Oct. 22, 1969

Dear Mr.

I thought of you when the author of the attached report came in to see me the other day. As you see, he has invented a better sleep machine. The machine is being used by co-author [redacted] I know enough about sleep physiology to detect some flagrant mistakes in the text, but am sending you a copy in hopes you may be able to give me an confidential evaluation. The reason I am asking you to go to the trouble is that [redacted] is giving a report on use of the machine in San Francisco [redacted] Do you think the machine is a lot of hookum or may he have something? [redacted] He says he is an electronic engineer.

Thanks for any help you can give.

Sincerely.

[redacted]

xerox copy to [redacted] for Information

Introd to Seq Smoothing + Prediction 1969. McGraw-Hill

Discrete funct. analysis stat Communic Theory John Wiley

REM ELECTRO-THERAPY

THE RUSSIANS PIONEERED "SLEEP THERAPY" OVER THIRTY YEARS AGO, AND HAVE TREATED MORE THAN 500,000 PERSONS IN SOME 300 SLEEP CLINICS LOCATED IN VARIOUS PARTS OF THEIR COUNTRY. AMERICAN SCIENTISTS HAVE BEEN SKEPTICAL OF ELECTROSLEEP BECAUSE OF THE WIDE RANGE OF CONDITIONS WHICH THE RUSSIANS CLAIM TO BENEFIT. LIKEWISE, THE RUSSIAN CHOICE OF THE NAME "ELECTROSLEEP" CREATED THE IMPRESSION THAT IT WAS A MACHINE TO INDUCE NATURAL SLEEP BY ELECTRICAL STIMULATION, AND THAT AN EXTRA HOUR OR TWO OF NATURAL SLEEP WAS RESPONSIBLE FOR ITS SUCCESS. HOWEVER, THE RUSSIANS DIDN'T KNOW HOW OR WHY IT WORKED ON SUCH AN APPARENTLY UNRELATED GROUP OF AILMENTS, BUT SINCE IT WAS FOUND THAT MANY OF THE OBSERVABLE AND MEASURABLE CHANGES THAT OCCUR WHEN AN INDIVIDUAL GOES FROM WAKEFULNESS TO SLEEP TOOK PLACE DURING STIMULATION, THE NAME "ELECTROSLEEP" PROBABLY SEEMED TO THEM AS A LOGICAL CHOICE. UNFORTUNATELY, WHEN AMERICAN INVESTIGATORS TESTED THE ELECTROSON SOLELY AS A SLEEP-INDUCING MACHINE RATHER THAN A MODALITY FOR TREATING VARIOUS AILMENTS AND FOUND THAT ONLY A PORTION OF THE SUBJECTS ACTUALLY FELL ASLEEP, THEY CONSIDERED THAT THE RUSSIAN CLAIMS WERE GREATLY EXAGGERATED.

HOWEVER, AT LONG LAST, AMERICAN DOCTORS ARE SHOWING INTEREST IN ELECTROSLEEP THERAPY BECAUSE OF THE LARGE AMOUNT OF AMERICAN RESEARCH ON SLEEP SINCE ABOUT 1955. THIS

INTEREST STEMMED FROM THE DISCOVERY OF A NEW KIND OF SLEEP AND FROM A NUMBER OF INVESTIGATIONS OF THE EFFECTS OF SLEEP DEPRIVATION. THIS NEW KIND OF SLEEP IS MOST COMMONLY CALLED REM, DREAM, OR DEEP SLEEP BECAUSE ITS MOST SALIENT FEATURES ARE RAPID EYE MOVEMENTS, DREAMING, AND EXTREME MUSCLE RELAXATION. QUIET, OR SLOW-WAVE, SLEEP IS SO NAMED BECAUSE OF THE ABSENCE OF THE OCCASIONAL BODY MOVEMENTS OF REM SLEEP AND THE FACT THAT THE BRAIN WAVES HAVE MUCH LOWER FREQUENCIES.

MODERN THEORIES ON SLEEP ARE DERIVED FROM A CONSIDERABLE AMOUNT OF RESEARCH USING THE ADVANCED TECHNIQUES OF ELECTRONIC INSTRUMENTATION, AND THIS RESEARCH DISCLOSES THAT THE ONSET OF SLEEP IS A VERY COMPLEX INTEGRATION OF MANY FACTORS WHICH INVOLVE BOTH EXCITATORY AND INHIBITORY PROCESSES. THESE THEORIES ARE FAR FROM BEING COMPLETE, BUT FOR THE PURPOSE OF THIS PAPER, AN ELEMENTARY DESCRIPTION OF PHENOMENA WHICH ARE PERTINENT TO AN EXPLANATION OF ELECTRICAL STIMULATION ARE PRESENTED HERE.

