndrome, Isaac syndrome, Isaac-

*Illustration in Section II

Merton syndrome, quantal squander syndrome, generalized *myokymia*, pseudomyotonia, normocalcemic *tetany* and neurotonia. Distinguish from *myotonia.*

***neuromyotonic discharge** Bursts of *motor unit action potentials* that fire at high rates (150 to 300 *Hz*) for a few seconds, often starting or stopping abruptly. The *amplitude* of the *waveforms* typically wanes. *Discharges* may occur spontaneously or be initiated by *needle electrode* movement, voluntary effort, ischemia, or percussion of a nerve. The activity originates in motor axons. Distinguish from *myotonic discharges* and *complex repetitive discharges.* One type of electrical activity recorded in patients who have clinical *neuromyotonia.*

neuropathic motor unit potential Abnormally high-*amplitude,* long-*duration,* polyphasic *motor unit action potential*. Use of term discouraged. Incorrectly implies a specific diagnostic significance of a motor unit action potential configuration. See *motor unit action potential.*

neuropathic recruitment A *recruitment* pattern characterized by a decreased number of *motor unit action potentials* firing at a rapid rate. Use of term discouraged. See preferred terms, *reduced interference pattern, discrete activity, single unit pattern.*

neuropathy Disorder of the peripheral nerves. May be classified by the anatomical structure of the nerve most affected by the disease: cell body (neuronopathy), the axon (axonopathy) or the myelin sheath (demyelinating neuropathy). May selectively affect *motor* or *sensory nerves* or both simultaneously. The etiology may be hereditary, metabolic, inflammatory, toxic, or unknown.

neurotmesis Partial or complete nerve severance including the axons, associated myelin sheaths, and supporting connective tissues, resulting in *axonal degeneration* distal to the injury site. Compare with *axonotmesis, neurapraxia.*

neurotonic discharges Repetitive *motor unit action potentials* recorded from intramuscular *electrodes* during *intraoperative monitoring.* Thought to arise from irritation or injury of nerves supplying the muscle from which the recording is made.

noise Electric activity not related to the signal of interest. In *electrodiagnostic medicine*, *waveforms* generated by *electrodes,* cables, amplifier, or storage media and unrelated to potentials of biologic origin. The term has also been used loosely to refer to one form of *end-plate activity.*

onset frequency The lowest stable *firing rate* for a single *motor unit action potential* that can be voluntarily maintained by a subject.

order of activation The sequence of appearance of different *motor unit action potentials* with increasing strength of voluntary *contraction.* See *recruitment.*

orthodromic Propagation of a nerve impulse in the same direction as physiologic conduction; e.g. conduction along *motor nerve* fibers towards the muscle and conduction along *sensory nerve* fibers towards the spinal cord. Contrast with *antidromic.*

paired stimuli Two consecutive stimuli delivered in a time-locked fashion. The time interval between the two stimuli and the intensity of each *stimulus* can be varied but should be specified. The first stimulus is called the *conditioning stimulus* and the second stimulus is the *test stimulus.* The conditioning stimulus may modify tissue *excitability,* which is then evaluated by the *response* to the test stimulus.

parasite potential See preferred term, *satellite potential.*

peak latency Interval between the onset of a *stimulus* and a specified peak of an evoked *waveform.*

peroneal neuropathy at the knee A *mononeuropathy* involving the common peroneal nerve as it passes around the head of the fibula. The presumed mechanism is compression of the nerve against the fibula. See also *crossed leg palsy*.

phase That portion of a *waveform* between the departure from, and the return to, the *baseline.*

plexopathy Axonal and/or demyelinating disorder affecting the nerve fibers exclusive to the cervical, brachial, lumbar, or sacral rearrangement of spinal nerve roots into peripheral nerves.

polarization The presence of an electric *potential* difference usually across an excitable cell membrane.

polyneuropathy Axonal and/or demyelinating disorder affecting nerve fibers, usually in a symmetrical fashion. The distal segments of the longer nerves in the lower extremities are usually the most severely affected. May be classified as sensory, motor, or sensorimotor depending on the function of nerve fibers affected.

polyphasic action potential An *action potential* with four or more *baseline* crossings, producing five or more *phases.* See *phase.* Contrast with *serrated action potential.*

polyradiculoneuropathy See *radiculopathy.*

***positive sharp wave** A biphasic, positive then negative *action potential* of a single muscle fiber. It is initiated by *needle electrode* movement (insertional or unsustained positive sharp wave) or occurs spontaneously. Typically *discharge* in a uniform, regular pattern at a rate of 1 to 50 *Hz;* the discharge *frequency* may decrease slightly just before cessation of discharge. The initial positive deflection is rapid (<1 ms), its *duration* is usually less than 5 ms, and the *amplitude* is up to 1 mV. The negative *phase* is of low amplitude, and its duration is 10 to 100 ms. A sequence of positive sharp waves is commonly referred to as a *train of positive sharp waves.* Assumed to be recorded from a damaged area of a muscle fiber. This configuration may result from the position of the needle electrode which is believed to be adjacent to the depolarized segment

*Illustration in Section II

of a muscle fiber injured by the electrode. Note that the positive sharp *waveform* is not specific for muscle fiber damage. May occur in association with *fibrillation potentials* and are thought by some to be equivalent discharges. *Motor unit action potentials* and potentials in *myotonic discharges* may have the configuration of positive sharp waves.

positive wave Loosely defined, the term refers to a *positive sharp wave*. See preferred term *positive sharp wave.*

postactivation The period following voluntary *activation* of a nerve or muscle. Contrast with *posttetanic.*

***postactivation depression** A reduction in the *amplitude* and area of the *M wave(s)* in response to a single *stimulus* or *train of stimuli* which occurs within a few minutes following a 10 to 60 second strong voluntary *contraction. Postactivation exhaustion* refers to the cellular mechanisms responsible for the observed phenomenon of postactivation depression. Also used to describe reduction of the M wave following a *tetanus,* which should more logically be termed *posttetanic depression*.

postactivation exhaustion A reduction in the safety factor (margin) of neuromuscular transmission after sustained *activation* at the neuromuscular junction. The changes in the configuration of the *M wave* due to postactivation exhaustion are referred to as *postactivation depression.*

postactivation facilitation See *facilitation.*

postactivation potentiation An increase in the force of *contraction* (mechanical *response*) after a strong voluntary contraction. Contrast *postactivation facilitation.*

posttetanic The period following *tetanus.* Contrast with *postactivation.*

posttetanic depression See *postactivation depression*.

posttetanic facilitation See *facilitation, potentiation.*

posttetanic potentiation 1) The incrementing mechanical *response* of muscle during and after *repetitive nerve stimulation.* 2) In central nervous system physiology, enhancement of *excitability* or *reflex* outflow of neuronal systems following a long period of high-*frequency* stimulation. See *facilitation, potentiation.*

potential 1) A difference in charges, measurable in volts, that exists between two points. Most biologically produced potentials arise from the difference in charge between two sides of a cell membrane. 2) A term for a physiologically recorded *waveform.*

potentiation Physiologically, the enhancement of a *response*. The convention used in this glossary is to use the term *potentiation* to describe the incrementing mechanical response of muscle elicited by *repetitive nerve stimulation*, e.g., *posttetanic potentiation*, whereas the term *facilitation* is used to describe the incrementing electrical response elicited by *repetitive nerve stimulation*, e.g., *postactivation facilitation*.

prolonged insertion activity See *insertion activity.*

propagation velocity of a muscle fiber The speed of transmission of a *muscle fiber action potential*.

pseudodecrement An *artifact* produced by movement of the *stimulating* or *recording electrodes* during *repetitive nerve stimulation*. The *amplitude* and area of the *M wave* can vary in a way that resembles a *decrementing response*, however the *responses* are generally irregular and not reproducible.

***pseudofacilitation** See *facilitation.*

pseudohypertrophy See *muscle hypertrophy.*

pseudomyotonic discharge Formerly used to describe *complex repetitive discharges.* Use of term discouraged.

pseudopolyphasic action potential Use of term discouraged. See preferred term, *serrated action potential.*

QEMG Abbreviation for *quantitative electromyography.*

QSART Abbreviation for *quantitative sudomotor axon reflex test.*

QST Abbreviation for *quantitative sensory testing.*

quantitative electromyography (QEMG) A systematic method for measuring the recordings made by an intramuscular *needle electrode.* Measurements include *motor unit action potential* characteristics such as *amplitude, duration,* and *phases,* or *interference pattern* characteristics. See *turns and amplitude analysis.*

quantitative sensory testing (QST) An instrumented method for measuring cutaneous sensation.

quantitative sudomotor axon reflex test (QSART) Test of post-ganglionic sympathetic sudomotor axons function by measuring sweat output following *activation* of axon terminals by local application of acetylcholine. *Antidromic* transmission of the impulse from the nerve terminals reaches a branch point, then travels *orthodromically* to release acetylcholine from the nerve terminals, inducing a sweating *response.* In small fiber *polyneuropathy*, the response may be reduced or absent. In painful *neuropathies,* and in *reflex* sympathetic dystrophy, the response may be excessive and persistent or reduced.

R1, R2 waves See *blink responses.*

radiculopathy Axonal and/or demyelinating disorder affecting the nerve fibers exclusive to one spinal nerve root or spinal nerve. May affect the anterior (motor) or posterior (sensory) spinal nerve roots, or both, at one spinal cord segment level. The resulting clinical syndrome may include pain, sensory loss, parethesia, weakness, *fasciculations,* and *muscle atrophy.* If more than one spinal root is involved, the term *polyradiculopathy* may be used as a descriptor.

*Illustration in Section II

raster A method for display of a free-running sweep in *electromyography.* Sweeps are off-set vertically so that each successive sweep is displayed below the one preceding it.

raw EMG Unprocessed *EMG* signal recorded with surface or intramuscular *electrodes.*

reciprocal inhibition Inhibition of a motor neuron pool secondary to the *activation* of the motor neuron pool of its antagonist. It is one of several important spinal mechanisms of motor control that help to make movements smoother and utilize less energy. There are multiple mechanisms for reciprocal inhibition, including one mediated by the Ia inhibitory interneuron that activates Ia afferents and disynaptically inhibits the muscle that is antagonist to the source of the Ia afferents.

recording electrode Device used to record electric *potential* difference. All electric recordings require two *electrodes.* The electrode close to the source of the activity to be recorded is called the *active* or *exploring electrode,* and the other recording electrode is called the *reference electrode.* Active electrode is synonymous with *input terminal 1*, or *E-1* (or older terms whose use is discouraged, *grid 1,* and *G1*). Reference electrode is synonymous with *input terminal 2*, or *E-2* (or older terms whose use is discouraged *grid 2,* and *G2).* In some recordings it is not certain which electrode is closer to the source of the biologic activity, e.g. recording with a *bifilar needle recording electrode,* or when attempting to define *far-field* potentials. In this situation, it is convenient to refer to one electrode as input electrode 1, or E-1, and the other as input electrode 2, or E-2. By present convention, a potential difference that is negative at the active electrode (input terminal 1, E-1) relative to the reference electrode (input terminal 2, E-2) causes an upward deflection on the display screen. The term "monopolar recording" is not recommended, because all recordings require two electrodes; however, it is commonly used to describe the use of one type of intramuscular *needle electrode*. A similar combination of needle electrodes has been used to record nerve activity and also has been referred to as "monopolar recording."

recruitment The successive *activation* of the same and additional *motor units* with increasing strength of voluntary muscle *contraction*. See *motor unit action potential.*

recruitment frequency *Firing rate* of a *motor unit action potential (MUAP)* when a different MUAP first appears during gradually increasing voluntary muscle *contraction.* This parameter is essential to assessment of *recruitment pattern.*

recruitment interval The *interdischarge interval* between two consecutive *discharges* of a *motor unit action potential (MUAP)* when a different MUAP first appears during gradually increasing voluntary muscle *contraction.* The reciprocal of the recruitment interval is the *recruitment frequency.* See also *interdischarge interval.*

***recruitment pattern** A qualitative and/or quantitative description of the sequence of appearance of *motor unit action potentials* during increasing voluntary muscle *contraction.* The *recruitment frequency* and *recruitment interval* are two quantitative measures commonly used. See *interference pattern, early recruitment, reduced recruitment* for qualitative terms commonly used.

recurrent inhibition Decreased probability of firing of a motor neuron pool mediated by Renshaw cells. Renshaw cells are activated by recurrent collaterals from the axons of alpha-motoneurons. Such inhibition influences the same cells that originate the excitatory impulses and their neighbors.

reduced insertion activity See *insertion activity.*

reduced interference pattern See *interference pattern.*

reduced recruitment pattern A descriptive term for the *interference pattern* when the number of *motor units* available to generate a muscle *contraction* are reduced. One cause for a *reduced interference pattern*. See *interference pattern, recruitment pattern*.

reference electrode See *recording electrode.*

reflex A stereotyped *motor response* elicited by a sensory *stimulus* and a *response.* Its anatomic pathway consists of an afferent, *sensory* input to the central nervous system, at least one synaptic connection, and an efferent output to an effector organ. The response is most commonly *motor*, but reflexes involving autonomic effector organs also occur. Examples include the *H reflex* and the sudomotor reflex. See *H wave*, *quantitative sudomotor axon reflex test.*

refractory period General term for the time following an *action potential* when an excitable membrane cannot be stimulated to produce another action potential. The *absolute refractory period* is the time following an action potential during which no *stimulus,* however strong, evokes a further *response.* The *relative refractory period* is the time following an action potential during which a stimulus must be abnormally large to evoke a second response. The *functional refractory period* is the time following an action potential during which a second action potential cannot yet excite the given region.

refractory period of transmission Interval following an *action potential* during which a nerve cannot conduct a second one. Distinguish from *refractory period*, as commonly used, which deals with the ability of a *stimulus* to produce an action potential.

regeneration motor unit potential Use of term discouraged. See *motor unit action potential.*

relative refractory period See *refractory period.*

***repair of the decrement** See *facilitation.*

repetitive discharge General term for the recurrence of an *action potential* with the same or nearly identi-

*Illustration in Section II

cal form. May refer to recurring potentials recorded in muscle at rest, during voluntary *contraction*, or in response to a single nerve *stimulus*. See *double discharge, triple discharge, multiple discharge, myokymic discharge, complex repetitive discharge, neuromyotonic discharge,* and *cramp discharge*.

***repetitive nerve stimulation** The technique of repeated *supramaximal stimulation* of a nerve while recording successive *M waves* from a muscle innervated by the nerve. Commonly used to assess the integrity of neuromuscular transmission. The number of *stimuli* and the *frequency* of stimulation should be specified. *Activation procedures* performed as a part of the test should be specified, e.g. sustained voluntary *contraction* or contraction induced by nerve stimulation. If the test includes an activation procedure, the time elapsed after its completion should also be specified. For a description of specific patterns of *responses,* see *incrementing response, decrementing response, facilitation,* and *postactivation depression*.

repolarization A return in membrane *potential* from a depolarized state toward the normal resting level.

residual latency The calculated time difference between the measured *distal latency* of a *motor nerve* and the expected latency, calculated by dividing the distance between the stimulating *cathode* and the active *recording electrode* by the maximum *conduction velocity* measured in a more proximal segment of the nerve. It is due in part to neuromuscular transmission time and to slowing of conduction velocity in terminal axons due to decreasing diameter and the presence of unmyelinated segments.

response An activity elicited by a *stimulus.*

resting membrane potential *Voltage* across the membrane of an excitable cell in the absence of a *stimulus*. See *polarization.*

rheobase See *strength-duration curve.*

rigidity A velocity independent increase in *muscle tone* and stiffness with full range of joint motion as interpreted by the clinical examiner from the physical examination. Often associated with simultaneous low-grade *contraction* of agonist and antagonist muscles. Like muscle *spasticity,* the involuntary *motor unit action potential* activity increases with activity or passive stretch. Does not seem to change with the velocity of stretch, and, on passive stretch, the increased tone has a "lead pipe" or constant quality. It is a cardinal feature of central nervous system disorders affecting the basal ganglia. Contrast with *spasticity.*

rise time The interval from the onset of a polarity change of a *potential* to its peak. The method of measurement should be specified.

