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THE EFFECT OF MICRO WAVES ON THE CENTRAL NERVOUS SYSTEM

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ABSTRACT

The autonomic nervous system is affected by the microwaves of the centimeter wave length band. These waves affect circulation, respiration, temperature control, water balance, albumin and sugar concentration in the cerebro-spinal fluid, hydrogen ion concentration, EEG, GSR, sleep, conscious awareness, etc. Depending on the applied dosage, these waves stimulate the sympathetic or parasympathetic system. Very small dosages produce analgesic effects; however, very large dosages are fatal. An undamped or modulated frequency is more effective than damped waves. The biological effect of these waves results from the resonance absorption in the ganglia. There are indications that only higher harmonics, and not the fundamental frequency, produce biological effects. The shielding of the test subject by metal screens increases these effects; however, magnetic fields remove them. Higher harmonics producing these biological effects have physical properties which are similar to those of the bio-electrical energy generated by the human body. The mechanism of hypnosis is explained by the transmission of this energy.

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Contents

INTRODUCTION

The present study demonstrates that short electromagnetic waves can have an extensive influence on the central nervous system. This involves a direct influence of high-frequency energy on the autonomic nervous system and the influence on the somatic nervous system takes place by the control of its readiness to function from the vegetative sphere. Such a process otherwise takes place only under hypnosis.

The human body has been found to be the generator of a wave energy which is propagated in the surrounding atmosphere in the form of electromagnetic waves. In its transmission to other persons, this energy influences the central nervous system in a manner similar to short electromagnetic waves. The hypothesis used for an explanation of suggestion is based on the transmission of this wave energy. It has been found that neither the entire electromagnetic field of a short-wave transmitter nor the entire electrical field in the environment of the human body can influence the central nervous system. Rather, the central nervous system is influenced by certain wave components contained in the electromagnetic waves generated by a short-wave transmitter as well as in the electrical field surrounding the human body. Since these wave components of short electromagnetic waves as well as those of the electrical field around the human body exhibit similar physical characteristics and exert similar influences on the central nervous system, it can be assumed that the same energy is involved in both cases. The possibility results to produce the energy which is effective in hypnosis by engineering methods. In this connection, the development of the instruments which are to produce this energy is to be based on guidelines which differ fundamentally from those presently utilized in the development of transmitters for short-wave diathermy.

In short-wave diathermy as it is used today, the heat generated in the patient is primarily utilized. The development of short-wave transmitters consequently followed the design of highly efficient instruments which produced a maximum heat generation in the patient. It was found that heat produces an effect opposite to that of the energy which influences the central nervous system. Consequently, the effective action of the energy influencing the central nervous system is considerably reduced by the heat formed in the patient. A further attenuation of the energy influencing the central nervous system was produced by the introduction of oscillators which generate undamped oscillations. For undamped waves produce much less prominent reactions of the central nervous system than damped waves or pulses. The introduction of transmitters built on this basis for short-wave diathermy together with the new dosage method which I have proposed and which is based on the principle of measuring the reaction of the autonomic nervous system to the electromagnetic energy absorbed by the body, will provide the practising physician with a new effective instrument permitting the treatment of patients by direct stimulation of the central nervous system.

I. INFLUENCE ON THE CENTRAL NERVOUS SYSTEM BY SHORT-WAVES AS WELL AS BY HIGH-FREQUENCY CURRENTS

1. Influence on motor and sensory nerves: — Several investigators have observed that electromagnetic waves in the VHF range and high-frequency currents in the same range stimulate the motor nerves, the effect of which can be recognized in the reduction of the threshold of the galvanic stimulus and in the constrictor of the areas supplied by these nerves.

The influence of short waves on motor nerves was observed for the first time in 1791 by Galvani.[26] The production of short waves in experiments carried out by Galvani was obtained with a transmitter-dipole, which was excited by a simple electric machine to undergo damped oscillations. The spark gap served as the contactor in the transmitter-dipole. The dipole length, determined from Fig. 1, corresponds to a wave length of about 1.0 m. A nerve-muscle specimen of a frog was connected into the circuit of the receiver-dipole. The identity of the two dipole lengths indicated in Fig. 1 represents the presence of resonance.