THE STATE OF WAKEFULNESS IS MAINTAINED BY TWO ENTIRELY DIFFERENT TYPES OF ACTIVATORY PROCESSES WHICH ARE CALLED SENSORY STIMULATION AND TONIC FACILITATION. IN SENSORY STIMULATION, THERE IS A FLOW OF INFORMATION FROM THE SENSE ORGANS WHICH ARE LOCATED BOTH PERIPHERALLY AND INTERNALLY THROUGH THE THALAMIC NUCLEUS IN THE BRAINSTEM TO VARIOUS REGIONS IN THE BRAIN WHICH ARE SPECIFIC TO EACH TYPE OF INFORMATION. THE FLOW IS CONTROLLED OR MODULATED BY THE SENSORY RECEPTORS, VARIOUS SYNAPSES, AND BY THE BRAINSTEM CONTROL CENTER. THESE STIMULI UNDER CERTAIN CONDITIONS ALSO MAY INDUCE A REVERSE FLOW FROM THE CEREBRAL CORTEX TO THE BRAINSTEM CAUSING FURTHER AROUSAL ACTIVATION. THE ONSET OF SLEEP MECHANISM STARTS WITH INHIBITION IN THIS SYSTEM. VISUAL AND AUDITORY STIMULI, MUSCLE TENSION, AND

MOTOR ACTIVITY ALL HAVE STRONG AROUSAL ACTION WHICH ARE NORMALLY INHIBITED WHEN WE LIE DOWN AND RELAX IN A QUIET, DARK ROOM. ARTIFICIAL INHIBITION OF AUDITORY AND VISUAL STIMULATION IS MOST EFFECTIVELY ACCOMPLISHED BY HABITUATION OF SPECIFIC MONOTONOUS AUDITORY STIMULI AFTER SOME MINIMUM NUMBER OF CLICKS ARE HEARD, OR BY A FLASHING LIGHT REPEATED FOR A PERIOD OF 300 TO 500 SECONDS. A FAR SUPERIOR VISUAL STIMULUS, HOWEVER, IS THE INDUCTION OF VISUAL IMAGES BY ELECTRICAL STIMULATION OF THE OPTIC SYSTEM, SINCE THE FREQUENCY OF THE FLICKER CAN BE INCREASED BY A FACTOR OF ABOUT THREE BEFORE THE FLICKER DISAPPEARS BY FUSION. A BY-PRODUCT OF THE HABITUATION OF THE AUDITORY AND VISUAL SYSTEMS IS THE DEACTIVATION OF MUSCLE TENSION INDUCING A GENERAL RELAXATION. THIS RESULT IS CONFIRMED NOT ONLY BY THE OBSERVED MUSCLE FLACIDITY BUT BY THE BRAIN-WAVE PATTERN AS PORTRAYED BY THE ENCEPHALOGRAPH WHICH SHOWS A CHANGE FROM THE ACTIVATORY PATTERN OF WAKEFULNESS TO THE ALPHA FORM OF THE RELAXED STATE. THE SENSORY SYSTEM IS INACTIVE DURING SLEEP AND IF NO STIMULATION IS PRESENT, SLEEP WILL FOLLOW. THIS PHENOMENON IS EXEMPLIFIED BY THE CASE OF A SUBJECT WHO, THROUGH INJURY, LOST THE SIGHT IN ONE EYE AND THE HEARING IN ONE EAR, WHO WOULD FALL ASLEEP EVENTUALLY WHENEVER THE GOOD EYE AND EAR WERE COVERED AND PLUGGED RESPECTIVELY.

IN ORDER TO PREVENT UNWANTED SLEEP THE BRAIN IS PROVIDED WITH A CONTINUOUS STIMULATION WHICH ORIGINATES IN THE MESENCEPHALIC HEMISPHERE OF THE BRAINSTEM. THIS TONIC FACILITATION WHICH KEEPS THE BRAIN AWAKE HAS A MAXIMUM INTENSITY AFTER AWAKENING AND IT IS CONTINUOUSLY SUPPRESSED DURING THE DAY WITH A MINIMUM MAGNITUDE AT BED-TIME. THE ORIGIN OF THIS SUPPRESSION OF TONIC FACILITATION IS RELATED TO THE NEED FOR RECOVERY WHICH PROGRESSES DURING THE DAY AND TERMINATES IN SLEEP. THE TIME FOR RECOVERY RANGES FROM MAGNITUDES MEASURED IN MILLISECONDS, SUCH AS

THE NERVES, TO HOURS IN THE CASE OF THE HIGHEST LEVEL OF CEREBRAL ACTIVITY. THIS HIGHEST LEVEL IS FOUND TO OCCUR IN LEARNING AND CONDITIONING WHICH IS THE REASON FOR THE LARGE AMOUNT OF TIME SPENT BY A BABY IN SLEEP. THIS ACTIVITY IS BELIEVED TO PRODUCE CHANGES IN THE LARGE GLIAL CELLS AND SYNAPSES IN THIS LEVEL, AND THESE CHANGES ARE CONSIDERED TO PROGRESSIVELY SUPPRESS THE TONIC FACILITATION OF THE MESENCEPHALON DURING THE DAY, SO THAT WHEN THE SENSORY STIMULI ARE CUT OFF, SLEEP WILL FOLLOW.

SOME PROCEDURES USED BY SCIENTISTS FOR FINDING A CORRELATION BETWEEN A SPECIFIC REGION AND ITS FUNCTIONS ARE TO STIMULATE THE REGION WITH VARIOUS CHEMICALS OR ELECTRICAL CURRENTS OF VARIOUS CHARACTERISTICS, AND OBSERVE THE PHENOMENA PRODUCED; AND TO CUT OR REMOVE A SPECIFIC REGION AND OBSERVE THE CHANGE IN PHENOMENA BEFORE AND AFTER RE-STIMULATION, SOMETIMES SUPPLEMENTED BY APPROPRIATE ELECTRONIC INSTRUMENTATION.