***satellite potential** A small *action potential* separated from the main *motor unit action potential* by an isoelectric interval which fires in a time-locked relationship to the main action potential. It usually follows, but may precede, the main action potential. Less preferred terms include *late component, parasite potential, linked potential,* and *coupled discharge.*

scanning EMG A technique by which a *needle electrode* is advanced in defined steps through muscle while a separate *SFEMG* electrode is used to trigger both the display sweep and the advancement device. Provides temporal and spatial information about the *motor unit*. Distinct maxima in the recorded activity are considered to be generated by muscle fibers innervated by a common branch of an axon. These groups of fibers form a *motor unit fraction*.

sea shell sound (sea shell roar or noise) Use of term discouraged. See *end-plate activity, monophasic.*

sensory latency Interval between the onset of a *stimulus* and the onset of the negative deflection of the *compound sensory nerve action potential.* This term has been used loosely to refer to the *sensory peak latency.* May be qualified as proximal sensory latency or distal sensory latency, depending on the relative position of the stimulus.

sensory nerve A nerve containing only sensory fibers, composed mainly of axons innervating cutaneous receptors.

sensory nerve action potential (SNAP) See *compound sensory nerve action potential.*

sensory nerve conduction velocity The speed of propagation of *action potentials* along a *sensory nerve.*

sensory peak latency Interval between the onset of a *stimulus* and the peak of the negative *phase* of the *compound sensory nerve action potential.* Contrast with *sensory latency.*

sensory potential Synonym for the more precise term, *compound sensory nerve action potential.*

sensory response Synonym for the more precise term, *compound sensory nerve action potential.*

SEP Abbreviation for *somatosensory evoked potential*.

serrated action potential A *waveform* with several changes in direction *(turns)* which do not cross the *baseline.* Most often used to describe a *motor unit action potential.* The term is preferred to *complex motor unit action potential* and *pseudopolyphasic action potential.* See also *turn* and *polyphasic action potential.*

SFEMG Abbreviation for *single fiber electromyography.*

shock artifact See *artifact.*

short-latency reflex A *reflex* with one (monosynaptic) or few (oligosynaptic) synapses. Used in contrast to *long-latency reflex.*

***short-latency somatosensory evoked potential (SSEP)** That portion of the *waveforms* of a *somatosensory evoked potential* normally occurring within 25 ms after stimulation of the median nerve in the upper extremity at the wrist, 40 ms

*Illustration in Section II

after stimulation of the common peroneal nerve in the lower extremity at the knee, and 50 ms after stimulation of the posterior tibial nerve at the ankle.

signal averager A digital device that improves the signal-to-*noise* ratio of an electrophysiological recording by adding successive time-locked recordings to preceding traces and computing the average value of each data point. A signal acquired by this method is described as an "averaged" *waveform.*

silent period A pause in the electric activity of a muscle that may be produced by many different *stimuli.* Stimuli used commonly in clinical neurophysiology include rapid unloading of a muscle, electrical stimulation of a peripheral nerve or *transcranial magnetic stimulation.*

***single fiber electromyography (SFEMG)** The technique and conditions that permit recording of single *muscle fiber action potentials.* See *single fiber needle electrode, blocking,* and *jitter.*

single fiber EMG See *single fiber electromyography.*

single fiber needle electrode A *needle electrode* with a small recording surface (usually 25 μm in diameter) which permits the recording of single *muscle fiber action potentials* between the recording surface and the cannula. See *single fiber electromyo-graphy*.

single unit pattern See *interference pattern.*

SNAP Abbreviation for *sensory nerve action potential.* See *compound sensory nerve action potential.*

snap, crackle, and pop A benign type of *increased insertion activity* that follows, after a very brief period of electrical silence, the normal *insertion activity* generated by *needle electrode* movement. It consists of trains of *potentials* that vary in length, however, they can persist for a few seconds. Each train consists of a series of up to 10 or more potentials in which the individual components fire at irregular intervals. The potentials consistently vary in *amplitude, duration,* and configuration. Individual potentials may be mono-, bi-, tri-, or multiphasic in appearance; they often have a positive *waveform*. The variation on sequential firings produces a distinctive sound, hence the name. See most often in those with mesomorphic builds, especially young adult males. Found most often in lower extremity muscles, especially the medial gastrocnemius.

somatosensory evoked potential (SEP) Electric *waveforms* of biologic origin elicited by electric stimulation or physiologic *activation* of peripheral *sensory nerves* and recorded from peripheral and central nervous system structures. Normally is a complex *waveform* with several components which are specified by polarity and average *peak latency*. The polarity and latency of individual components depend upon 1) subject variables, such as age, gender, and body habitus, 2) *stimulus* characteristics, such as intensity and rate of stimulation, and 3) recording parameters, such as amplifier time constants, *electrode* placement, and electrode combinations. See *short-latency somatosensory evoked potentials*.

spasticity A velocity-dependent increase in *muscle tone* due to a disease process that interrupts the suprasegmental tracts to the alpha motor neurons, gamma motor neurons, or segmental spinal neurons. May be elicited and interpreted by the clinical examiner during the physical examination by brisk passive movement of a limb at the joint. Almost uniformly accompanied by hyperreflexia, a Babinski sign, and other signs of upper motor neuron pathology, including clonus and the clasp-knife phenomenon. The clasp-knife phenomenon is a rapid decrease of tone following a period of increased tone during passive rotation of the joint. The pathophysiology is not certain and may include more than dysfunction of the corticospinal tracts.

spike 1) A short-lived (1 to 3 ms), all-or-none *waveform* that arises when an excitable membrane reaches *threshold.* 2) The electric record of a nerve or muscle impulse.

spinal evoked potential Electric *waveforms* of biologic origin recorded over the spine in response to electric stimulation or physiologic *activation* of peripheral sensory fibers. See preferred term, *somatosensory evoked potential*.

spontaneous activity Electric activity recorded from muscle at rest after *insertion activity* has subsided and when there is not voluntary *contraction* or an external *stimulus.* Compare with *involuntary activity.*

SSEP Abbreviation for *short-latency somatosensory evoked potential.*

staircase phenomenon The progressive increase in muscle *contraction* force observed in response to continued low rates of muscle *activation.*

startle (reflex) A *response* produced by an unanticipated *stimulus* that leads to alerting and protective movements such as eye lid closure and flexion of the limbs. Auditory stimuli are typically most efficacious.

stiffman syndrome A disorder characterized by continuous muscle *contraction* giving rise to severe stiffness. Axial muscles are typically affected most severely. Patients have difficulty moving. Walking and voluntary movements are slow. Sensory stimulation often induces severe spasms. *Electromyography* demonstrates continuous activity of *motor unit action potentials* in a normal pattern that cannot be silenced by contraction of the antagonist muscle. It is often associated with circulating antibodies to glutamic acid decarboxylase (GAD), and the resulting deficiency of GABA may play a role in its pathophysiology. Since women are affected in equal or greater numbers than men, the term *stiff-person syndrome* may be preferable.

*Illustration in Section II

stiffperson syndrome Synonym for *stiffman syndrome*.

stigmatic electrode A term of historic interest. Used by Sherrington for *active* or *exploring electrode.*

stimulated SFEMG See preferred term s*timulation SFEMG.*

stimulating electrode Device used to deliver electric current. All electric stimulation requires two *electrodes;* the negative terminal is termed the *cathode,* and the positive terminal is the *anode.* By convention, the stimulating electrodes are called *bipolar* if they are encased or attached together and are called *monopolar* if they are not. Electric stimulation for *nerve conduction studies* generally requires application of the cathode in the vicinity of the neural tissue to produce *depolarization.*

stimulation single fiber electromyography (stimulation SFEMG) Use of electrical stimulation instead of voluntary *activation* of *motor units* for the analysis of *single fiber electromyography*. The method is used in patients who are unable to produce a steady voluntary muscle *contraction*. The stimulation can be delivered to intramuscular axons, nerve trunks, or muscle fibers.

stimulus Any external agent, state or change that is capable of influencing the activity of a cell, tissue, or organism. In clinical *nerve conduction studies*, an electric stimulus is applied to a nerve. It may be described in absolute terms or with respect to the *evoked potential* of the nerve or muscle. In absolute terms, it is defined by a *duration* (ms), a *waveform* (square, exponential, linear, etc.), and a strength or intensity measured in *voltage* (V) or current (mA). With respect to the evoked potential, the stimulus may be graded as *subthreshold, threshold, submaximal, maximal,* or *supramaximal*. A threshold stimulus is one just sufficient to produce a detectable *response*. Stimuli less than the threshold stimulus are termed subthreshold. The maximal stimulus is the stimulus intensity after which a further increase in intensity causes no increase in the *amplitude* of the evoked potential. Stimuli of intensity below this level but above threshold are submaximal. Stimuli of intensity greater than the maximal stimulus are termed supramaximal. Ordinarily, supramaximal stimuli are used for nerve conduction studies. By convention, an electric stimulus of approximately 20% greater voltage/current than required for the maximal stimulus is used for supramaximal stimulation. The *frequency*, number and duration of a series of stimuli should be specified.

stimulus artifact See *artifact*.

strength-duration curve Graphic presentation of the relationship between the intensity (Y axis) and various *durations* (X axis) of the *threshold* electric *stimulus* of a nerve or muscle. The *rheobase* is the intensity of an electric current of infinite duration necessary to produce a minimal *action potential*. The *chronaxie* is the time required for an electric current twice the rheobase to elicit the first visible action potential. Measurement of the strength-duration curve is not a common practice in modern *electrodiagnostic medicine*.

stretch reflex A *reflex* produced by passive lengthening of a muscle. The principal sensory *stimuli* come from group Ia and group II muscle spindle afferents. It consists of several *phases.* The earliest component is monosynaptic and is also called the myotatic reflex, or tendon reflex. There are also long-*latency* stretch reflexes. See also *muscle stretch reflex, T wave*.

submaximal stimulus See *stimulus.*

subnormal period A time interval that immediately follows the *supernormal period* of nerve which is characterized by reduced *excitability* compared to the resting state. Its *duration* is variable and is related to the *refractory period*.

subthreshold stimulus See *stimulus.*

supernormal period A time interval that immediately follows the *refractory period* which corresponds to a very brief period of partial *depolarization*. It is characterized by increased nerve *excitability* and is followed by the *subnormal period*.

supraclavicular plexus That portion of the *brachial plexus* which is located superior to the clavicle.

supraclavicular stimulation Percutaneous nerve stimulation at the base of the neck which activates the upper, middle, and/or lower trunks of the *brachial plexus*. This term is preferred to *Erb's point stimulation*.

supramaximal stimulus See *stimulus.*

surface electrode Conducting device for stimulating or recording placed on the skin surface. The material (metal, fabric, etc.), configuration (disk, ring, etc.), size, and separation should be specified. See *electrode (ground, recording, stimulating).*

***sympathetic skin response** Electrical *potential* resulting from electrodermal activity in sweat glands in response to both direct and *reflex* peripheral or sympathetic trunk stimulation of autonomic activity.

synkinesis Involuntary movement made by muscles distant from those activated voluntarily. It is commonly seen during recovery after *facial neuropathy.* It is due to aberrant reinnervation and/or *ephaptic transmission*.

***T wave** A *compound muscle action potential* evoked from a muscle by rapid stretch of its tendon, as part of the *muscle stretch reflex*.

tardy ulnar palsy A type of *mononeuropathy* involving the ulnar nerve at the elbow. The nerve becomes compressed or entrapped due to deformity of the elbow from a previous injury. See also *cubital tunnel syndrome* and *ulnar neuropathy at the elbow*.

template matching An automated method used in *quantitative electromyography* for selecting *motor unit action potentials* for measurement by extract-

*Illustration in Section II

ing only *potentials* which resemble an initially identified potential.

temporal dispersion Relative desynchronization of components of a *compound muscle action potential* due to different rates of conduction of each synchronously evoked component from the stimulation point to the *recording electrode*. It may be due to normal variability in individual axon *conduction velocities*, especially when assessed over a long nerve segment, or to disorders that affect myelination of nerve fibers.

terminal latency Synonymous with preferred term, *distal latency.* See *motor latency* and *sensory latency.*

TES Abbreviation for *transcranial electrical stimulation.*

test stimulus See *paired stimuli.*

tetanic contraction The *contraction* produced in a muscle through repetitive maximal direct or indirect stimulation at a sufficiently high *frequency* to produce a smooth summation of successive maximum twitches. The term may also be applied to maximum voluntary contractions in which the firing frequencies of most or all of the component *motor units* are sufficiently high that successive twitches of individual motor units fuse smoothly. Their combined tensions produce a steady, smooth, maximum contraction of the whole muscle.

tetanus 1) The continuous *contraction* of muscle caused by repetitive stimulation or *discharge* of nerve or muscle. Contrast with *tetany*. 2) A clinical disorder caused by circulating tetanus toxin. Signs and symptoms are caused by loss of inhibition in the central nervous system and are characterized by muscle spasms, hyperreflexia, seizures, respiratory spasms, and paralysis.

tetany A clinical syndrome manifested by muscle twitching, cramps, and carpal and pedal spasm. These clinical signs are manifestations of peripheral and central nervous system nerve irritability from several causes. In these conditions, *repetitive discharges (double discharge, triple discharge, multiple discharge*) occur frequently with voluntary *activation* of *motor unit action potentials* or may appear as *spontaneous activity*. This activity is enhanced by systemic alkalosis or local ischemia.

tetraphasic action potential *Action potential* with three *baseline* crossings, producing four *phases*.

thermography A technique for measuring infrared emission from portions of the body surface. The degree of emission depends upon the amount of heat produced by the region that is studied. Its use in the diagnosis of *radiculopathy*, peripheral nerve injury, and disorders of the autonomic nervous system is controversial.

thermoregulatory sweat test A technique for assessing the integrity of the central and peripheral efferent sympathetic pathways. It consists of measuring the sweat distribution using an indicator powder while applying a controlled heat *stimulus* to raise body temperature sufficient to induce sweating.

thoracic outlet syndrome An *entrapment neuropathy* caused by compression of the neurovascular bundle as it traverses the shoulder region. Compression arises from acquired or congenital anatomic variations in the shoulder region. Symptoms can be related to compression of vascular structures, portions of the *brachial plexus*, or both.

threshold The level at which a clear and abrupt transition occurs from one state to another. The term is generally used to refer to the *voltage* level at which an *action potential* is initiated in a single axon or muscle fiber or a group of axons or muscle fibers.

threshold stimulus See *stimulus.*

tic Clinical term used to describe a sudden, brief, stereotyped, repetitive movement. When associated with vocalizations, may be the primary manifestation of Tourette syndrome.

tilt table test A test of autonomic function that is performed by measuring blood pressure and heart rate before and a specified period of time after head up tilt. The *duration* of recording and amount of tilt should be specified.

TMS Abbreviation for *transcranial magnetic stimulation.*

tone The resistance to passive stretch of a joint. When the resistance is high, this is called *hypertonia,* and when the resistance is low, this is called *hypotonia.* Two types of hypertonia are *rigidity* and *spasticity.*

train of positive sharp waves See *positive sharp wave.*

train of stimuli A group of *stimuli*. The *duration* of the group or the number of stimuli as well as the stimulation *frequency* should be specified.

transcranial electrical stimulation (TES) Stimulation of the cortex of the brain through the intact skull and scalp by means of a brief, very high *voltage*, electrical *stimulus*. *Activation* is more likely under the *anode* rather than the *cathode*. Because it is painful, this technique has largely been replaced by *transcranial magnetic stimulation*.

transcranial magnetic stimulation (TMS) Stimulation of the cortex of the brain through the intact skull and scalp by means of a brief magnetic *stimulus*. In practice, a brief pulse of strong current is passed through a coil of wire in order to produce a time-varying magnetic field in the order of 1 to 2 Tesla. Contrast with *transcranial electrical stimulation*.

tremor Rhythmical, involuntary oscillatory movement of a body part.

triphasic action potential *Action potential* with two *baseline* crossings, producing three *phases*.

triple discharge Three *motor unit action potentials* of the same form and nearly the same *amplitude*, occurring consistently in the same relationship to one another and generated by the same axon. The

*Illustration in Section II

interval between the second and third *action potentials* often exceeds that between the first two, and both are usually in the range of 2 to 20 ms. See also *double discharge, multiple discharge*.

triplet Synonym for the preferred term, *triple discharge*.

turn Point of change in polarity of a *waveform* and the magnitude of the *voltage* change following the turning point. It is not necessary that the voltage change pass through the *baseline*. The minimal excursion required to constitute a change should be specified.

turns and amplitude analysis See preferred term *interference pattern analysis.* Refers to the interference pattern analysis developed by Robin Willison in the 1960s.

ulnar neuropathy at the elbow A *mononeuropathy* involving the ulnar nerve in the region of the elbow. At least two sites of *entrapment neuropathy* have been recognized. The nerve may be entrapped or compressed as it passes through the retrocondylar groove at the elbow. Alternatively, it may be entrapped just distal to the elbow as it passes through the cubital tunnel. Anatomic variations or deformities of the elbow may contribute to nerve injury. See also *cubital tunnel syndrome* and *tardy ulnar palsy*.

unipolar needle electrode See synonym, *monopolar needle recording electrode*.

upper motor neuron syndrome A clinical condition resulting from a pathological process affecting descending motor pathways including the corticospinal tract or its cells of origin. Signs and symptoms include weakness, *spasticity*, and slow and clumsy motor performance. On *electromyographic* examination of weak muscles, there is slow *motor unit action potential* firing at maximal effort.

utilization time See preferred term, *latency of activation.*

Valsalva maneuver A forcible exhalation against the closed glottis which creates an abrupt, transient elevation of intrathoracic and intra-abdominal pressure. This results in a characteristic pattern of heart rate and blood pressure changes that can be used to quantify autonomic function. See *Valsalva ratio*.