Galvani was able to observe that clear twitching of the nerve-muscle specimen took place with every spark transmitted to the receiver-dipole.

These experiments, however lead neither to the discovery of electromagnetic waves nor to their biological importance. The historical development took another course. As we know, the experiments of Galvani first lead to the development of chemical sources of energy.

I was able to observe rhythmic contractions of the left arm in a patient during treatment of the left side of the body in the condensor field of a 6 m wave-length transmitter; these contractions promptly disappeared after the transmitter was shut off. Treatment was conducted with a large electrode gap of 10 cm with no detectable generation of heat in the patient.

Kellner[54] observed twitching of muscle fibers at the site of paralysis in patients with facial pareses. These contractions occurred under the influence of electromagnetic waves generated by a transmitter with audiofrequency modulation with a wave length of 10 m.

Schliephake[91] reported the following: when a mouse is placed into the condensor field and the plate current of transmitter tubes is cut in or cut off, a clear contraction of the animal can be observed. Furthermore, he was clearly able to detect a sensation of vibration when he placed his hand into the condensor field, where the vibrations appeared to coincide with the frequency of 50 cps of the AC circuit. The anode of the transmitter tube was supplied by alternating current, so that the muscle spasms form in synchronous manner with the connection and disconnection of the field.

Jellinek observed that mice suddenly exhibited paralysis at the time when transmitter was turned on; this paralysis was only interrupted by periodic tremors of the hind legs. The animals resumed normal mobility, after the transmitter was turned off. He employed a small transmitter of three meter wave length.

Saidman[84] observed that butterflies suddenly dropped in the condensor field when the current was connected and showed no signs of life. Invigoration and full mobility of the butterflies was regained only about 15 min. after disconnection of the current.

Archangelsky[3] observed that the muscle-nerve specimen of the spinal frog exhibits individual contractions with the connection and disconnection of a high-frequency current, with a tetanic reaction of the preparation at the moment of connection, changing to a prolonged state of inhibition at the moment of disconnection. Tetanus appears and disappears synchronously with connection and disconnection of the field. The author furthermore divided the sciatic nerve of the muscle-nerve preparation into approximately four equal parts and observed that excitation under the influence of the high-frequency field changes in a different manner in each of the 4 zones and that the type and direction of displacement in each zone depends upon its previous condition. All spasms remain absent during connection and disconnection of the current in the part of the muscle-nerve preparation that was subjected to a sympathicotectomy. On the other hand, contractions continue in the intact portion.

Audiat[5] investigated the change of the threshold of the galvanic stimulus in the muscle-nerve preparation under the influence of short-waves and found that the threshold drops even though the temperature had increased from 16° to 40° in the experimental vessel. It is known that the threshold of a galvanic stimulus increases with a temperature increase. If the high-frequency current is disconnected, however, the galvanic threshold rises sharply and then decreases gradually again. The sudden increase of the threshold values after disconnection of the high-frequency current is attributed to the resumed influence of the elevated temperature of the liquid medium, while the high-frequency current counteracts the heat. The author conducted his experiments with a wave length of 400 m (damped) and one of 10 m (undamped).

Dalton[16] also investigated the influence of short-waves on the galvaniotonic contraction of the frog gastrocnemius. The contractions produced by nerve stimulation were considerably reduced by the treatment in the short-wave field until they were completely extinguished. A wave-length of 11.3 m with an output of 1 watt and a large electrode gap was utilized. No detectable heating could be observed even with the most sensitive thermocouples. A mere heating of the preparation even produced the opposite effect, i.e. an increase in the contractual intensity. According to further studies of the author, the effect probably takes place mainly in the nerves: for a direct stimulation of the muscle only resulted in a very minor change in the excitability, which occurred only after much more prolonged current flow. This direct effect on the muscle could be eliminated by toxification of the synapses with nicotine and curare. Subsequently no reduction in muscle contractions was observed after direct stimulation. Dalton therefore assumes that the transmission of current through the preparation also forms an inhibiting influence of the nerves on direct muscular contractions. With the use of a very intense short-wave dosage, Weissenberg[114] was able to observe the appearance of muscle spasms in the treated parts of the body.