WHEN THE MESENCEPHALON IS REMOVED IN ANIMALS A SLEEP-LIKE STATE CHARACTERIZED BY EYE CLOSURE, MUSCLE RELAXATION, LOWERED PULSE AND RESPIRATION RATES, AND INSENSIBILITY TO TACTILE PRESSURE HAS BEEN PRODUCED. THE SAME SLEEP-LIKE STATE HAS BEEN INDUCED BY INSERTING MICRO ELECTRODES AND PASSING A LOW FREQUENTY CURRENT THROUGH THE MESENCEPHALON.

IN REVIEW, IT HAS BEEN ESTABLISHED THAT THREE STIMULI CAN PROVIDE THE CONDITIONS FOR THE ONSET OF SLEEP, NAMELY, AN AUDITORY MONOTONE FOR HABITUATING THE AUDITORY CORTEX, AN ELECTRICAL FLICKER FOR HABITUATING THE VISUAL CORTEX - EITHER ONE OF WHICH WILL INDUCE A RELAXED MUSCULATURE

AND A LOW FREQUENCY ELECTRICAL CURRENT WHICH MUST PASS THROUGH THE BRAINSTEM IN ORDER TO DEACTIVATE THE MESENCEPHALON. HOWEVER, A NEW PROBLEM EXISTS BECAUSE TWO DIFFERENT ELECTRIC CURRENTS FLOWING IN THE SAME REGION WILL INTERFERE WITH EACH OTHER. THIS PROBLEM WAS SOLVED BY SYNCHRONIZING THE TWO ELECTRICAL CURRENTS. THIS SYNCHRONIZATION PRODUCED AN AMAZING RESULT - THE ELECTRICAL FLICKER WAS TWICE AS BRIGHT IF THE LOW FREQUENCY CURRENT THROUGH THE BRAINSTEM WAS THE SAME AS THE ALPHA RHYTHM, AND IF THE FLICKER CURRENT FREQUENCY WAS FOUR TIMES THE ALPHA FREQUENCY. THE RESULTS WERE OPTINUM WHEN THE MONOTONE WAS ALSO SYNCHRONIZED WITH THE TWO ELECTRICAL STIMULI. THE THREE SYNCHRONIZED STIMULI - AUDITORY MONOTONE, ALPHA DRIVE, AND ELECTRICAL FLICKER - INDUCE A STATE OF RELAXATION, A SLEEP-LIKE STATE, OR SLEEP.

CONCERN OVER LOSS OF SLEEP BY THE ARMED FORCES DURING WAR RESULTED IN NUMEROUS STUDIES ON THE EFFECTS OF SLEEP DEPRIVATION SINCE IT HAD BEEN KNOWN FOR A LONG TIME THAT SLEEP DEPRIVATION LEADS TO MAL-FUNCTION, PERMANENT DAMAGE, AND FINALLY DEATH; AND ALSO THAT TEMPORARY SLEEP LOSS IS MADE UP BY INCREASED SLEEPING TIME DURING THE RECOVERY PERIOD. THE MENTAL SYMPTOMS OF SLEEP LOSS FOLLOW A SLOW AND PREDICTABLE PATTERN, AND THE CHANGES ACCELERATE AS TIME PASSES. SOME OF THE CHANGES FOLLOWING SLEEP DEPRIVATION ARE: INATTENTION, WEARINESS, LACK OF CONCENTRATION, LOSS OF MEMORY, SLURRED AND FAULTY SPEECH, LISTLESS BEHAVIOR, REDUCED MUSCULAR EXERTION, ANXIETY, SKIN SENSATIONS, WITHDRAWAL FROM REALITY, TIME DISORIENTATION, VISUAL DISTORTIONS, ILLUSIONS, HALLUCINATIONS, SEVERE PERSONALITY CHANGES, AND FINALLY A PSYCHOTIC STATE. THE EEG'S OF BRAIN WAVES SHOWED AN ALTERNATION BETWEEN THE ALPHA FORM AND THE SLOW SLEEP-LIKE WAVES, AND THESE ALTERNATIONS ARE CALLED "MICROSLEEPS".

SLEEP IS PRECEDED BY A DECLINE IN ACTIVITIES OR PERFORMANCE AND BY SUBJECTIVE FEELINGS OF TIREDNESS, WHICH HAVE BEEN CONSIDERED TO BE DUE TO AN ACCUMULATION DURING WAKEFULNESS OF WASTE PRODUCTS WHICH ARE DISPOSED OF DURING SLEEP OR OF A DEPLETION DURING WAKFEULNESS OF VITAL CHEMICALS WHICH ARE REPLENISHED DURING SLEEP. WHEN CEREBROSPINAL FLUID FROM FATIGUED DOGS IS INJECTED INTO NON-FATIGUED DOGS, THE LATTER SHOWED SIGNS OF DROWSINESS AND SLEEP, THUS INDICATING THAT A HYPNOGENIC SUBSTANCE ACCUMULATED DURING WAKEFULNESS. SEROTONIN, WHICH IS A "HORMONE"-LIKE SUBSTANCE EXHIBITING A WIDE RANGE OF POWERFUL EFFECTS ON THE BRAIN AND OTHER ORGANS OF THE BODY, IS FOUND IN CEREBROSPINAL FLUID. SIMILAR EXPERIMENTS WITH WATER-SOLUBLE EXTRACTS FROM THE BRAINS OF SLEEPING ANIMALS PRODUCED SLEEP IN THE RECIPIENT ANIMALS. THE MEDULLA AT THE BASE OF THE BRAINSTEM CONTAINS THE RAPHE NUCLEI WHICH ARE NOTED FOR THEIR PRODUCTION OF SEROTONIN. WHEN 80% OF THE CELLS OF THESE NUCLEI ARE DESTROYED THE EXPERIMENTAL ANIMALS SLEPT LESS THAN 10% OF THEIR NORMAL PERIOD. SIMILARLY, THERE IS A LOCUS COERULEUS NUCLEUS JUST BELOW THE RAPHE NUCLEI WHICH CONTAINS THE SYSTEM FOR PRODUCING REM SLEEP, AND THIS NUCLEUS USES NORADRENALIN FOR ITS ACTIVATING AGENT.