Valsalva ratio The ratio of the fastest heart rate occurring at the end of a forced exhalation against a closed glottis (*phase* II of the *Valsalva maneuver*), and the slowest heart rate within 30 seconds after the forced exhalation (phase IV). In patients with disorders of the autonomic nervous system, the ratio may be reduced.

VEP Abbreviation for *visual evoked potential.*

VER Abbreviation for *visual evoked response.* See *visual evoked potential.*

***visual evoked potential (VEP)** Electric *waveforms* of biologic origin recorded over the cerebrum and elicited in response to visual stimuli. They are classified by *stimulus* rate as transient or steady state, and they can be further divided by stimulus presentation mode. The normal transient VEP to checkerboard pattern reversal or shift has a major positive occipital peak at about 100 ms (P100), often preceded by a negative peak (N75). The precise range of normal values for the *latency* and *amplitude* of P100 depends on several factors: 1) subject variables, such as age, gender, and visual acuity, 2) stimulus characteristics, such as type of stimulator, full-field or half-field stimulation, check size, contrast and luminescence, and 3) recording parameters, such as placement and combination of *recording electrodes*.

visual evoked response (VER) Synonym for preferred term, *visual evoked potential*.

volitional activity Synonymous with *voluntary activity*.

voltage *Potential* difference between two recording sites usually expressed in volts (V) or millivolts (mV).

volume conduction Spread of current from a *potential* source through a conducting medium, such as body tissues.

voluntary activity In *electromyography*, the electric activity recorded from a muscle with consciously controlled *contraction*. The effort made to contract the muscle may be specified relative to that of a corresponding normal muscle, e.g. minimal, moderate, or maximal. If the recording remains isoelectric during the attempted contraction and equipment malfunction has been excluded, it can be concluded that there is no voluntary activity.

wake-up test A procedure used most commonly in spinal surgery. During critical portions of an operation in which the spinal cord is at risk for injury, the level of general anesthesia is allowed to decrease to the point where the patient can respond to commands. The patient is then asked to move hands and feet, and a movement in response to commands indicates the spinal cord is intact. This procedure is used routinely in some centers. *Somatosensory evoked potential* monitoring has supplanted its use in most centers, except sometimes in the situation where they indicate the possibility of spinal cord injury.

wallerian degeneration Degeneration of the segment of an axon distal to nerve injury that destroys its continuity.

*Illustration in Section II

waning discharge A *repetitive discharge* that gradually decreases in *frequency* or *amplitude* before cessation. Contrast with *myotonic discharge.*

wave A transient change in *voltage* represented as a line of differing directions over time.

waveform The shape of a *wave.* The term is often used synonymously with *wave.*

wire electrodes Thin wires that are insulated except for the tips, which are bared. The wire is inserted into muscle with a needle. After the needle is withdrawn, the wire remains in place. Wire electrodes are superior to *surface electrodes* for *kinesiologic EMG*, because they are less affected by *cross talk* from adjacent muscles. They also record selectively from the muscle into which they are inserted.

SECTION II:
ILLUSTRATIONS OF SELECTED WAVEFORMS

Each illustration is accompanied by a complete explanation that is, in most cases, the same as that given in the alphabetic section. The definitions have been repeated in full with the illustrations so that readers do not need to refer back and forth between the illustration and definition.

The illustrations have been modified and adapted from materials submitted by AAEM members. The illustrations of the short-latency somatosensory evoked potentials were reprinted from the *Journal of Clinical Neurophysiology* (1978;1:41-53) with permission of the journal editor and the authors.

COMPOUND SENSORY NERVE ACTION POTENTIALS

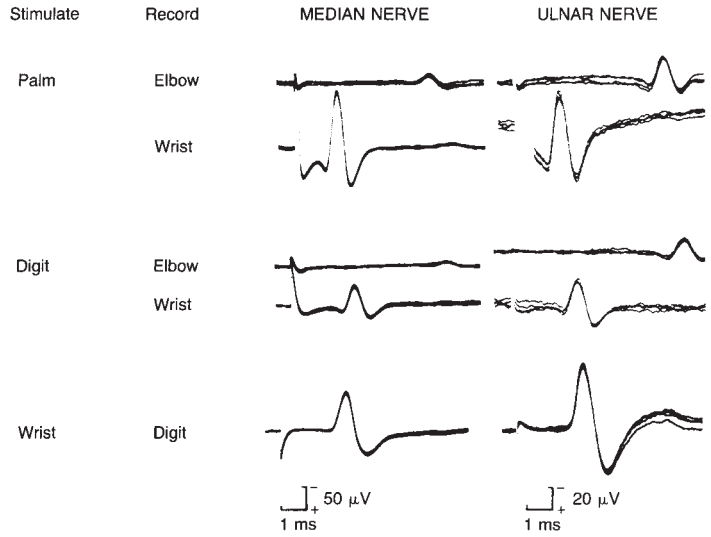

Figure 1. *Compound sensory nerve action potentials* recorded with surface *electrodes* in a normal subject. A *compound nerve action potential* is considered to have been evoked from afferent fibers if the recording electrodes detect activity only in a *sensory nerve* or in a sensory branch of a *mixed nerve*, or if the electric *stimulus* is applied to a sensory nerve or a dorsal nerve root, or an adequate stimulus is applied synchronously to sensory receptors. The *amplitude*, *latency*, *duration*, and configuration should be noted. Generally, the amplitude is measured as the maximum peak-to-peak *voltage* when there is an initial positive deflection or from *baseline*-to-peak when there is an intial negative deflection. The latency is measured as either the latency to the initial deflection or the peak latency to the negative peak, and the duration as the interval from the first deflection of the *waveform* from the baseline to its final return to the baseline. The compound sensory nerve action potential is also referred to by the less preferred terms *sensory response*, *sensory potential*, or *SNAP.*

SHORT-LATENCY SOMATOSENSORY EVOKED POTENTIAL (SSEP)

MEDIAN NERVE

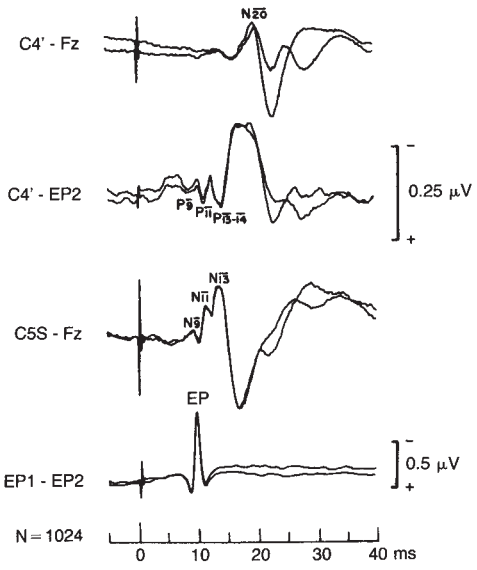

Figure 2. *Short-latency somatosensory evoked potentials* evoked by stimulation of the median nerve in a normal subject. Recordings were made from the scalp to a cephalic reference (C4'-Fz), the scalp to contralateral Erb's point (C4'-EP2), cervical spine to a frontal reference (C5S-Fz), and ipsilateral Erb's point to the contralateral Erb's point (EP1-EP2). Short-latency somatosensory evoked potentials elicited by electric stimulation of the median nerve at the wrist occur within 25 ms of the *stimulus* in normal subjects. Normal short-latency response components to median nerve stimulation are designated P9, P11, P13, P14, N20, and P23 in records taken between scalp and noncephalic *reference electrodes*, and N9, N11, N13, and N14 in cervical spine-scalp derivation. It should be emphasized that *potentials* having opposite polarity but similar *latency* in spine-scalp and scalp-noncephalic reference derivations do not necessarily have identical *generator* sources. The C4' designation indicates that the recording scalp electrode was placed 2 cm posterior to the International 10-20 C4 electrode location.

SHORT-LATENCY SOMATOSENSORY EVOKED POTENTIAL (SSEP)

COMMON PERONEAL NERVE

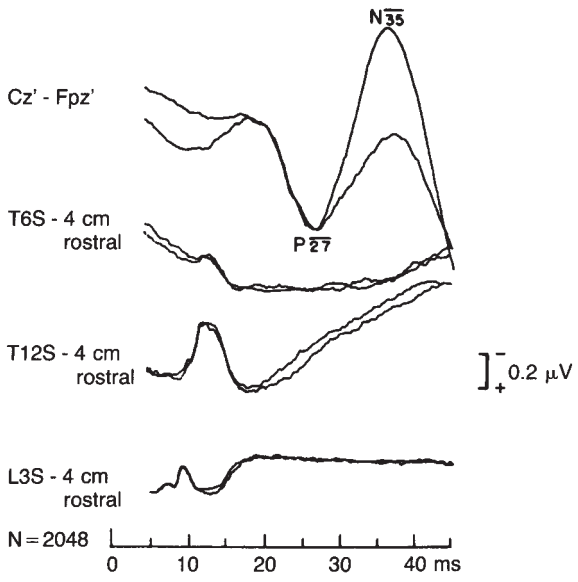

Figure 3. *Short-latency somatosensory evoked potentials* evoked by stimulation of the common peroneal nerve in a normal subject. Recordings were made from the scalp (Cz'-Fpz'), the mid-thoracic spine (T6S-4 cm rostral), the lower thoracic spine (T12S-4 cm rostral), and the lumbar spine (L3S-4 cm rostral). Short-latency somatosensory evoked potentials elicited by stimulation of the common peroneal nerve at the knee occur within 40 ms of the *stimulus* in normal subjects. It is suggested that individual response components be designated as follows: (1) Spine components: L3 and T12 spine potentials. (2) Scalp components: P27 and N35. The Cz' and Fpz' designations indicate that the recording scalp *electrode* was placed 2 cm posterior to the International 10-20 Cz and Fpz electrode locations.

SHORT-LATENCY SOMATOSENSORY EVOKED POTENTIAL (SSEP)

POSTERIOR TIBIAL NERVE

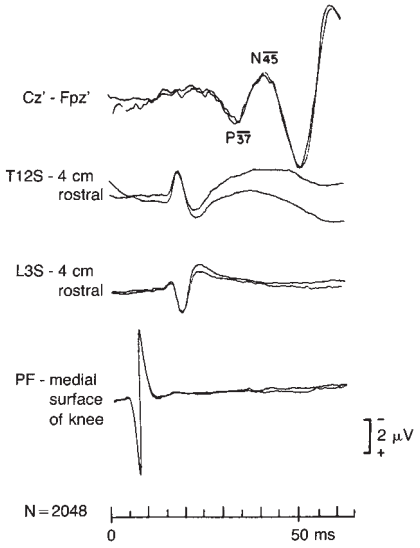

Figure 4. *Short-latency somatosensory evoked potentials* evoked by stimulation of the posterior tibial nerve at the ankle. Recordings were made from the scalp (Cz'-Fpz'), The lower thoracic spine (T12S-4cm rostral), the lumbar spine (L3S-4cm rostral), and the popliteal fossa (PF-medial surface of knee). Short-latency somatosensory evoked potentials elicited by electric stimulation of the posterior tibial nerve at the ankle occur within 50 ms of the *stimulus* in normal subjects. It is suggested that individual response components be designated as follows: (1) Nerve trunk (tibial nerve) component in the popliteal fossa: PF potential. (2) Spine components: L3 and T12 potentials. (3) Scalp components: P37 and N45 waves. The Cz' and Fpz' designations indicate that the recording scalp *electrode* was placed 2 cm posterior to the *International 10-20 system* Cz and Fpz electrode locations.

VISUAL EVOKED POTENTIAL (VEP)

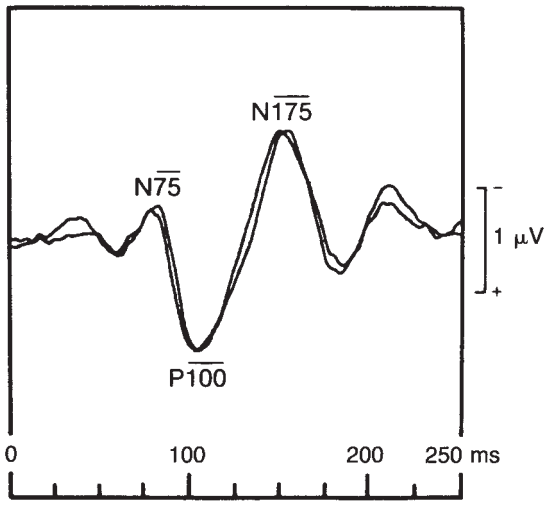

Figure 5. Normal occipital visual evoked potential to checkerboard pattern reversal stimulation recorded between occipital (01) and vertex (Cz) electrodes showing N75, P100 and N175 peaks. Visual evoked potentials are electric waveforms of biologic origin recorded over the cerebrum and elicited by visual *stimuli.* VEPs are classified by stimulus rate as transient or steady state and can be further divided by stimulus presentation mode. The normal transient VEP to checkerboard pattern reversal or shift has a major positive occipital peak at about 100 ms (P100), often preceded by a negative peak (N75). The precise range of normal values for the *latency* and *amplitude* of P100 depends on several factors: (1) subject variables, such as age, gender, and visual acuity, (2) stimulus characteristics, such as type of stimulator, full-field or half-field stimulation, check size, contrast and luminescence, and (3) recording parameters, such as placement and combination of *recording electrodes.*

BRAINSTEM AUDITORY EVOKED POTENTIAL (BAEP)

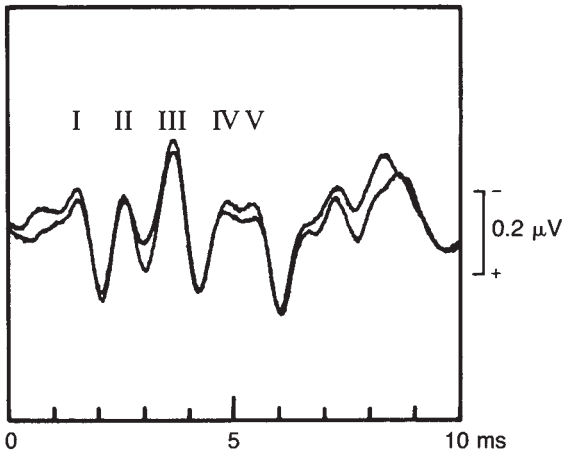

Figure 6. Normal brainstem auditory evoked potential to stimulation of the left ear, recorded between left ear (A1) and vertex (Cz) electrodes. Brainstem auditory evoked potentials are electric *waveforms* of biologic origin elicited in response to sound *stimuli.* The normal BAEP consists of a sequence of up to seven waves, designated I to VII, which occur during the first 10 ms after the onset of the stimulus and have positive polarity at the vertex of the head. In this recording, negativity in input terminal 1 or positivity in input terminal 2 causes an upward deflection.