The application of a lethal dosage results in phenomena which indicate that such a high excitation of motor nerves takes place that a general convulsion results. Schliephake[91] placed mice and rats in glass vessels into the condensor field of a transmitter and exposed them to a lethal dosage. He observed a strange rigidity, which was particularly evident in the tails of the animals, directly after death had occurred.

The influence of high-frequency energy results not only in an excitation of the motor but also of the sensory nerves. This excitation becomes manifest with the appearance and disappearance of pain under the influence of short waves.

Gebhardt, Saidman, Cahen, Dausset and Weissenberg[27] observed that patients who had recovered from neuralgia and neuritis and who were in the vicinity of a short-wave transmitter, in some cases sensed a slightly painful tingling, even though the disease had not been manifest for years. These sensations extended exclusively to the nerve region which had previously been pathologically affected; thus, a weak high-frequency energy, which is transmitted to the human body in the form of electromagnetic waves, is sufficient to influence sensory nerves. Weissenberg furthermore reports that when patients with acute neuralgia were exposed to the condensor field, they suffered such violent pain that the equipment had to be disconnected.

Schweitzer[98] even reports that the severest pain reactions were sometimes observed in cases of neuritis with the application of minimum dosage. This is in accord with the experiences of other authors, who described a dosage which generates heat to be stimulating in cases of neuralgia and neuritis.

The influence on sensory nerves by high-frequency energy is expressed not only by the occurrence of pain but also by its removal. The analgesic action of short waves is well known.

Weissenberg[108] reports a very favorable reaction to short waves of pain such as it occurs more frequently in the region of the central nervous system, which usually can hardly be influenced by therapy. The author was able to observe in a number of such patients, that a short-wave treatment of the area subjected to surgery causes pain to disappear almost instantaneously and that this good effect extends for several hours. Treatment was carried out by irradiation with electromagnetic waves generated by a portable transmitter of about 1 watt.

Hunecke[47] reports on the elimination of pain by a special method of short-wave treatment, the so-called "remote effect of short waves." It is claimed that the application of an ordinary short-wave current for a period of 0.5 to 1 min., for example, eliminates cephalgia even when electrodes are applied at any part of the body, such as to the epigastrium. The author observed that such reflexes occur with a speed which cannot be attributed to the influence of heat, but rather that a major role is played by the electrical influence of the vegetative nervous system. The extremely brief application of short waves is necessary because it was found that a prolongation of irradiation, i.e., increase of the dosage, can negate the successful result. Hunecke considers such syndromes to be caused by electrostatic charges. The short waves then alleviate pain in an equalization of electrostatic states of tension.

The analgesic action of short waves was even acknowledged by an opponent of the athermal influence of short waves.

Kowarschik[56] acknowledges the excellent analgesic action of short waves. Although he denies any specific action of short waves, he is nevertheless forced to give them their due. "In many cases," he writes, "the analgesic action of short waves is nearly specific; the reason for this action in principle is still unknown."

Groag and Tomberg[34] report on a surprisingly rapid alleviation of pain under short-wave treatment. In their interpretation of the analgesic effect they hesitate to give an explanation and limit themselves to the remark that short waves are superior to all other types of physical methods in their analgesic action. The antagonistic effect of short waves on the sensory nerves (aggravation and inhibition of pain) is the result of the dosage applied as well as the particular sensitivity of the patient to stimulation.

Schliephake[91] was able to observe that symptoms of pain appeared when certain field strengths were exceeded.

Weissenberg[108] reports that short waves of a given wave length have a different influence on different individuals and that this influence even varies for different times in one patient (perhaps corresponding to his sensitivity to stimuli at the time). Short waves sometimes produce an analgesic action, while at other times they induce pain.

The influence on sensory nerves by short waves cannot be considered to be specific for the waves (for a certain wave length) and not even as specific with respect to short waves (for the entire short-wave range from 15-3 m); similar phenomena occur also in the longer wave range — in diathermy as well as d'arsonvalism, Kowarschik,[56] Liebesny,[61] Stieböck[101] and numerous French authors have pointed out that diathermy of neuralgias, in particular, has proved today that an analgesic action can be obtained with the smallest current strengths, which are incapable of producing heat. On the other hand, high current strengths with a distinct heat effect can aggravate pain.

Kowarschik[56] reported that high-frequency current as it is utilized in d'arsonvalism, mainly has an analgesic action.