IT HAS BEEN LONG SUSPECTED THAT THERE IS A STRONG LINK BETWEEN INSOMNIA AND MENTAL ILLNESS. IN ONE TWO-YEAR SURVEY OF SEVERAL HUNDRED MENTAL PATIENTS (WITH PSYCHOSES, DEPRESSIONS, AND OTHER AILMENTS), IT WAS FOUND THAT 81% OF THEM HAD BEEN SUFFERING FROM SLEEP DISORDERS, AND MANY OF THEM WERE COGNIZANT THAT SLEEP LOSS WAS THE CAUSE OF THEIR AILMENT. IN ANOTHER STUDY OF A LARGE NUMBER OF PATIENTS HAVING HEART SURGERY, IT WAS FOUND THAT A HOSPITAL IS NO PLACE TO FIND REST. PATIENTS COMPLAINED BITTERLY OF LACK OF SLEEP IN A BUSY WARD WITH HOURLY MEDICAL CHECKS AND

EXTENDED NURSING CARE. THIS STUDY DISCLOSED THE FACT THAT IN A THREE TO FIVE DAY POST-OPERATIVE PERIOD, OVER ONE-THIRD OF THE PATIENTS HAD DEVELOPED PARANOID SUSPICIONS, DELIRIUM, DISORIENTATION, AND HALLUCINATIONS WHICH VANISHED AFTER THE PATIENT WAS PLACED IN A QUIET ROOM WITH A MINIMUM NUMBER OF INTERRUPTIONS. THESE AND OTHER STUDIES BRING LOSS OF SLEEP INTO FOCUS AS AN IMPORTANT FACTOR IN MEDICAL PRACTICE SINCE THE SLEEP DEPRIVATION STUDIES SHOWED THAT THE SYMPTOMS APPEARING WERE ESSENTIALLY THE SAME AS FOUND IN THE MENTALLY ILL. THE IMPORTANT QUESTION IS, THEREFORE, WHICH KIND OF SLEEP LOSS IS THE CULPRIT.

SEVERAL STUDIES OF REM SLEEP DEPRIVATION WERE MADE AFTER OVERCOMING THE DIFFICULTIES OF DETERMINING THE EXACT TIME THAT REM DREAMING STARTED AND ENDED. WHEN AN INDIVIDUAL GOES TO SLEEP, HIS INITIAL QUIET SLOW-WAVE SLEEP LASTS FOR A PERIOD OF 60 TO 90 MINUTES AFTER WHICH HE STARTS DREAMING. THERE ARE NORMALLY FOUR OR FIVE OF THESE REM PERIODS, IN WHICH THE FIRST ONE IS THE SHORTEST AND THE LAST ONE IS THE LONGEST, AND ONLY THE DREAMS OF THE LAST ONE ARE REMEMBERED. THE TOTAL REM SLEEPING TIME IS, ON THE AVERAGE, 20% OF THE TOTAL PERIOD. THESE STUDIES DISCLOSED THE AMAZING FACT THAT THE LOSS OF REM SLEEP PRODUCED ESSENTIALLY THE SAME MAL-FUNCTIONING THAT OCCURRED WITH TOTAL SLEEP DEPRIVATION. THE SUBJECTS ACTUALLY SLEPT MUCH LONGER THAN USUAL IN THE QUIET SLOW-WAVE PHASES AND THEY WERE EXTREMELY DIFFICULT TO AWAKEN. THE DISCOVERY OF THIS BASIC PHENOMENON PROVIDES THE SCIENTIST WITH A NEW TOOL FOR ATTACKING SLEEP DISORDERS AND THEIR DERIVATIVE AILMENTS. THIS THIRD STATE OF CONSCIOUSNESS CAN BE IDENTIFIED BY ITS SALIENT CHARACTERISTICS SUCH AS AN EEG PATTERN RESEMBLING THAT OF WAKEFULNESS, RAPID EYE MOVEMENTS, OFTEN JERKING OF THE LIMBS, MARKED FLACIDITY OF NECK MUSCLES, AND ALMOST ALWAYS A REPORT OF DREAMING WHEN AWAKENED.

ANOTHER IMPORTANT FACET OF TOTAL SLEEP DEPRIVATION IS THAT THERE IS A CHANGE IN QUALITY OF SLEEP, AND THIS CHANGE IS FOR THE WORST SINCE THERE IS A LARGER PERCENTAGE LOSS OF THE REM STATE.