M WAVE

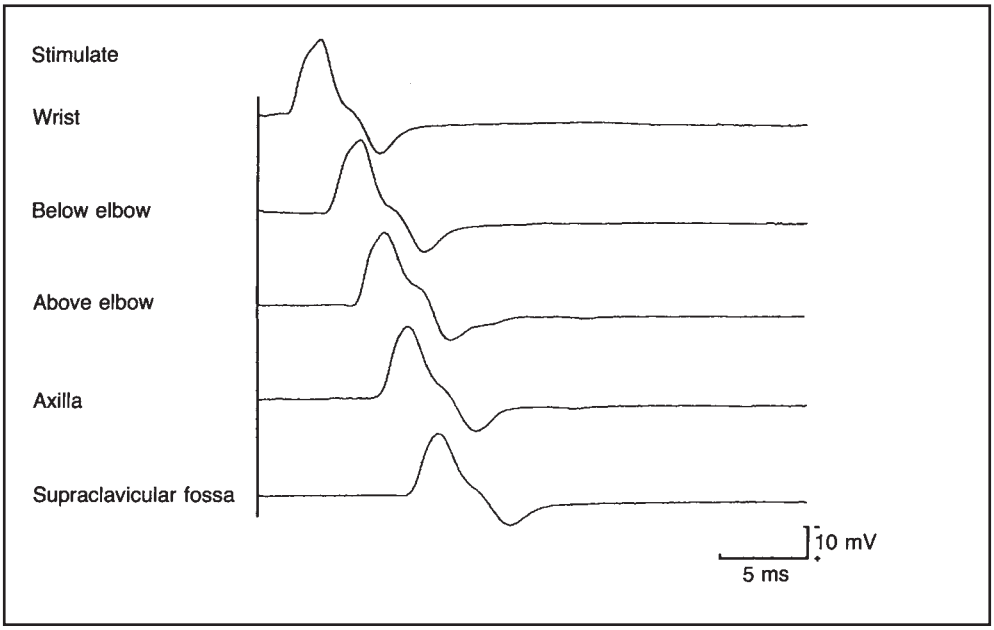

Figure 7. *M waves* recorded with surface *electrodes* over the abductor digiti quinti muscle elicited by electric stimulation of the ulnar nerve at several levels. The M wave is a *compound muscle action potential* evoked from a muscle by an electric *stimulus* to its *motor nerve.* By convention, the M wave elicited by a supramaximal stimulus is used for motor *nerve conduction studies.* Ideally, the *recording electrodes* should be placed so that the initial deflection of the *evoked potential* from the *baseline* is negative. The *latency,* commonly called the motor latency, is the time from stimulation (ms) to the onset of the first *phase* (positive or negative) of the M wave. The *amplitude* (mV) is the baseline-to-peak amplitude of the first negative phase, unless otherwise specified. The *duration* (ms) refers to the duration of the first negative phase, unless otherwise specified. Normally, the configuration of the M wave (usually biphasic) is quite stable with repeated stimuli at slow rates (1-5 *Hz*). See *repetitive nerve stimulation.*

F WAVE

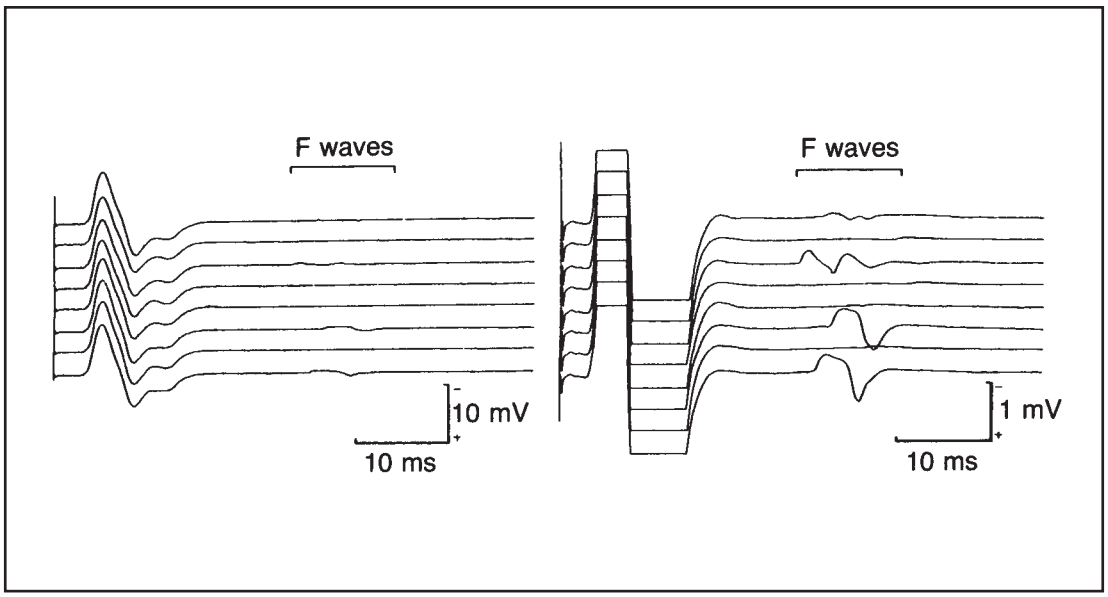

Figure 8. *F waves* recorded with *surface electrodes* over the abductor digiti quinti muscle elicited by electric stimulation of the ulnar nerve at the wrist with two different gain settings. The F wave is an *action potential* evoked intermittently from a muscle by a supramaximal *stimulus* to the nerve. Compared with the maximal *amplitude M wave* of the same muscle, the F wave has a smaller amplitude (1-5% of the M wave), variable configuration and a longer, more variable *latency.* The F wave can be found in many muscles of the upper and lower extremities, and the latency is longer with more distal sites of stimulation. The F wave is due to *antidromic activation* of motor neurons. It was named by Magladery and McDougal in 1950. Compare with the *H wave* and the *A wave.* One of the *late responses.*

H WAVE

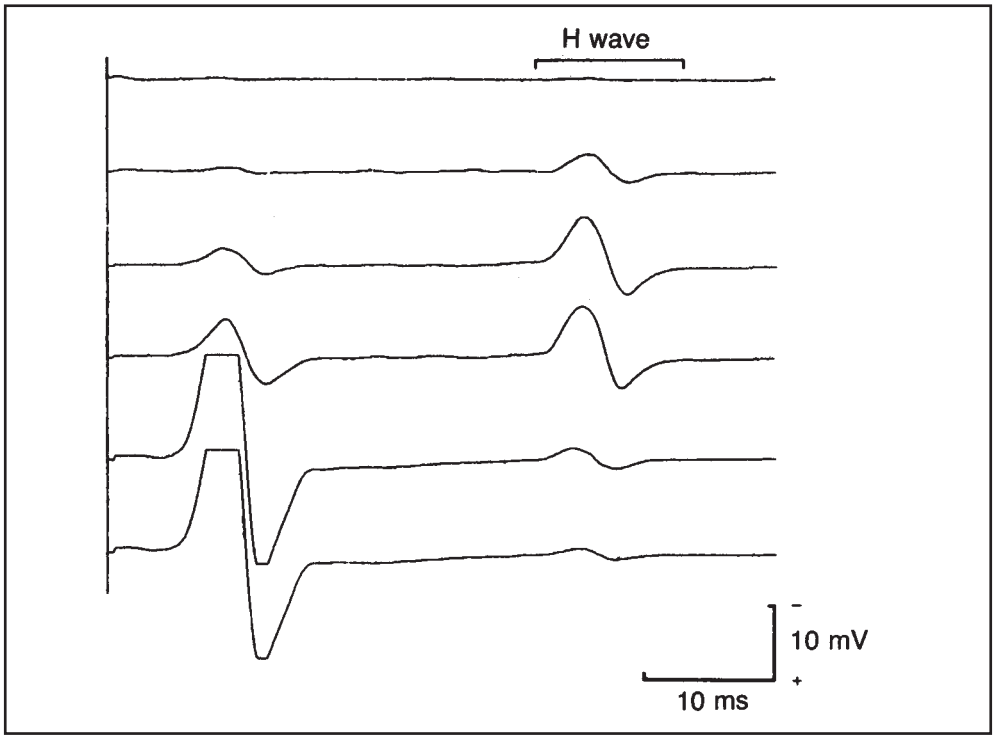

Figure 9. *H waves* recorded with *surface electrodes* over the soleus muscle elicited by electric stimulation of the posterior tibial nerve at the knee. The *stimulus* intensity was gradually increased (top tracing to bottom tracing). The H wave is a *compound muscle action potential* having a consistent *latency* evoked regularly, when present, from a muscle by an electric *stimulus* to the nerve. It is regularly found in adults only in a limited group of physiologic extensors, particularly the calf muscles. The H wave is most easily obtained with the *cathode* positioned proximal to the *anode.* Compared with the maximum *amplitude M wave* of the same muscle, the H wave has a smaller amplitude, a longer *latency,* and a lower optimal stimulus intensity. The latency is longer with more distal sites of stimulation. A stimulus intensity sufficient to elicit a maximal amplitude M wave reduces or abolishes the H wave. The H wave is thought to be due to a spinal *reflex,* the Hoffmann reflex, with electric stimulation of afferent fibers in the *mixed nerve* to the muscle and activation of motor neurons to the muscle mainly through a monosynaptic connection in the spinal cord. The reflex and wave are named in honor of Hoffmann's description in 1918. Compare with the *F wave.*

A WAVE

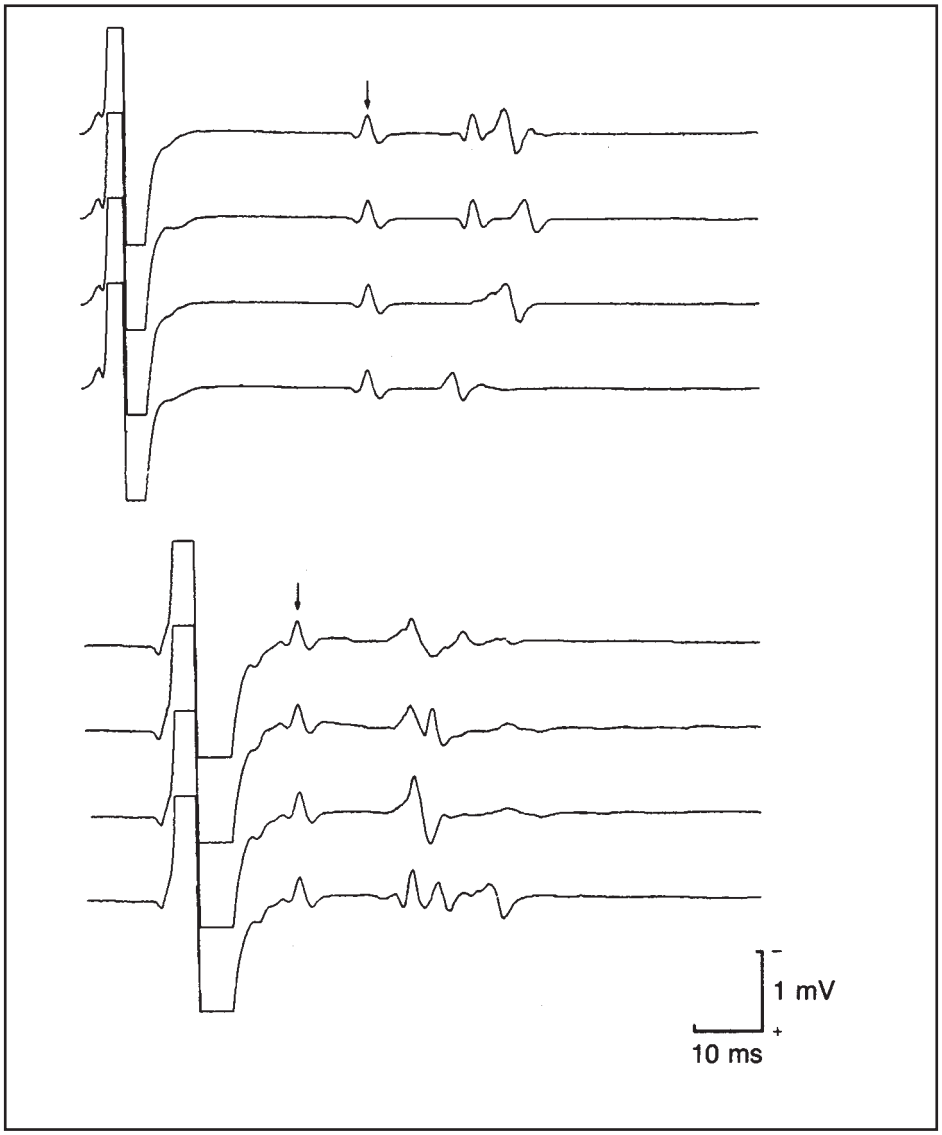

Figure 10. *A waves* (under arrow markers) recorded with surface *electrodes* over the abductor hallucis brevis elicited by electric stimulation of the posterior tibial nerve at the level of the ankle (top four traces) and at the level of the knee (bottom four traces). The A wave is a *compound muscle action potential* evoked consistently from a muscle by *submaximal stimuli* to the nerve and frequently abolished by *supramaximal stimuli.* The *amplitude* of the A wave is similar to that of the *F wave,* but the *latency* is more constant. The A wave usually occurs before the F wave, but may occur afterwards. It is thought to be due to extra *discharges* in the nerve, *ephapses* between adjacent nerve fibers, or axonal branching. Compare with the *F wave.*

T WAVE

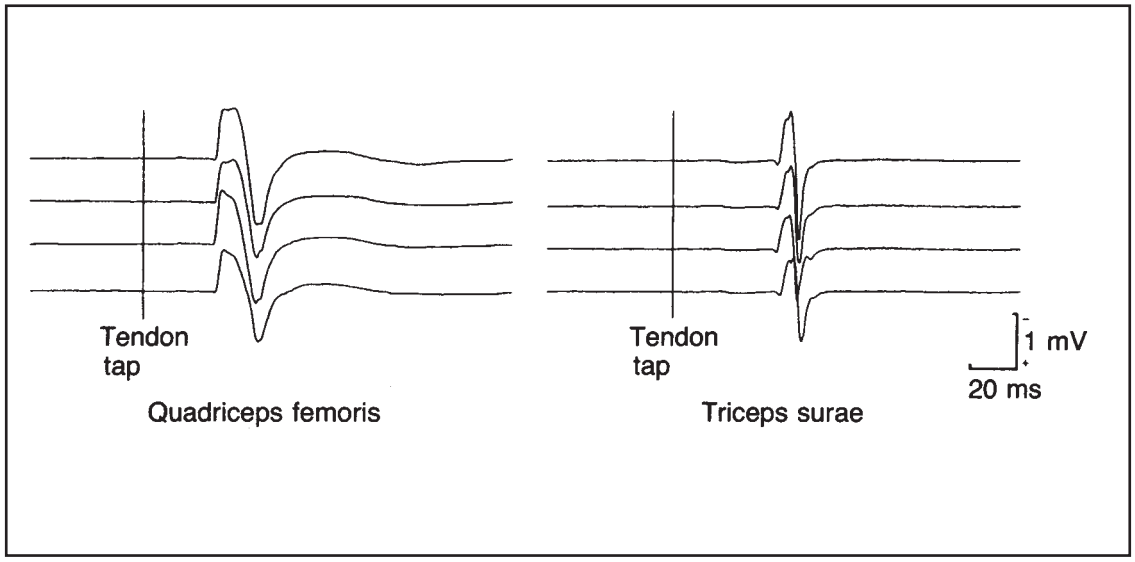

Figure 11. *T waves* produced by triggering a microswitch in the handle of a *reflex* hammer by striking the patellar tendon (quadriceps femoris) or the Achilles tendon (triceps surae). The T wave is a *compound muscle action potential* evoked by rapid stretch of a tendon, as part of the *muscle stretch reflex.*

BLINK RESPONSES

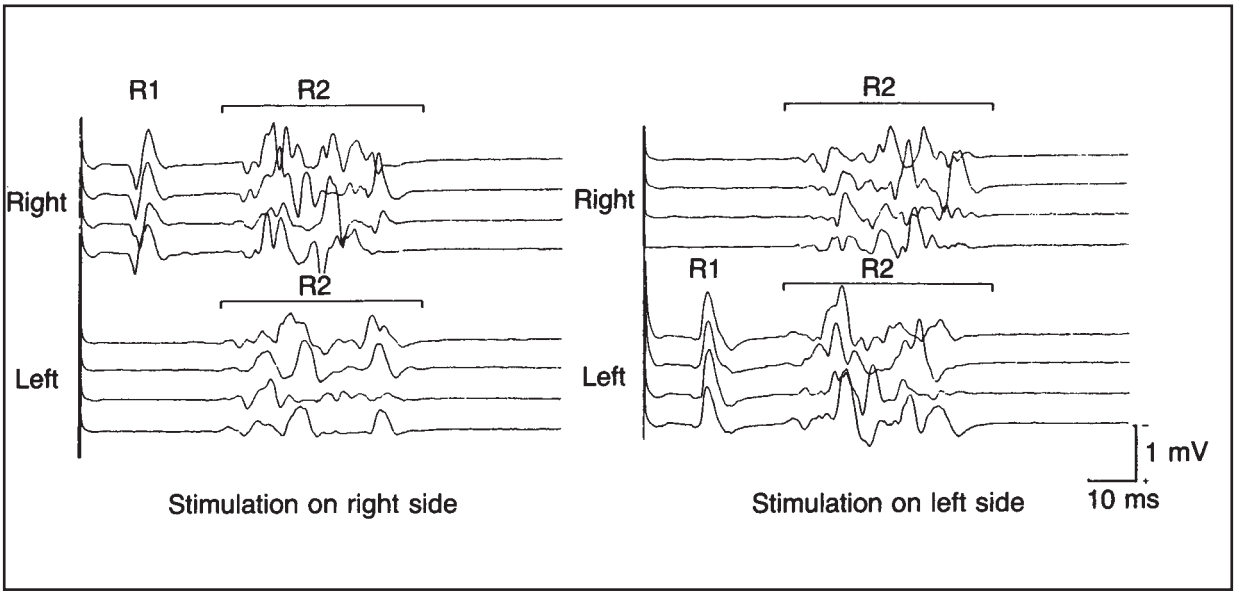

Figure 12. *Blink responses* recorded with surface *electrodes* over the right orbicularis oculi (upper tracings) and left orbicularis oculi (lower tracings) elicited by electric stimulation of the supraorbital nerve on the right (left tracings) and on the left (right tracings). The blink responses are *compound muscle action potentials* evoked from orbicularis oculi muscles as a result of brief electric or mechanical *stimuli* to the cutaneous area innervated by the supraorbital (or less commonly, the infraorbital) branch of the trigeminal nerve. Typically, there is an early compound muscle action potential (*R1 wave*) ipsilateral to the stimulation site with a *latency* of about 10 ms and a bilateral late compound muscle action potential (*R2 wave*) with a latency of approximately 30 ms. Generally, only the R2 wave is associated with a visible twitch of the orbicularis oculi. The configuration, *amplitude, duration,* and latency of the two components, along with the sites of recording and the sites of stimulation, should be specified. R1 and R2 waves are oligosynaptic and polysynaptic brainstem *reflexes*, respectively, together called the *blink reflex.* The afferent arc is provided by the sensory branches of the trigeminal nerve, and the efferent arc is provided by facial nerve motor fibers.