Interpretation of the influence of high-frequency energy on motor and sensory nerves: — Since a direct electrical excitation of motor and sensory nerves by high-frequency energy and electromagnetic waves in the VHF range (3-15 m) must be entirely impossible, since the frequency limit above which practically no further electrical stimulation of the sensory and motor nerves occurs is found at about $2 \cdot 10^5$ to $3 \cdot 10^5$ cps, according to the studies of Gildemeister,[30] a stimulation of motor nerves by the thermal energy generated by high-frequency treatment should also be entirely impossible. Under the influence of intermittent high-frequency energy, the generation of heat, if it takes place at all, is so minimal that, particularly in the case of the action of electromagnetic waves, any detectable effect of heat generated by them on the test subject is quite out of the question. If it is assumed nevertheless that this heat represents a stimulus for the nerves, it must be assumed that the heat can form and expire periodically in synchronous manner with the fluctuations of the high-frequency field, which would be impossible in the case of the rapid oscillations. The decrease of the threshold of the galvanic stimulus observed by Audiet and Dalton under the influence of a constant short-wave energy also cannot be explained by heat, since heat is known to induce the opposite effect. The same is true for the phenomena observed by Weissenberg as well as by Schliephake, since these represent only the phenomenon described by Audiet and Dalton in a more intensified degree (for further explanations on this subject, see chapter 2). The effect of high-frequency energy on sensory nerves also cannot be explained by heat, since analgesic results are generally observed with minimum current-strength dosage without any heat effect and pain is enhanced at higher dosage with the evolution of heat.

If heat were the cause of these phenomena, then a counteracting effect would have to be involved, since heat generally has an analgesic action and furthermore since the heat effect in all described cases is so slight, that it would be highly improbable that it can exert any detectable influence on sensory nerves.

It remains to be assumed that all of these cases involve a reflex phenomenon which is the result of short-wave action as a consequence of a direct influence on the central nervous system (sympathetic nerve stimulus). This is primarily supported by the finding of Archangolsky; in portions of the muscle-nerve preparation subjected to sympathectomy, every contraction remains absent with a connection and disconnection of the current, while these contractions continue in the intact portion of the preparation. The decrease of the galvanic stimulus threshold found by Audiet and Dalton under the influence of short waves also is in favor of the influence on the central nervous system. It is indicated by the findings of Dalton that when the synapses are eliminated by toxification, the reduction of the galvanic stimulus threshold is canceled. Since the synapses represent the junction for the impulses transmitted from the central nervous system to peripheral nerves and their elimination represents an interruption of conduction between the central nervous system and the peripheral nerves. For this reason, the reduced excitability of peripheral nerves resulting under the influence of short waves can be attributed to the elevation in the degree of muscle tone which is under the influence of the action current from the central nervous system. The action current of muscle tone, which is under the influence of the central nervous system, encounters the action current which forms due to the stimulation of motor nerves and attenuates the latter. Similar processes of interaction of meeting excitation waves were analyzed experimentally by P. Hoffmann.[42] On the basis of this concept we can assume that the application of higher field strengths leads to a further enhancement of the stimulation of the sympathetic nervous system and thus to a more intense excitation of motor nerves, manifested in spasms (Weissenberg). In the case described by Schliephake, in which mice and rats were electrocuted in the condensor field together with a hyperemia produced by heat, a universal convulsion occurs due to the stimulation of the sympathetic nervous system, expressed by the rigidity (particularly of the extremities) observed by the author. The assumption that the death of the animals in the condensor field is caused not only by pure heating but also by a simultaneous universal convulsion is also supported by the finding of McGeiit and McKinley[63] that the death of the animals due to heating alone under the influence of hot air occurs only at 160^{o}, while the animals in the condensor field die already at 50^{o}.

The fact that the intermittent short-wave energy has a more intensive influence on motor nerves can be explained by the fact that a stimulation of the sympathetic nervous system with an intermittent high-frequency energy excites all nerve fibres synchronously with the excitation impulses flowing from the sympathetic nervous system and thus synchronously with the pulses of the short-wave field. As a result of this synchronization, all nerve fibres are excited simultaneously, leading to a considerable increase of the intensity of the action current. In the stimulation of the sympathetic nervous system with a constant high-frequency energy, the excitation pulses passing through the nerve fibres (action current components) are desynchronized and the resulting action current consequently is considerably weaker than is the case with the synchronization of its components.