SLEEPING PILLS AND TRANQUILIZERS ARE USED IN LARGE QUANTITIES FOR THEIR HYPNOGENIC EFFECTS, AND, SINCE THERE ARE TWO KINDS OF SLEEP, INVESTIGATIONS WERE CONDUCTED ON THE KIND OF SLEEP WHICH THEY INDUCED. THE SURPRISING RESULTS WERE THAT BARBITURATES, TRANQUILIZERS, AMPHETAMINES AND ALCOHOL SUPPRESS THE REM STATE WHEN TAKEN REGULARLY.

WHEN REM SLEEP DEPRIVATION IS TERMINATED THERE IS A REBOUND IN THE RECOVERY PERIOD IN WHICH THE SUBJECT SLEEPS FROM 11 TO 14 HOURS AFTER SEVERAL NIGHTS OF SLEEP LOSS WITH A MUCH HIGHER THAN NORMAL PROPORTION OF REM SLEEP. WITH LONGER PERIODS OF DEPRIVATION THE PROPORTION OF REM INCREASED. ANIMAL STUDIES DETERMINED THAT AFTER REM SLEEP DEPRIVATION THEY SEEMED TO RECOVER ABOUT 60% OF THEIR LOST DREAM PERIODS. FURTHER STUDIES WERE MADE ON THE RECOVERY PERIOD PHENOMENON USING TWO GROUPS OF RATS DEPRIVED OF SLEEP FOR FOUR OR FIVE DAYS WHERE ONE GROUP WAS GIVEN A SLIGHT ELECTRIC SHOCK BY TOUCHING THE ELECTRODE TO THE EAR. THE UNSHOCKED CONTROL GROUP SHOWED THE USUAL INCREMENTAL COMPENSATORY PERIOD OF REM SLEEP BUT THE SHOCKED GROUP SPENT A MUCH SMALLER PERIOD IN REM SLEEP. THIS KEY EXPERIMENT PROVIDES A NEW METHOD OF QUICKLY REMOVING REM SLEEP DEPRIVATION EFFECTS IN THE RAT WHICH WAS SUBSEQUENTLY VERIFIED IN THE CAT- NAMELY, BY PASSING AN ELECTRICAL CURRENT THROUGH THE HEADS OF THESE ANIMALS. THIS EXPERIMENT SUGGESTS THAT THE ELECTRIC CURRENT CAUSES THE RELEASE OF A COMPOUND THAT COULD BLOCK THE FLOW OF THE ACTIVATING AGENT FOR REM SLEEP, WHICH HAS BEEN IDENTIFIED AS NORADRENALIN. IT HAS BEEN KNOWN FOR

SOMETIME THAT THE PONTINE RETICULAR FORMATION CONTAINS A TIMING DEVICE WHICH PRODUCES REM SLEEP AT REGULAR INTERVALS BUT WHICH IS INTERRUPTED DURING WAKEFULNESS. IT HAS BEEN DETERMINED EXPERIMENTALLY THAT A SPECIFIC DOSE OF RESERPINE IN CATS LEADS TO A COMPLETE ELIMINATION OF REM SLEEP FOR AS LONG AS FOUR DAYS. A POSSIBLE HYPOTHESIS IS, THEREFORE, THAT THE ELECTRIC CURRENT COUNTERACTED THE BLOCKING EFFECT OF A RESERPINE-LIKE SUBSTANCE OF EITHER THE TIMING DEVICE OR OF THE EXCRETION OF NORADRENALIN FROM THE LOCUS COERULEUS REGION. IF THE CAUDAL PONTINE RETICULAR FORMATION IS CUT OR REMOVED, REM SLEEP IS COMPLETELY ELIMINATED, BUT IF THIS REGION IS STIMULATED ELECTRICALLY WHILE MAN IS IN A SLOW SLEEP-LIKE STATE, REM SLEEP WILL FOLLOW. IT IS POSSIBLE FOR STRONG AROUSAL STIMULI OR DRUGS, SUCH AS AMPHETAMINE, TO COUNTERACT THIS ELECTRICAL STIMULATION. THUS, WE FIND THAT ELECTRICAL STIMULATION OF THE BRAINSTEM AFTER SENSORY HABITUATION LEADS TO A QUIET SLEEP-STATE FOLLOWED BY THE REM STATE IN WHICH SYMPTOMS OF REM SLEEP DEPRIVATION ARE REVERSED. THESE CHANGES ARE DRAMATIC IN A LARGE NUMBER OF CASES FOR IN MANY INSTANCES A SINGLE ONE-HOUR STIMULATION COMPLETELY REVERSES THE SYMTOLOGY OF DEPRESSION AND OTHER SIMILAR MENTAL DISORDERS INDUCING A STATE OF CALMNESS AND WELL-BEING.

THE CLINICAL APPLICATION OF ELECTRICAL STIMULATION TO MAN INTRODUCES THE PROBLEM OF PASSING AN ELECTRICAL CURRENT THROUGH THE HEAD, BY MEANS OF EXTERNALLY ATTACHED ELECTRODES INSTEAD OF THE USE OF INTRA-SKULL MICRO-ELECTRODES PLACED IN A SPECIFIC REGION OF THE BRAINSTEM. THE SIZE OF THE RETICULAR FORMATION OF THE BRAINSTEM IS NO BIGGER THAN THE LITTLE FINGER, SO IT IS OBVIOUS THAT AN ELECTRICAL CURRENT FROM EXTERNAL ELECTRODES WOULD PASS

THROUGH ALL REGIONS OF THE RETICULAR FORMATION IF IT PASSED THROUGH THE BRAINSTEM AT ALL.