REPETITIVE NERVE STIMULATION

NORMAL RESPONSE

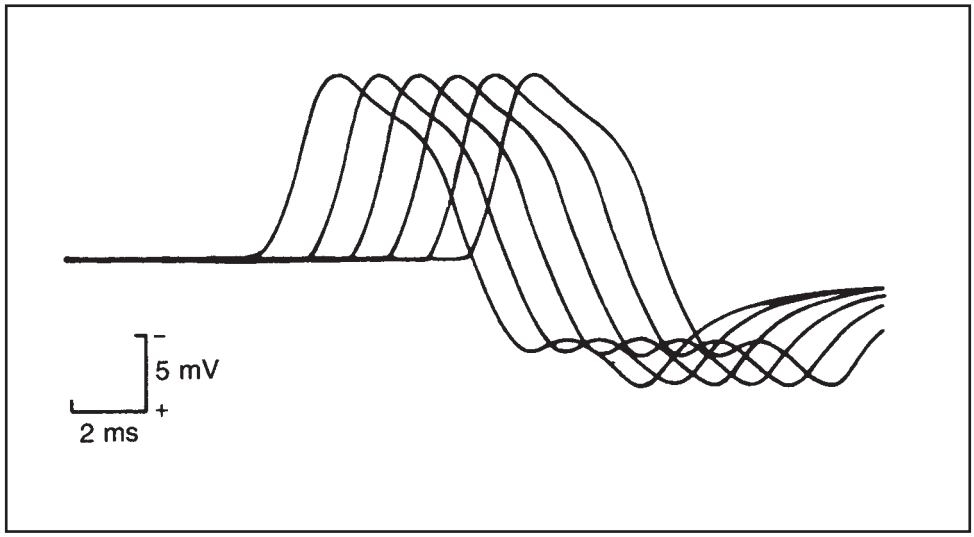

Figure 13. *Repetitive nerve stimulation* study in a normal subject. The successive *M waves* are displayed to the right. The M waves were recorded with *surface electrodes* over the hypothenar eminence (abductor digiti quinti) during ulnar nerve stimulation at a rate of 3 *Hz.* Note the configuration of the successive M waves is unchanged. Repetitive nerve stimulation is a technique of repeated *supramaximal stimulation* of a nerve while recording M waves from the muscle innervated by the nerve. It is commonly used to assess the integrity of neuromuscular transmission. The number of *stimuli* and the *frequency* of stimulation should be specified. *Activation procedures* performed prior to the test should be specified, e.g., sustained voluntary *contraction* or contraction induced by nerve stimulation. If the test was performed after an activation procedure, the time elapsed after it was completed should also be specified. The technique is commonly used to assess the integrity of neuromuscular transmission. For a description of specific patterns of responses, see *incrementing response, decrementing response, facilitation,* and *postactivation depression.*

REPETITIVE NERVE STIMULATION

DECREMENTING RESPONSE

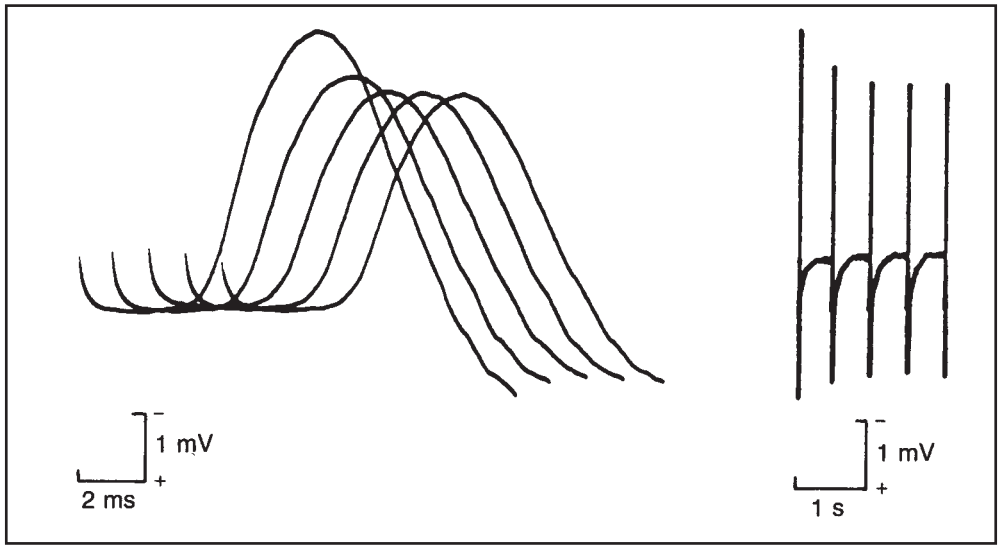

Figure 14. *Repetitive nerve stimulation* study in a patient with *myasthenia gravis.* Successive *M waves* were recorded with *surface electrodes* over the rested nasalis muscle during repetitive facial nerve stimulation at a rate of 2 *Hz,* with a display to permit measurement of the *amplitude* and *duration* of the negative *phase* (left) or peak-to-peak amplitude (right). A *decrementing response* is a reproducible decline in the amplitude and/or area of the M wave of successive responses to repetitive nerve stimulation. The rate of stimulation and the total number of *stimuli* should be specified. Decrementing responses with disorders of neuromuscular transmission are most reliably seen with slow rates (2 to 5 Hz) of nerve stimulation. A decrementing response with repetitive nerve stimulation commonly occurs in disorders of neuromuscular transmission, but can also be seen in some *polyneuropathies, myopathies,* and *motor neuron disease.* An *artifact* resembling a decrementing response can result from movement of the stimulating or *recording electrodes* during repetitive nerve stimulation (*pseudodecrement*). Contrast with *incrementing response.*

REPETITIVE NERVE STIMULATION
INCREMENTING RESPONSE

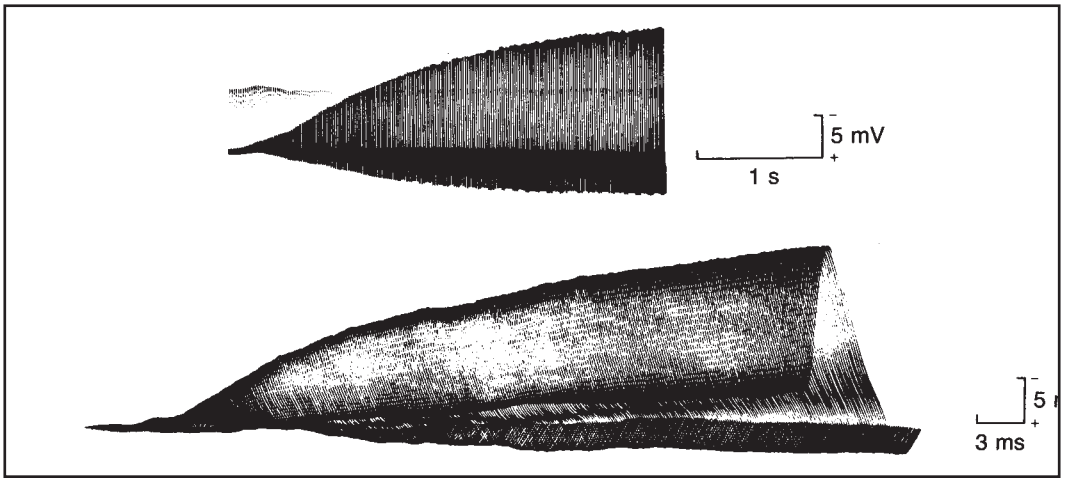

Figure 15. *Repetitive nerve stimulation* study in a patient with Lambert-Eaton myasthenic syndrome (LEMS). An *incrementing response* was recorded with *surface electrodes* over the hypothenar eminence (abductor digiti quinti) during repetitive ulnar nerve stimulation at a rate of 50 *Hz* with a display to permit measurement of the peak-to-peak *amplitude* (top) or amplitude and *duration* of the negative *phase* (bottom). An incrementing response is a reproducible increase in amplitude and/or area of successive responses (*M waves*) to repetitive nerve stimulation. The rate of stimulation and the number of *stimuli* should be specified. An incrementing response is commonly seen in two situations. First, in normal subjects the configuration of the M wave may change with repetitive nerve stimulation so that the amplitude progressively increases as the duration decreases, but the area of the M wave remains the same. This phenomenon is termed *pseudofacilitation.* Second, in disorders of neuromuscular transmission, the configuration of the M wave may change with repetitive nerve stimulation so that the amplitude progressively increases as the duration remains the same or increases, and the area of the M wave increases. This phenomenon is termed *facilitation.* Contrast with *decrementing response.*

REPETITIVE NERVE STIMULATION
NORMAL (N), MYASTHENIA GRAVIS (MG), LAMBERT-EATON MYASTHENIC SYNDROME (LEMS)

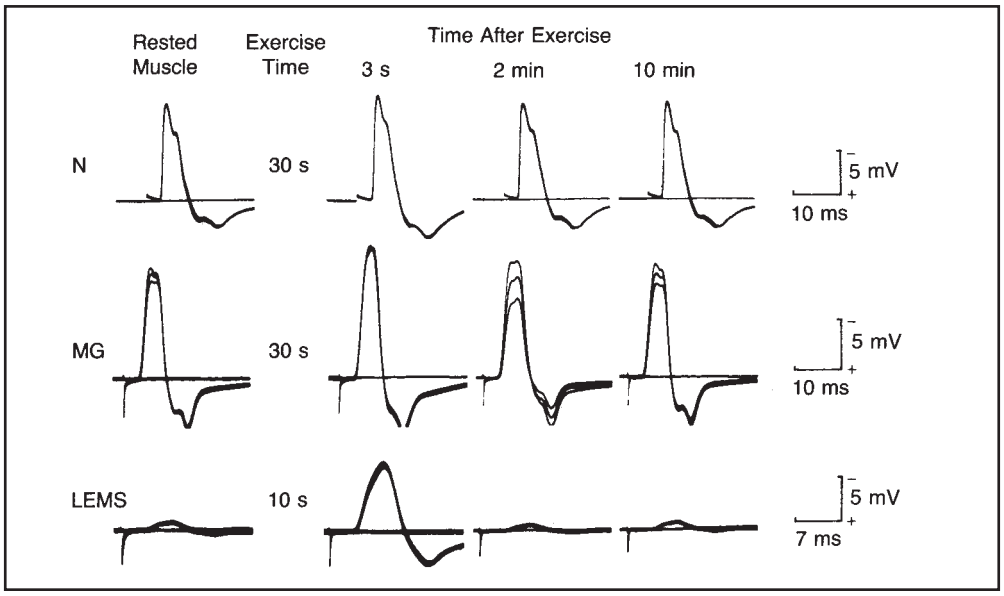

Figure 16. *Repetitive nerve stimulation* studies in a normal subject (N) and patients with *myasthenia gravis* (MG) and Lambert-Eaton myasthenic syndrome (LEMS). Three successive *M waves* were elicited by repetitive nerve stimulation at a rate of 2 *Hz.* The three *responses* were superimposed. This method of display emphasizes a change in the configuration of successive responses, but does not permit identification of their order. In each superimposed display of three responses where the configuration did change, the highest amplitude response was the first, and the lowest amplitude response was the third. After testing the rested muscle, the muscle was maximally contracted for 10 to 30 seconds (exercise time). Repetitive nerve stimulation was carried out again 3 s, 2 min, and 10 min after the exercise ended. The results illustrate *facilitation* and *postactivation depression.*

REPETITIVE NERVE STIMULATION

PSEUDOFACILITATION

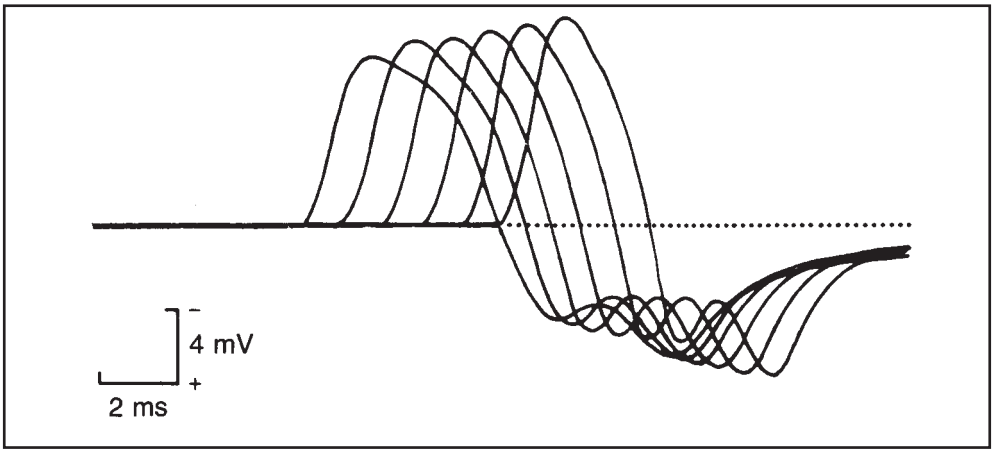

Figure 17. *Repetitive nerve stimulation* study in a normal subject. The successive M waves were recorded with *surface electrodes* over the hypothenar eminence (abductor digiti quinti) during ulnar nerve stimulation at a rate of 30 *Hz. Pseudofacilitation* may occur in normal subjects with repetitive nerve stimulation at high (20-50 Hz) rates or after strong volitional *contraction*, and probably reflects a reduction in the *temporal dispersion* of the summation of a constant number of *muscle fiber action potentials* due to increases in the propagation velocity of muscle cell *action potentials* with repeated activation. Pseudofacilitation should be distinguished from *facilitation.* The recording shows an *incrementing response* characterized by an increase in the *amplitude* of the successive M waves with a corresponding decrease in the *duration*, resulting in no change in the area of the negative *phase* of successive M waves.