ACCORDING TO OSCILLATOR THEORY, THE IMPEDANCE TO CURRENT FLOW IS A MINIMUM FOR FREQUENCIES APPROXIMATING THE SPONTANEOUS RHYTHMS, AND THE RHYTHMS WHICH ARE FOUND IN THE REGIONS IMPLICATED IN THE INDUCTION OF SLEEP HAVE FREQUENCIES WHICH RANGE FROM LESS THAN 1 CYCLE/SEC. TO ABOUT 14 CYCLES/SEC. FOR EXAMPLE, THE WAVES IN THE PONTINE RETICULAR FORMATION DURING REM SLEEP ARE 6 TO 8 CYCLES/SEC., AND THE WAVES FOR DROWSINESS ARE 8 TO 12 CYCLES/SEC. WHICH ARE ESSENTIALLY THE ALPHA RHYTHM. HOWEVER, THE MOST EFFECTIVE ELECTRICAL FLICKER FREQUENCY IS 32 TO 40 CYCLES/SEC. WHICH IS THE THIRD HARMONIC OF THE ALPHA RHYTHM, AND THEREFORE WILL PROVIDE MINIMAL STIMULATION OF STRUCTURES WITH SPONTANEOUS FREQUENCIES OF 8 TO 10 CYCLES/SEC. THUS, WE FIND THAT FOR OPTIMUM STIMULATION OF THE OPTIC NERVE AND THE BRAINSTEM RETICULAR FORMATION, TWO OSCILLATORS ARE REQUIRED WITH A 4:1 FREQUENCY RATIO.

THERE ARE THREE LOW IMPEDANCE PATHS IN THE HEAD: JUST UNDER THE SCALP, THROUGH THE SURFACE AT THE BASE OF THE BRAIN, AND ALONG THE OPTIC NERVE WHICH EXTENDS FROM THE EYES TO THE VISUAL CORTEX. ELECTRICAL FLICKER CAN BE INDUCED WITH MINIMAL CURRENT INTENSITY WITH ELECTRODES ON THE MASTOIDS BEHIND THE EARS, WITH CORRESPONDING ELECTRODES OVER THE EYES, BUT THIS ARRANGEMENT PRODUCES PSYCHOLOGICAL EFFECTS, SUCH AS ANXIETY AS WELL AS THE SIDE EFFECTS OF ~~EXCITO BURNS~~, BLURRED VISION IN SOME PATIENTS, INFREQUENT LARYNGEAL SPASMS, IN ADDITION TO MINIMAL CURRENT IN THE BRAINSTEM. FOR MAXIMUM CURRENT IN THE BRAINSTEM, THE CURRENT SHOULD FLOW EITHER BETWEEN THE TWO MASTOIDS OR FROM AN ELECTRODE AT

THE BACK OF THE HEAD AT THE BASE OF THE OCCIPITAL LOBE TO FOREHEAD OR TEMPLE ELECTRODES. THE LATTER ARRANGEMENT IS SUPERIOR BUT IT INTRODUCED A NEED FOR THE DEVELOPMENT OF A NEW TYPE OF ELECTRODE FOR CARRYING CURRENT FROM THE SURFACE OF THE HAIR, WHICH IS PARTICULARLY THICK ON WOMEN AND HIPPIES, TO THE SCALP. THE IDEAL FLICKER ELECTRODE ARRANGEMENT IS EITHER WITH TEMPLE OR FOREHEAD ELECTRODES, JUST OVER THE EYES.

SUMMARIZING THE PHENOMENOLOGY, WE FIND THAT SLEEP DISORDERS ARE THE GENESIS FOR A MAJOR PORTION OF MENTAL ILLNESS AND THAT REM-STATE SUPPRESSION IS THE ACTIVATING AGENT, AND THAT MOST OF THE DRUGS FOR TREATING MENTAL ILLNESS NOT ONLY DO NOT HAVE MUCH CURATIVE VALUE BUT ARE THEMSELVES A PARTIAL CAUSE OF THE CONDITIONS WHICH THEY ARE SUPPOSED TO TREAT. APPROPRIATE ELECTRICAL STIMULATION APPEARS TO PROVIDE THE BEST SOLUTION BECAUSE IT HAS NO SIDE EFFECTS, SUPPRESSES DRUG WITHDRAWAL REBOUND, AND PRODUCES IMMEDIATE RELIEF OF SYMPTOMS IN A SUBSTANTIAL PROPORTION OF THE MENTALLY ILL.

LOOKING AT THE CLINICAL APPLICATIONS OF REM ELECTRO-THERAPY, A GUIDING PRINCIPLE FOR PROGNOSTICATING ITS PROBABLE EFFICACY IN TREATING VARIOUS AILMENTS WOULD BE TO LOOK FOR CORRELATIONS BETWEEN THE REM DEPRIVATION PHENOMENA AND THE SYMPTOLOGY OF VARIOUS AILMENTS TEMPERED BY THE KNOWLEDGE THAT THE MODUS OPERANDI OF REM ELECTRO-THERAPY INCLUDES: RAPID DISSIPATION OF REM HYPNOTOXINS, REHABILITATION DURING REM SLEEP, AND THE SUGGESTIBILITY OF THE APPARATUS *PER SE*. THIS SUGGESTIBILITY MAY BE EITHER FACILITATIVE OR COUNTERACTIVE DEPENDING ON THE THOUGHTS WHICH WILL BE BROUGHT INTO CONSCIOUSNESS BY ASSOCIATION WITH THE STORED MEMORIES OF PAST EXPERIENCE. FOR EXAMPLE,

THE PATIENT REACTION TO THE APPARATUS HAS BEEN 100% COUNTERACTIVE IN ALL CASES OF PATIENTS WHO HAVE PREVIOUSLY BEEN GIVEN ELECTRO-CONVULSIVE SHOCK TREATMENTS. ANOTHER EXAMPLE WHICH PROVIDES A QUANTITATIVE RESULT IS OBTAINED FROM A CLINICAL PRACTICE ANALYSIS OF ONE THOUSAND PATIENTS IN JAPAN TREATED BY AN ELECTROSLEEP MACHINE WHICH USED EYE ELECTRODES. THE APPARATUS PROVED TO BE COUNTERACTIVE TO ALMOST ONE-FOURTH OF THE PATIENTS SINCE IT WAS FOUND THAT 26.7% OF THEM SHOWED NO CHANGE OR RESPONSE DURING OR AFTER TREATMENT, BUT NEARLY ALL BECAME DROWSY OR SLEPT AFTER RESTIMULATION WHICH FOLLOWED THE ADMINISTRATION OF A MILD SLEEPING DRUG WHICH WAS INEFFECTIVE BY ITSELF. THE FACILITATIVE EFFECTS OF THE APPARATUS WERE DEMONSTRATED BY THE FACT THAT AFTER FOUR OR FIVE TREATMENTS, A SUBSTANTIAL NUMBER OF THE PATIENTS WENT INTO FIRST-STAGE SLEEP AFTER THE ELECTRODES WERE ATTACHED BUT BEFORE THE CURRENT WAS TURNED ON.

AN EXAMINATION OF ELECTROSLEEP CASE HISTORIES REVEALS THE CONCLUSION THAT THE MAJORITY OF THE AILMENTS TREATED COULD BE DIVIDED INTO TWO DOMAINS - THE REM STATE AND THE NEUROGENIC DOMAINS, WHEREIN THE FIRST INCLUDES ALL CASES IN WHICH THE SYMPTOLOGY IS RELATED TO REM DEPRIVATION PHENOMENA, AND THE SECOND INCLUDES THOSE ILLNESSES WHEREIN REM ELECTRO-THERAPY WOULD ONLY CONTRIBUTE NEUROGENICALLY TO THE RELIEF OF SYMPTOMS RESPECTIVELY. THE REM STATE DOMAIN WOULD OBVIOUSLY INCLUDE INSOMNIA, DEPRESSION, SCHIZOPHRENIA, ETC., WHEREAS THE NEUROGENIC DOMAIN WOULD INCLUDE DERMATITIS, ULCERS, HYPERTENSION, ETC., WHEREIN PHYSIOLOGICAL CHANGES MIGHT ALSO BE IMPORTANT CAUSAL FACTORS. A QUANTITATIVE EXAMPLE OF THE NEUROGENIC DOMAIN IS GIVEN BY THE RUSSIAN STUDY OF 376 PATIENTS SUFFERING FROM ARTERIAL CONGESTION IN WHICH ELECTROSLEEP

TREATMENTS

BRAIN TISSUE IS CAPABLE OF TOLERATING SOME TYPES OF STIMULATION OVER LONG PERIODS OF TIME. TISSUE DAMAGE CAN OCCUR IN TWO WAYS, VIZ., ELECTROLYTICALLY AND THERMALLY. ELECTROLYTIC DAMAGE OCCURS WITH ANY DIRECT CURRENT STIMULUS AT ANY CURRENT DENSITY, RESULTING IN DECOMPOSITION OF ELECTROLYTES AND DIFFUSION OF METAL INTO TISSUES. UNIDIRECTIONAL CURRENT PULSES CAUSE THE SAME DAMAGE BECAUSE SINGLE PULSES ARE CUMULATIVE OVER SHORT INTERVALS OF TIME. THE HISTORY OF ELECTRICAL STIMULATION OF THE BRAIN DISCLOSES THAT SEVERAL FORMS OF ELECTRICAL CURRENT HAVE BEEN USED INCLUDING DIRECT, ALTERNATING, AND UNIDIRECTIONAL PULSES. TODAY, THERE ARE THREE BASIC TYPES OF CURRENT IN USE - BALANCED, UNBALANCED RECTANGULAR PULSES, AND THE LATTER PULSES SUPERIMPOSED ON DIRECT CURRENT. A BALANCED RECTANGULAR PULSE HAS A FORWARD CURRENT EQUAL TO THE BACKWARD CURRENT WHICH WOULD BECOME AN UNBALANCED PULSE IF THE FORWARD AND BACKWARD FLOWS ARE UNEQUAL. AN UNBALANCED PULSE HAS A UNIDIRECTIONAL COMPONENT. TISSUE TOLERANCE STUDIES HAVE DETERMINED THAT BALANCED RECTANGULAR PULSES CAN PASS THROUGH TISSUE FOR AN INDEFINITE PERIOD OF TIME, SUCH AS WOULD BE REQUIRED OF A PERMANENT IMPLANT PROVIDING THAT THE AMOUNT OF ELECTRICAL CHARGE IN EACH PULSE DID NOT EXCEED 200 MICRO COULOMBS. OBVIOUSLY, MUCH LARGER CHARGES COULD BE USED FOR INFREQUENT STIMULATION. HOWEVER, IF THE PULSES ARE UNIDIRECTIONAL, THE CHARGE PER PULSE FOR EQUAL TOLERANCE IS LESS THAN 20 MICRO COULOMBS. DATA ON DIRECT CURRENT BIAS TOLERANCE IS NOT AVAILABLE BUT OF COURSE THE CORRESPONDING CURRENT MAGNITUDE WOULD BE MUCH LOWER. THE LATEST PRIOR ART ELECTROSLEEP GENERATORS USE AN UNBALANCED PULSE WITH A DIRECT CURRENT BIAS AND THEREFORE WILL CAUSE ELECTROLYTIC DISSOCIATION AND DEPOSITION OF METALLIC IONS IN THE BRAIN TISSUE. THE NATURE OF THE EFFECTS OF THIS DEPOSITION IS SUGGESTED BY CONVULSIVE ELECTRO-SHOCK TREATMENTS IN WHICH MEMORIES OF CONTEMPORARY EXPERIENCE ARE DESTROYED. THE REASONS FOR