INSERTION ACTIVITY

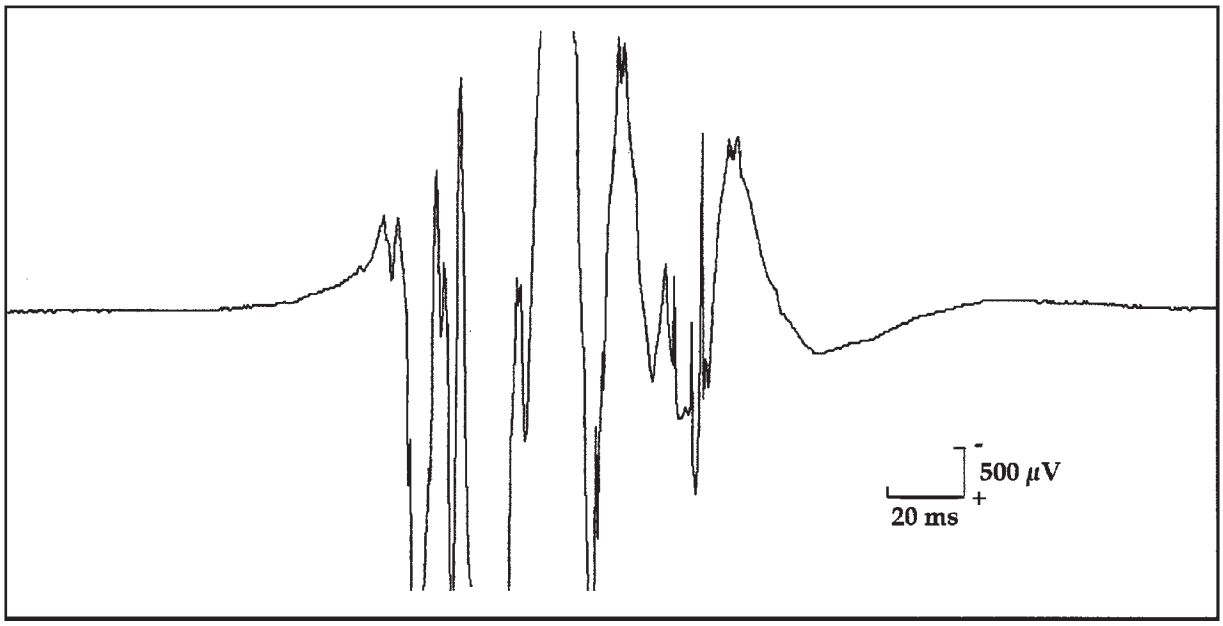

Figure 18. *Insertion activity* recorded by an intramuscular *needle electrode* in a normal subject. Insertion activity is the electric activity caused by insertion or movement of a needle electrode within a muscle. The amount of the activity may be described as normal, reduced, or increased (prolonged), with a description of the *waveform* and repetitive rate.

END-PLATE ACTIVITY

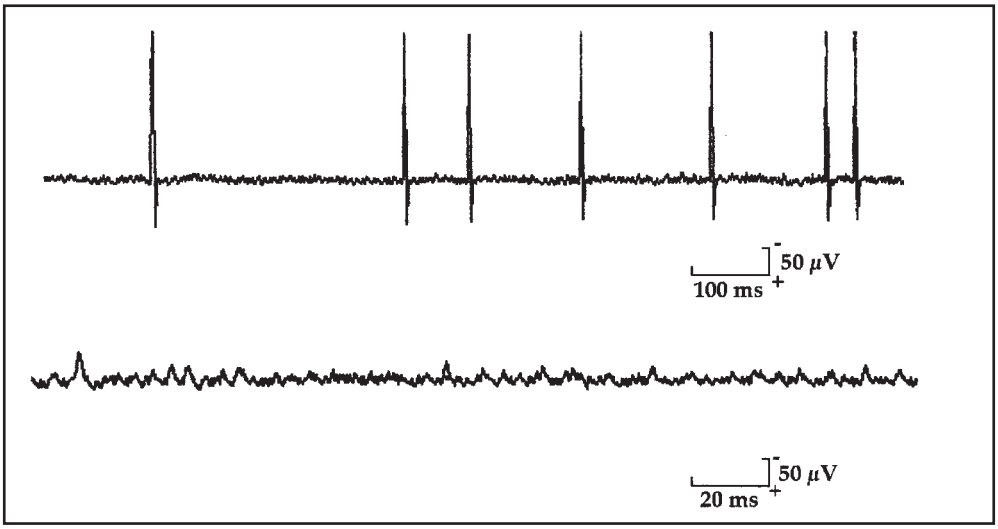

Figure 19. *Spontaneous activity* recorded by an intramuscular *needle electrode* close to muscle end-plates. May be either of two forms:

1. *Monophasic end-plate activity* (upper and lower traces): Low *amplitude* (10 to 20 μV), short-duration (0.5 to 1 ms), monophasic (negative) *potentials* that occur in a dense, steady pattern and are restricted to a localized area of the muscle. Because of the multitude of different potentials occurring, the exact *frequency,* although appearing to be high, cannot be defined. These nonpropagated potentials are probably *miniature end-plate potentials* recorded extracellularly. This form of end-plate activity has been referred to as *end-plate noise* or *sea shell sound (sea shell noise or roar).*
2. *Biphasic end-plate activity* (upper trace): Moderate amplitude (100 to 300 μV), short-duration (2 to 4 ms), biphasic (negative-positive) *spike* potentials that occur irregularly in short bursts with a high frequency (50 to 100 *Hz*), restricted to a localized area within the muscle. These propagated potentials are generated by muscle fibers excited by activity in nerve terminals. These potentials have been referred to as *end-plate spikes,* and, incorrectly, *nerve potentials.*

FIBRILLATION POTENTIAL

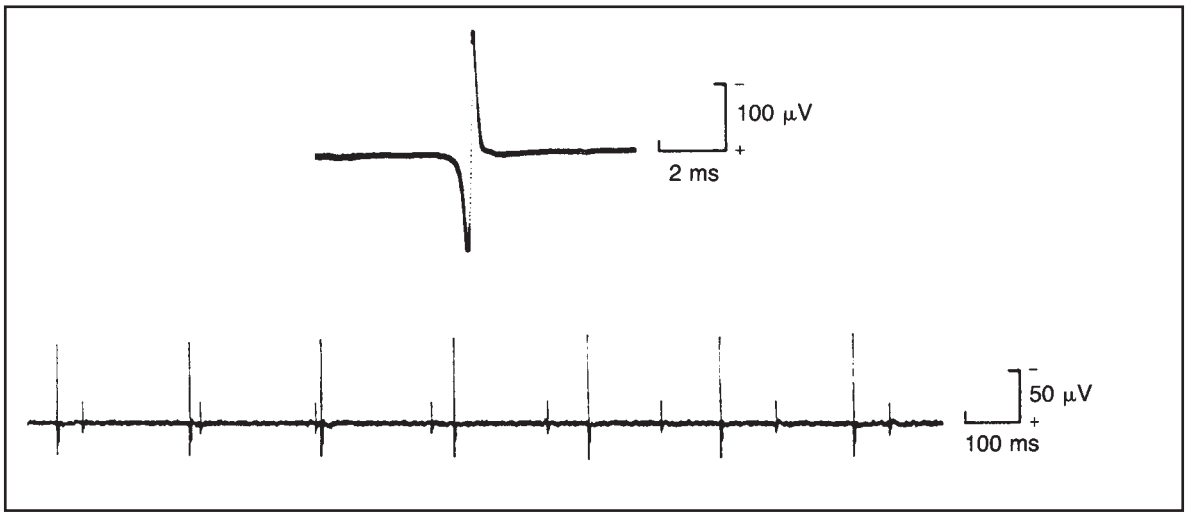

Figure 20. *Fibrillation potentials* recorded by an intramuscular *needle electrode.* The top trace shows the *waveform* of a single fibrillation potential. The bottom trace shows the pattern of discharge of two other fibrillation potentials which differ with respect to *amplitude* and discharge *frequency.* A fibrillation potential is the electric activity associated with a spontaneously contracting (fibrillating) muscle fiber. It is the *action potential* of a single muscle fiber. The action potentials may occur spontaneously or after movement of the needle electrode. They usually fire at a constant rate, although a small proportion fire irregularly. Classically, the potentials are biphasic *spikes* of short *duration* (usually less than 5 ms) with an initial positive phase and a peak-to-peak amplitude of less than 1 mV. When recorded with concentric or *monopolar needle electrodes,* the firing rate has a wide range (1 to 50 Hz) and often decreases just before cessation of an individual discharge. A high-pitched regular sound is associated with the discharge of fibrillation potentials and has been described in the older literature as "rain on a tin roof." In addition to this classic form of fibrillation potentials, *positive sharp waves* may also be recorded from fibrillating muscle fibers when the action potentials arise from an area immediately adjacent to the needle electrode.

POSITIVE SHARP WAVE

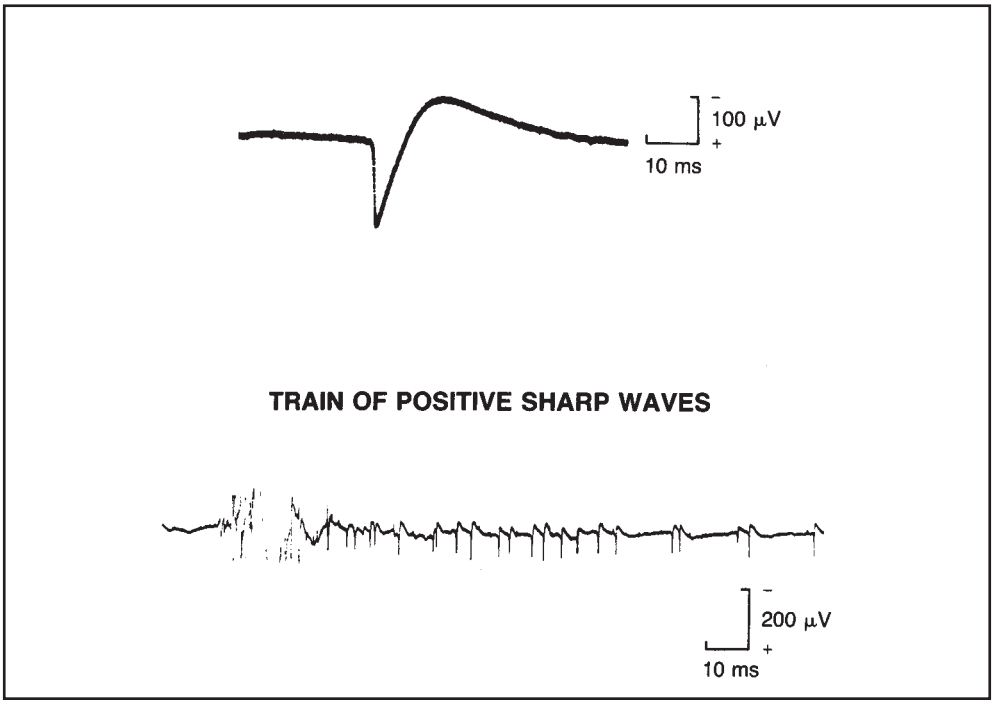

Figure 21. *Positive sharp waves* recorded by an intramuscular *needle electrode.* The top trace shows a single positive sharp wave. The bottom trace shows the pattern of initial *discharge* of a number of different positive sharp waves after movement of the needle electrode in a denervated muscle. A positive sharp wave is a biphasic, positive-negative *action potential* initiated by needle movement and recurring in a uniform, regular pattern at a rate of 1 to 50 *Hz.* The discharge *frequency* may decrease slightly just before cessation. The initial positive deflection is rapid (<1 ms), its *duration* is usually less than 5 ms, and the *amplitude* is up to 1 mV. The negative *phase* is of low amplitude, with a duration of 10 to 100 ms. A sequence of positive sharp waves is commonly referred to as a *train of positive sharp waves.* Positive sharp waves can be recorded from the damaged area of fibrillating muscle fibers. Their configuration may result from the position of the needle electrode which is believed to be adjacent to the depolarized segment of a muscle fiber injured by the electrode. Note that the positive sharp *waveform* is not specific for muscle fiber damage. *Motor unit action potentials* and potentials in *myotonic discharges* may have the configuration of positive sharp waves.

MYOTONIC DISCHARGE

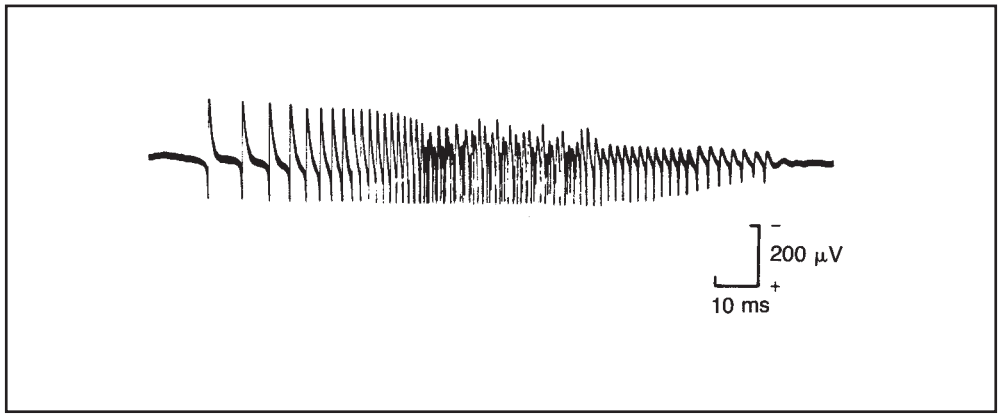

Figure 22. *Myotonic discharge* recorded by an intramuscular needle electrode. A myotonic discharge is a *repetitive discharge* which fires at rates of 20 to 80 *Hz.* There are two types: (1) biphasic (positive-negative) *spike potentials* less than 5 ms in *duration* resembling *fibrillation potentials,* and (2) *positive waves* of 5 to 20 ms duration resembling *positive sharp waves.* Both potential forms are recorded after *needle electrode* insertion, voluntary muscle *contraction* or muscle percussion, and are due to independent, repetitive discharges of single muscle fibers. The *amplitude* and *frequency* of the potentials must both wax and wane to be identified as a myotonic discharge. This change produces a characteristic musical sound in the audio display of the *electromyograph* due to the corresponding change in pitch, which has been likened to the sound of a "dive bomber." Contrast with *waning discharge.*

COMPLEX REPETITIVE DISCHARGE

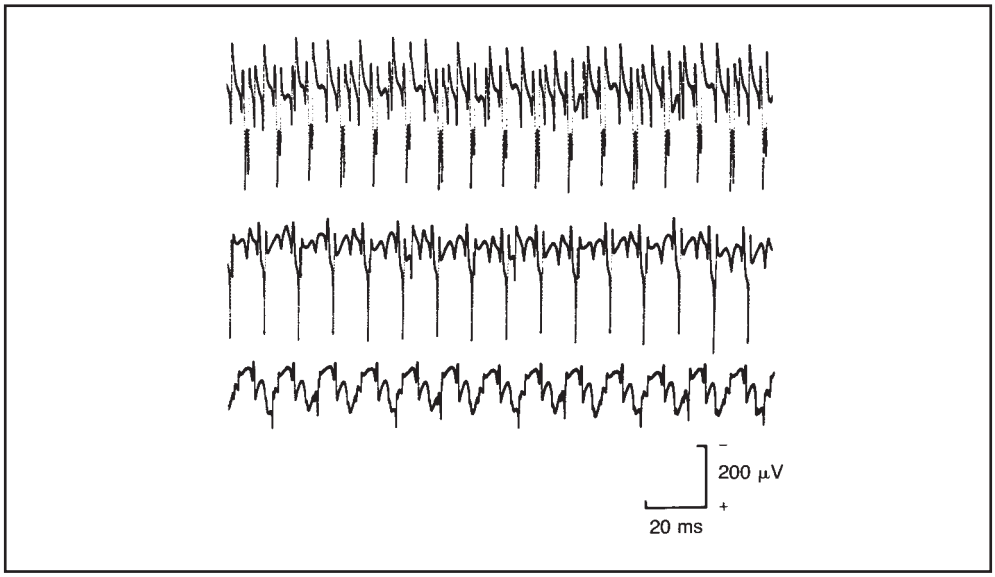

Figure 23. *Complex repetitive discharges* recorded by an intramuscular *needle electrode.* A complex repetitive discharge is a polyphasic or serrated *action potential* that may begin spontaneously or after needle movement. The *discharges* have a uniform *frequency,* shape, and *amplitude,* with abrupt onset, cessation, or change in configuration. Amplitudes range from 100 μV to 1 mV and the frequency of discharge from 5 to 100 Hz. This term is preferred to *bizarre high frequency discharge, bizarre repetitive discharge, bizarre repetitive potential,* or *pseudomyotonic discharge.*

FASCICULATION POTENTIAL

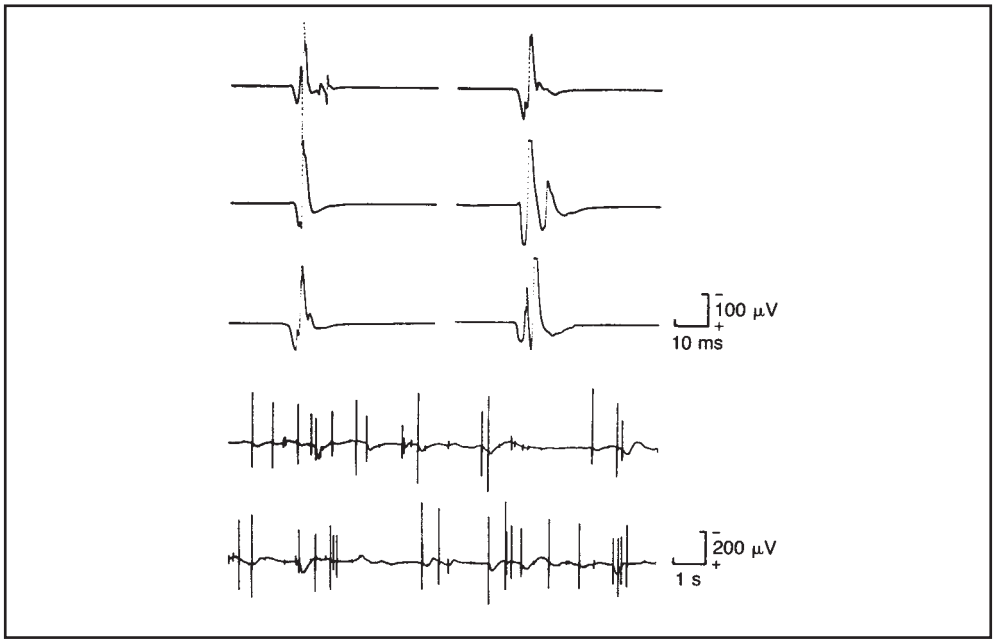

Figure 24. *Fasciculation potentials* recorded by an intramuscular *needle electrode.* Six different fasciculation potentials are displayed in the top traces, on a time scale which permits characterization of the individual *waveforms.* The bottom two traces display fasciculation potentials on a time scale which demonstrates the random discharge pattern. A fasciculation potential is an *action potential* which is often associated with a visible *fasciculation.* It has the configuration of a *motor unit action potential* but occurs spontaneously. Most commonly these potentials occur sporadically and are termed "single fasciculation potentials." Occasionally, the potentials occur as a *grouped discharge* and are termed a "brief *repetitive discharge.*" The repetitive firing of adjacent fasciculation potentials, when numerous, may produce an undulating movement of muscle (see *myokymia*). Use of the terms *benign fasciculation* and *malignant fasciculation* is discouraged. Instead, the configuration of the potentials, peak-to-peak *amplitude, duration,* number of *phases,* and stability of configuration, in addition to the *frequency* of occurrence, should be specified.