THE MARGINAL BRAINSTEM STIMULATION OBTAINED WITH THESE GENERATORS ARE THAT THE EYES CAN ONLY TOLERATE A VERY SMALL CURRENT AND THAT ONLY SMALL CURRENTS SHOULD BE USED FOR MINIMAL IRREVERSIBLE BRAIN TISSUE CHANGES. THERE ARE TWO KINDS OF BALANCED PULSES - SYMMETRIC AND ASYMMETRIC WHEREIN THE CHARGE IN ONE-HALF OF THE ASYMMETRIC PULSE MAY BE OBTAINED BY A LARGER CURRENT FLOWING FOR A SHORTER TIME, AND VICE VERSA IN THE OTHER HALF OF THE PULSE. THE SITUATION IN THE SYMMETRIC PULSE IS SELF-EVIDENT. THE EFFICACITY OF THE ALPHA DRIVE OSCILLATOR IN THE INDUCTION OF SYNERGISTIC EFFECTS WHEN SYNCHRONIZED WITH THE SENSORY STIMULATORS IS A MAXIMUM WHEN THE RECTANGULAR PULSES ARE BOTH BALANCED AND SYMMETRIC. THUS IT IS ESTABLISHED THAT THE CHOICE OF BOTH THE FORM OF THE CURRENT AND THE TYPE AND POSITION OF THE ELECTRODES ARE OF PARAMOUNT IMPORTANCE IN DETERMINING THE PERFORMANCE OF THE STIMULATOR.

CLINICAL PRACTICE WITH ELECTROSLEEP STIMULATORS UNCOVERED A RECURRING PROBLEM, NAMELY, THE AROUSAL ACTION OF AN UNEXPECTED OR UNUSUAL SOUND. IT HAS BEEN FOUND EXPERIMENTALLY THAT WHEN A SUBJECT IS HABITUATED TO A SPECIFIC MONOTONOUS AUDITORY STIMULUS, SUCH AS A SOUND OF CONSTANT AMPLITUDE AND PITCH, AND IF THE PITCH OF THE SOUND IS DISCREETLY CHANGED BY A LARGE ENOUGH INCREMENT, THE AUDITORY CORTEX WILL BE DEHABITUATED CAUSING THE AWAKENING OF THE SUBJECT, PARTICULARLY IF IN THE REM STATE. THE PROBLEM WAS SOLVED BY PLACING THE MONOTONE TRANSMITTER IN THE STIMULATOR CABINET AND TRANSMITTING THE SOUND THROUGH TUBES TO SOUND-ISOLATING PLASTIC CUPS HELD IN PLACE OVER THE EARS. BY THIS MEANS ANY EXTERNAL SOUNDS WOULD BE ATTENUATED TO A LEVEL AFTER FILTERING THROUGH THE CUP WALLS WHICH IS FAR BELOW THE THRESHOLD OF AUDIBILITY CREATED BY THE MONOTONE ENTERING

THE CAVITIES VIA RUBBER TUBES. THE MONOTONE APPLICATOR EXTENDS THE USE OF THE STIMULATOR BEYOND THE QUIET PRIVATE ROOM TO THE NOISY OFFICE ROOM OR HOSPITAL WARD.

IN CONCLUSION, AN ELECTROPHYSIOLOGICAL STIMULATOR PROVIDING THREE BALANCED, SYMMETRIC AND SYNCHRONIZED STIMULI - AUDITORY MONOTONE, ELECTRICAL FLICKER, AND ALPHA DRIVE - APPLIED TO THE HEAD VIA MONOTONE EAR CAVITIES, FLICKER TEMPLE OR FOREHEAD ELECTRODES, AND ALPHA DRIVE OCCIPITAL ELECTRODES RESPECTIVELY, CAN BRING A NEW ORDER OF EFFECTIVENESS TO REM ELECTRO-THERAPY.