MYOKYMIC DISCHARGE

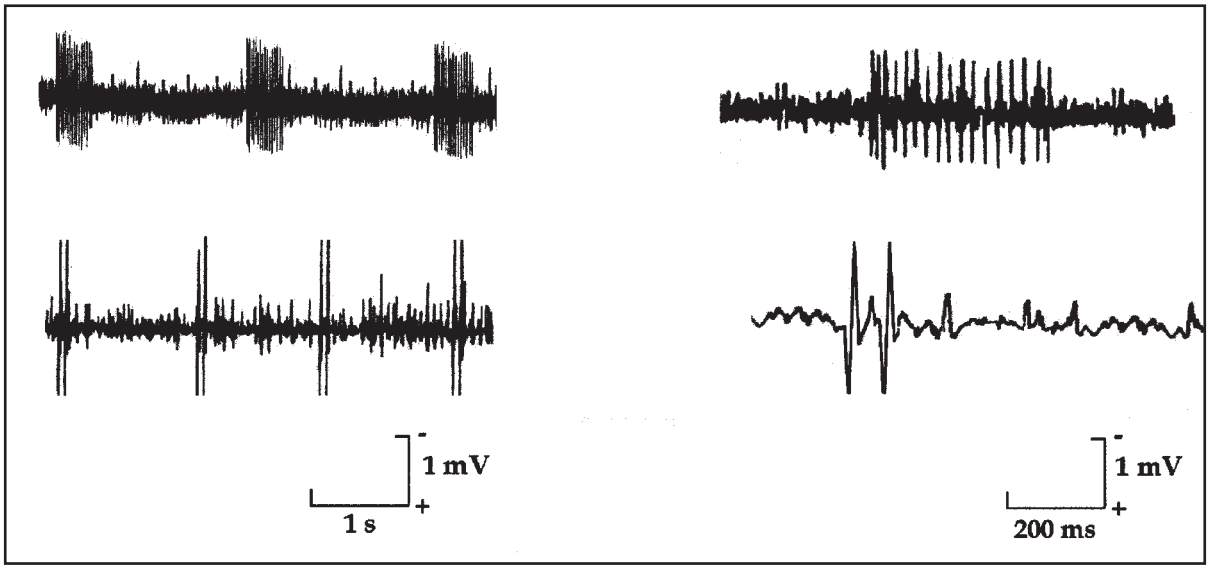

Figure 25. Tracings of two different *myokymic discharges* recorded with an intramuscular *needle electrode* are displayed on a time scale (left) which illustrates the firing pattern and with a different time scale (right) which illustrates that the individual *potentials* have the configuration of a *motor unit action potential.* A myokymic discharge is a group of motor unit action potentials that fire repetitively and may be associated with clinical *myokymia.* Two firing patterns have been described. (1) Commonly, the discharge is a brief, repetitive firing of single motor unit action potentials for a short period (up to a few seconds) at a uniform rate (2 to 60 *Hz*) followed by a short period (up to a few seconds) of silence, with repetition of the same sequence for a particular *potential.* (2) Rarely, the potential recurs continuously at a fairly uniform firing rate (1 to 5 Hz). Myokymic discharges are a subclass of *grouped discharges* and *repetitive discharges.*

NEUROMYOTONIC DISCHARGE

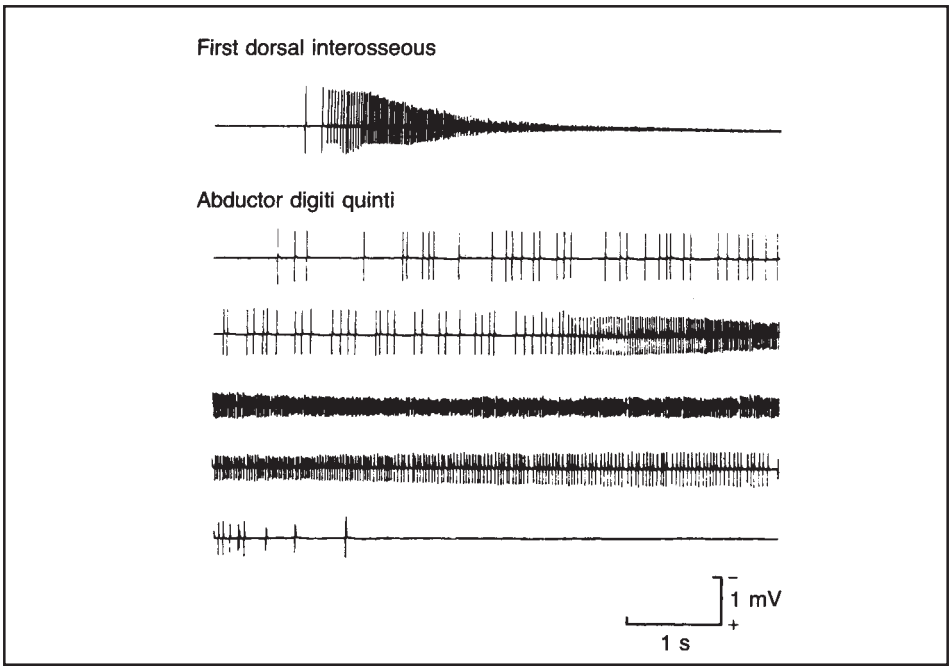

Figure 26. *Neuromyotonic discharges* recorded by an intramuscular *needle electrode* are shown on a time scale which illustrates the characteristic firing pattern. A neuromyotonic discharge is a burst of *motor unit action potentials* which originates in motor axons firing at high rates (150 to 300 *Hz*) for a few seconds. They often start and stop abruptly. The *amplitude* of the *waveforms* typically wanes. *Discharges* may occur spontaneously or be initiated by *needle electrode* movement, voluntary effort, ischemia, or percussion of a nerve. These discharges should be distinguished from *myotonic discharges* and *complex repetitive discharges.* They are one type of electrical activity that may be recorded in patients who have clinical *neuromyotonia.*

CRAMP DISCHARGE

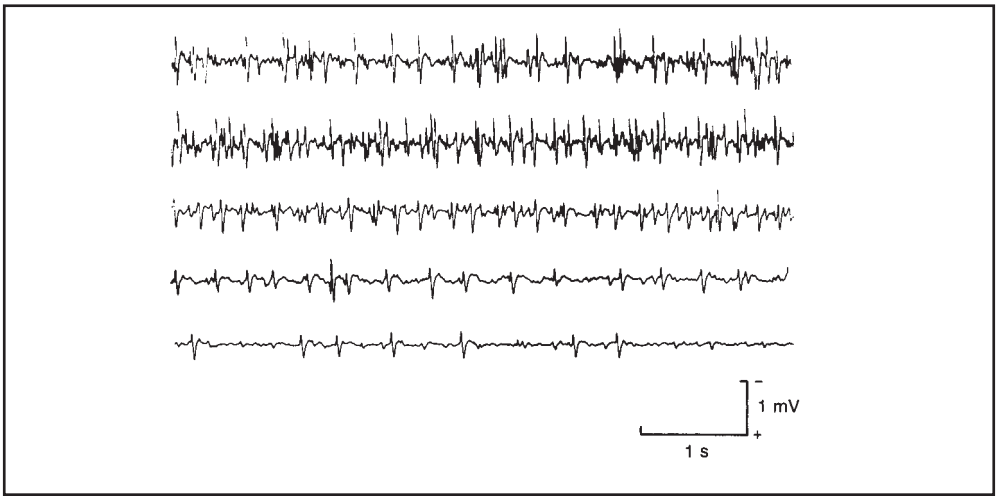

Figure 27. *Cramp discharges* recorded by an intramuscular *needle electrode.* A cramp discharge arises from the involuntary repetitive firing of *motor unit action potentials* at a high *frequency* (up to 150 *Hz*) in a large area of muscle, usually associated with painful muscle *contraction*. Both the *discharge frequency* and the number of motor unit action potentials firing increase gradually during development, and both subside gradually with cessation. See *muscle cramp.*

MOTOR UNIT ACTION POTENTIALS

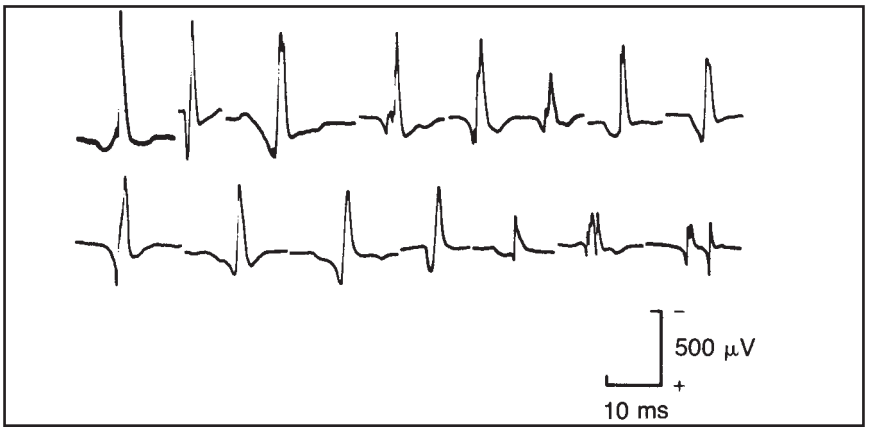

Figure 28. A selection of different *motor unit action potentials* recorded with an intramuscular *needle electrode.* A motor unit action potential is a *potential* which reflects the electrical activity of a single *motor unit.* It is the *compound action potential* of those muscle fibers within the recording range of an *electrode.* When it is produced by voluntary muscle contraction, the potential is characterized by its consistent appearance and relationship to the force of contraction. The following parameters may be specified, quantitatively if possible, after the *recording electrode* is placed randomly within the muscle.

1. Configuration
   a. *Amplitude,* peak-to-peak (μV or mV).
   b. *Duration,* total (ms).
   c. Number of *phases (monophasic, biphasic, triphasic, tetraphasic, polyphasic).*
   d. Sign of each *phase* (negative, positive).
   e. Number of *turns.*
   f. Variation of shape (*jiggle*), if any, of consecutive *discharges.*
   g. Presence of *satellite (linked potentials),* if any.
   h. *Spike* duration, the duration of the spike including satellites.
2. *Recruitment* characteristics
   a. *Threshold* of activation (first recruited, low threshold, high threshold).
   b. *Onset frequency*
   c. *Recruitment frequency (Hz)* or *recruitment interval* (ms) of individual potentials.

Descriptive terms implying diagnostic significance are not recommended, e.g., *myopathic, neuropathic, regeneration, nascent, giant, BSAP* and *BSAPP.* See *polyphasic action potential, serrated action potential.*

SATELLITE POTENTIAL

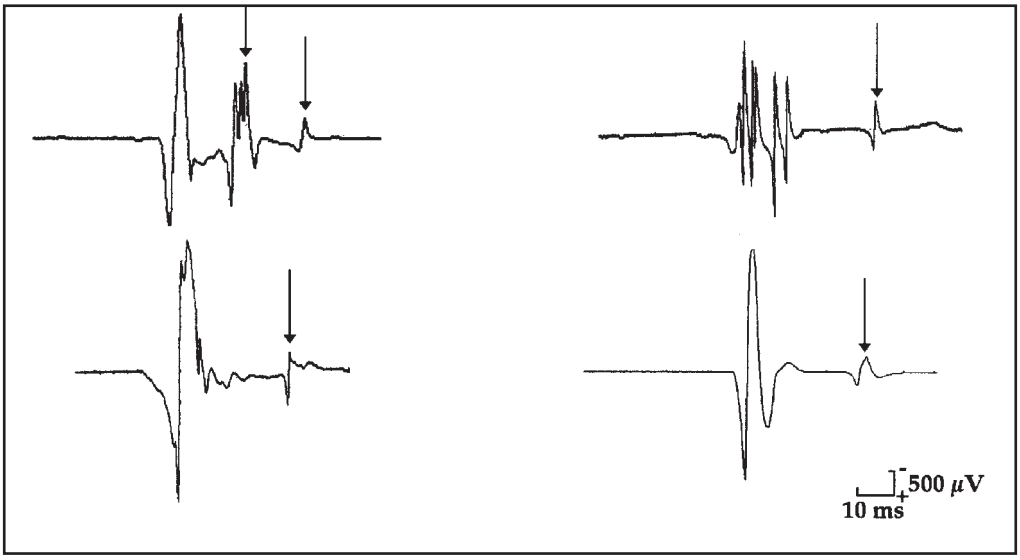

Figure 29. Four discharges of the same *motor unit action potential* with *satellite potentials* are indicated by the arrows. A satellite potential is a small *action potential* separated from the main motor unit action potential by an isoelectric interval which fires in a time-locked relationship to the main action potential. These *potentials* usually follow, but may precede, the main action potential. Less preferred terms include *late component, parasite potential, linked potential,* and *coupled discharge.*

RECRUITMENT PATTERN/INTERFERENCE PATTERN

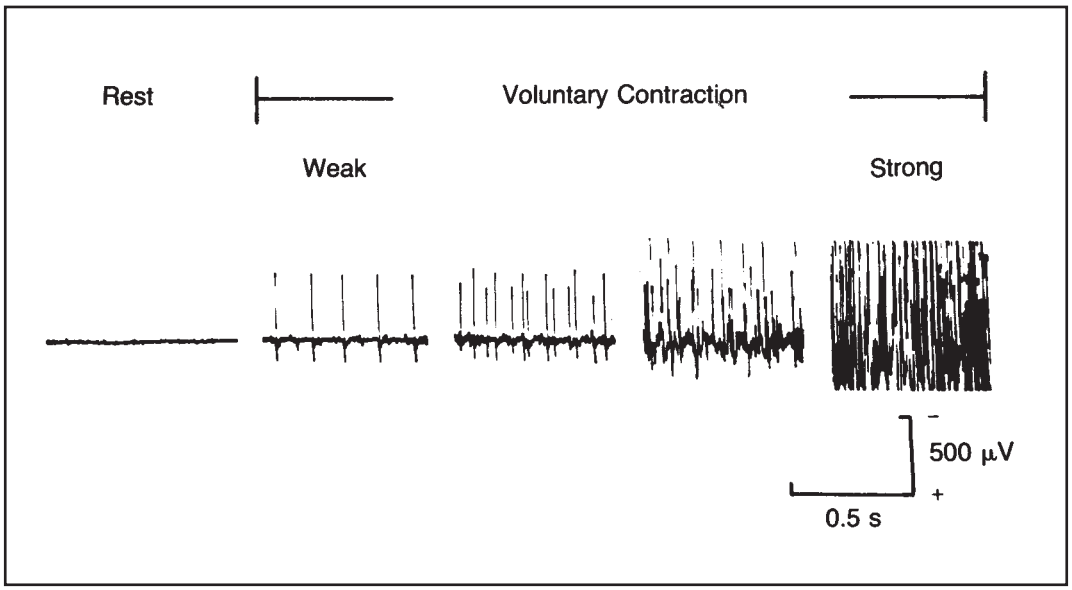

Figure 30. Recordings made with an intramuscular *needle electrode* at five different levels of force of voluntary *contraction. Recruitment* refers to the successive *activation* of the same and new *motor units* with increasing strength of voluntary muscle contraction. The recruitment pattern is a qualitative and/or quantitative description of the sequence of appearance of *motor unit action potentials* during increasing voluntary muscle contraction. The *recruitment frequency* and *recruitment interval* are two quantitative measures commonly used. The *interference pattern* is the electric activity recorded from a muscle with a *needle electrode* during maximal voluntary effort. A full interference pattern implies that no individual motor unit action potentials can be clearly identified (see tracing on far right). A reduced interference pattern (intermediate interference pattern) is one in which some of the individual motor unit action potentials may be identified while others cannot due to superimposition of *waveforms.* The term discrete activity is used to describe the electric activity recorded when each of several different motor unit action potentials can be identified due to limited superimposition of waveforms. The term single unit pattern is used to describe a single motor unit action potential, firing at a rapid rate (should be specified) during maximum voluntary effort. The force of contraction associated with the interference pattern should be specified.

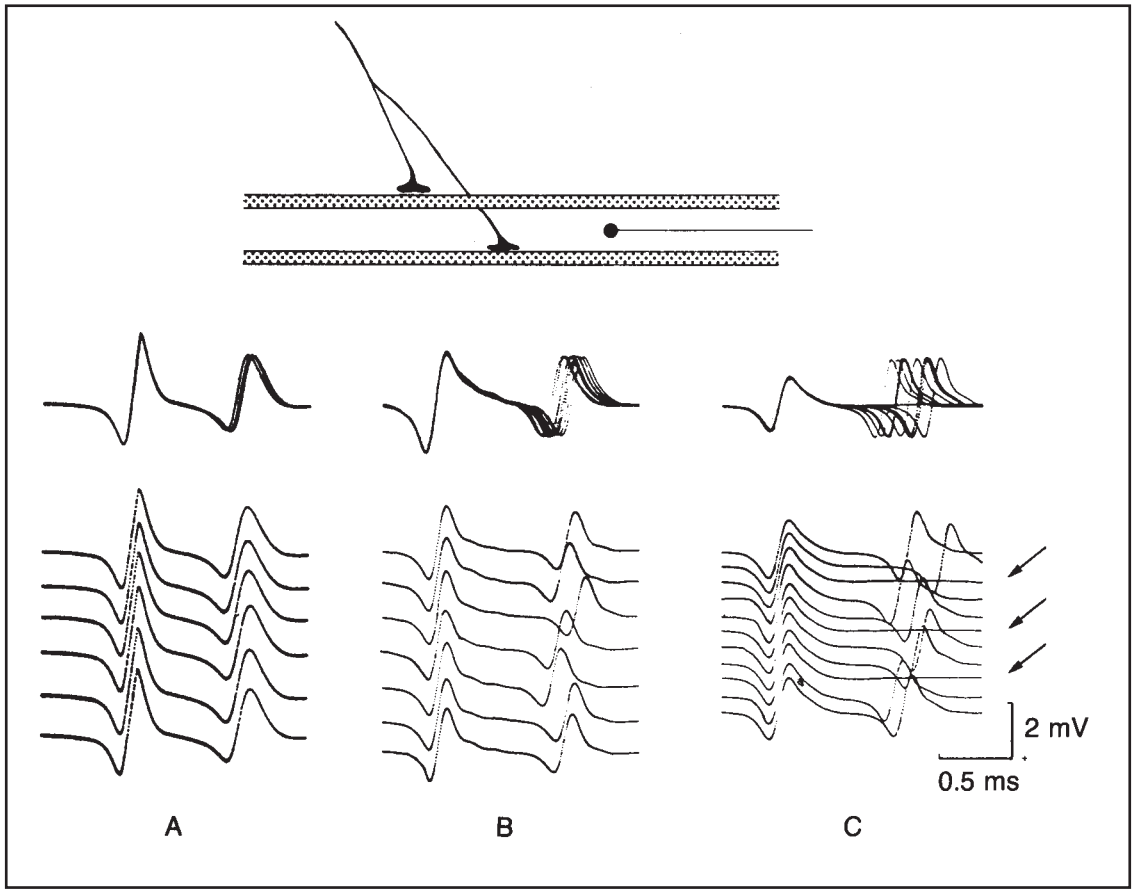

Figure 31. Schematic representation of the location of the recording surface of a *single fiber needle electrode* recording from two muscle fibers innervated by the same motor neuron (row 1). Consecutive *discharges* of a *potential* pair are shown in a superimposed display (row 2) and in a *raster* display (row 3). The potential pairs were recorded from the extensor digitorum communis of a patient with *myasthenia gravis*. They show normal jitter (column A), increased *jitter* (column B), and increased jitter and *impulse blocking* (column C, arrows). Jitter is synonymous with "single fiber electromyographic jitter." It is the variability of the *interpotential interval* between two *muscle fiber action potentials* belonging to the same *motor unit* on consecutive discharges. It is usually expressed quantitatively as the mean value of the difference between the interpotential intervals of successive discharges (the *mean consecutive difference, MCD*). Under certain conditions, jitter is expressed as the mean value of the difference between interpotential intervals arranged in the order of decreasing interdischarge intervals (the *mean sorted difference, MSD*).

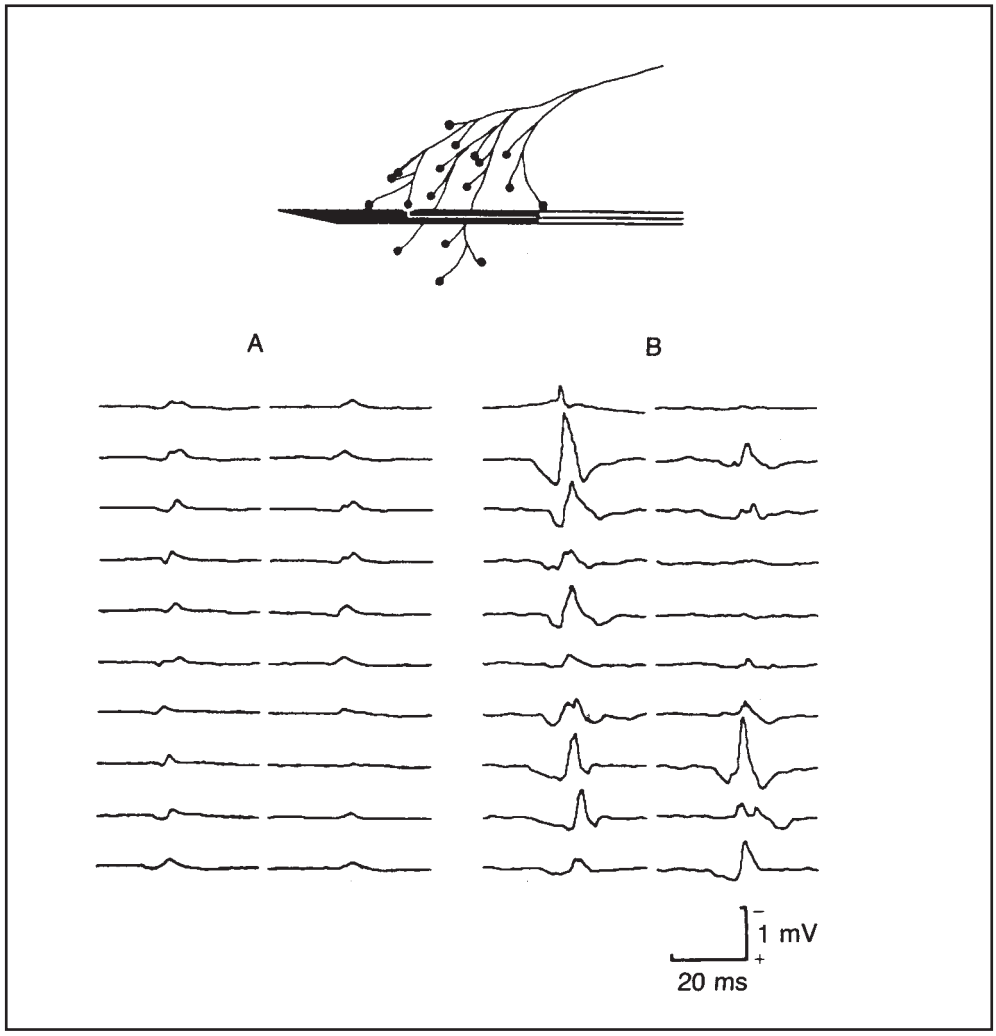

Figure 32. Schematic representation of the location of the recording surface of the *macro-EMG needle electrode* recording from all the muscle fibers innervated by the same motor neuron (upper diagram). *Macro motor unit potentials* recorded by the technique of *macroelectromyography* (lower traces) from a healthy subject (column A) and from a patient with amyotrophic lateral sclerosis (column B). Macroelectromyography is a general term referring to the technique and conditions that approximate recording of all *muscle fiber action potentials* arising from the same *motor unit.*

NEEDLE ELECTRODES

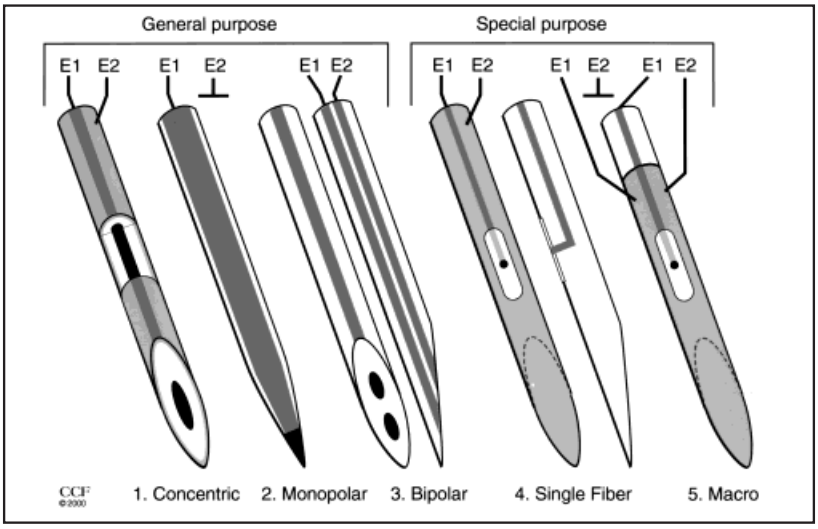

Figure 33. Schematic representation of five different types of needle electrodes. (1) The *concentric needle electrode* consists of a hollow, stainless steel cannula (light gray) containing a centrally located wire (black) from which it is insulated. The latter serves as the *active electrode (E1),* while the entire barrel of the needle serves as the *reference electrode (E2).* (2) The *monopolar needle electrode* consists of a solid stainless steel needle coated with insulation except for its distal tip, which serves as the cone-shaped recording surface (E1). The reference electrode (E2) consists of either another monopolar needle electrode or a *surface electrode.* (3) The *bipolar needle electrode* consists of a stainless steel hollow cannula which contains two wires, insulated from each other and from the cannula itself. The exposed distal tips of these wires on the bevel surface serve as the active (E1) and reference (E2) electrodes. (4) *Single fiber needle electrode.* Similar to the concentric needle electrode, the proximal portion of this electrode consists of a hollow cannula, which contains a central wire from which it is insulated. This wire, instead of ending on the bevel tip, is exposed through a side port in the cannula opposite the bevel tip. The bared area serves as the active electrode (E1) while the surface of the cannula serves as the reference electrode (E2). (5) The *macro-EMG needle electrode* consists mainly of a modified single fiber needle electrode. Two different *potentials* are recorded. The first is recorded from the single fiber EMG needle electrode. The recording surface opposite the bevel of the needle serves as the active electrode (E1), and the uninsulated portion of the cannula (light gray) serves as the reference electrode (E2). The potential recorded from this electrode is used to trigger the sweep for recording the *macro motor unit potential* from the second electrode. The second electrode consists of the uninsulated portion of the cannula, which serves as the active electrode (E1). A surface electrode serves as the reference electrode (E2).

FULL WAVE RECTIFIED EMG

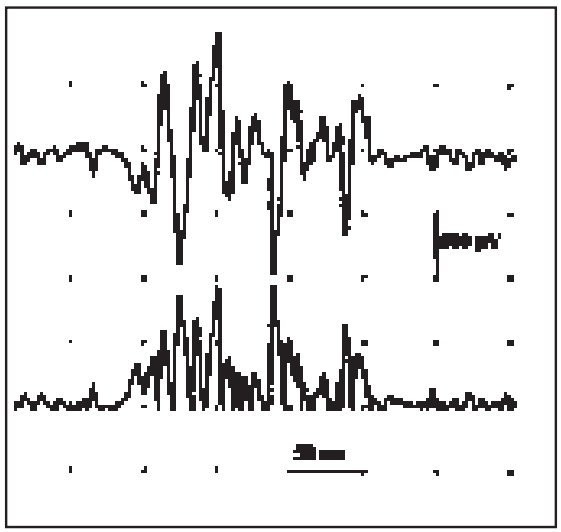

Figure 34. *Motor unit action potentials* recorded normally (top sweep) and simultaneously as a *full wave rectified EMG* signal (bottom sweep). A full wave rectified EMG signal is the absolute value of the raw EMG signal. Full wave rectification involves inverting all the *waveforms* below the *isopotential line* and displaying them with opposite polarity above the line. A technique used to analyze *kinesiologic EMG* signals.

SYMPATHETIC SKIN RESPONSE

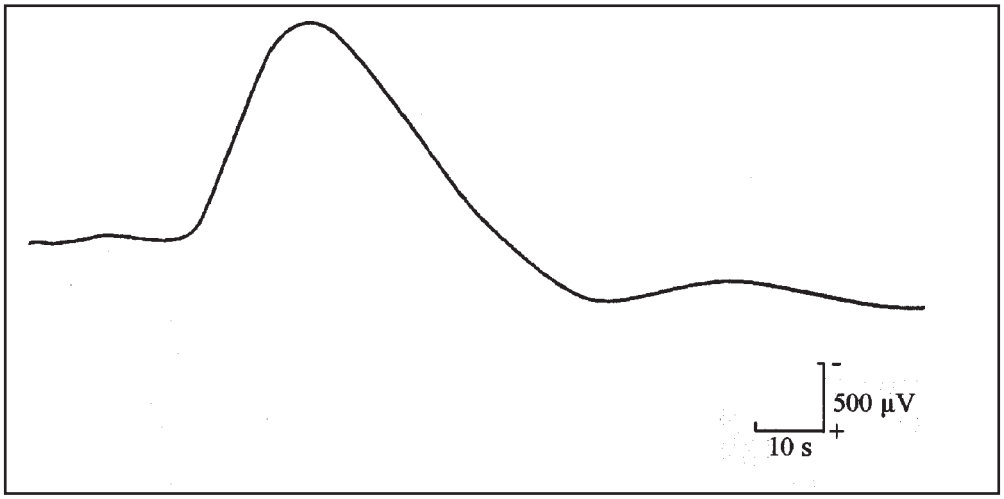

Figure 35. *Sympathetic skin response* recorded from the palm following stimulation of the contralateral median nerve. The sympathetic skin response is an electric *potential* resulting from electrodermal activity in sweat glands in response to both direct and peripheral or sympathetic trunk stimulation of autonomic activity.

SECTION III:
ABBREVIATIONS

The Glossary follows the recommendations of the Council of Biology Editors Style Manual (6th edition)[1] for abbreviations of units of measurement. The abbrevations are as follows:

meter	m	millivolt	mV
centimeter	cm	microvolt	μV
millimeter	mm	ampere	A
hour	h	milliampere	mA
minute	min	microampere	μA
second	s	ohm	Ω
millisecond	ms	hertz	Hz
microsecond	μs	cycles per second	cps or c/s
volt	V		

1. CBEStyle Manual Committee. *Scientific Style and Format: The CBE Manual for Authors, Editors, and Publishers.* 6th ed Council of Biology Editors, 1994.