The influence of short-wave energy on sensory nerves as well as on motor nerves cannot be attributed to the evolution of heat in the test subject; since the dosage utilized by most of the above-mentioned authors was so small that any heat effect is impossible and the slightest heat effect produced pain, and heat is known to cause the opposite effect. The findings reported by Weissenberg and by Hunecke clearly indicate that a direct influence on the central nervous system is involved here. Analogous with phenomena occurring in the influence on motor nerves, we can assume that the abatement of pain under the influence of short waves is to be attributed to an inhibition of the sympathetic nervous system and an aggravation of pain to a stimulation of the sympathetic nervous system.

Läwen[60] found that it is possible to influence pain by acting on the sympathetic nervous system. In his opinion "an action on Rv. communicans or perhaps even on the Truncus sympathicus removes the cause of pain."

On the other hand, a relationship exists between the signs of pain and changes in cutaneous galvanic resistance, which decreases with an increase of pain and increases with a decrease of pain. Since changes in cutaneous galvanic resistance can be objectively controlled, they can be utilized as a means for the observation of pain symptoms under the influence of short-wave energy. Such a control of pain sensations by changes in cutaneous galvanic resistance was carried out by Weissenberg. The author states that the galvanic skin resistance to direct current is lower on the pathological side than on the sound side. By short-wave irradiation of the pathological side, the galvanic skin resistance approaches that of the sound side. Under pathological conditions, to the extent to which they are localized on one side of the body, considerable differences in the resistance values of the sound and the diseased side usually result. Resistance changes by stimulation generally can be detected bilaterally, provided the pathological side has not been eliminated by destruction of the nerve paths transmitting the stimulus. Weissenberg observed that an attack of pain is preceded for several minutes by a clear decrease of the resistance and that the beginning of the loss of pain becomes manifest several minutes before by an increased resistance. Under a small short-wave dosage, the galvanic skin resistance is increased, while it decreases with a high dose (see chapter 1, section 12).

On the other hand, it is known that the autonomic nervous system has a pronounced influence on the galvanic skin resistance. Minor[65] has shown that a destruction of the cervical sympathetic nervous system increases the galvanic skin resistance in humans, while the latter is decreased by stimulation of the sympathetic nervous system. Marinesco, Copelman, Alexianti-Buttu[62] report that a patient with Basedow's disease, whose sympathetic nervous system is extensively enervated, exhibits a small rest potential of the skin with a particularly pronounced reflex. Thus, if changes of the galvanic skin resistance are the result of stimulation and inhibition of the sympathetic nervous system, and if the symptoms of pain are parallel to changes in galvanic skin resistance, it can be concluded that changes in pain symptoms under short-wave treatment are to be attributed to the influence on the sympathetic nervous system. These influences can take place under the direct action of short-waves on the sympathetic nervous system as well as by the stimulation of higher autonomic centers in the diencephalon and as a consequence of this stimulation, an influence on the sympathetic nervous system.

2. Influence on the circulation and respiration: — Several investigators have observed that short-wave energy has a particular influence on circulatory function. This influence is manifested by a dilatation and constriction of vessels and a resulting increase or decrease of blood pressure as well as a change in the heart rate. Arsonval[4] already found a blood pressure depression as a result of vascular dilatation under the influence of short waves.

Pflomm[76] conducted a detailed study of the effect of short waves on the vascular system. He found that a dilatation of the blood vessels and particularly of the capillaries takes place under the influence of short waves. The capillary dilatation attains the 3-10-fold value. In the capillaries with maximum dilatation, a pulsating backflow from the venous region results. This capillary dilatation persists for several days following short-wave treatment. These phenomena cannot be explained by the action of heat, since:

a) Since the dilatation of vessels occurring with a heating of the vessels in Moll's solution, primarily the capillary dilatation, is by far not as pronounced as after short-wave treatment;

b) A capillary dilatation persisting for many days cannot be achieved by simple heating. Pflomm considers these special vessel dilatations to be caused by an influence on the autonomic nervous system by short waves in the manner of an inhibition of the sympathetic nervous system and an increase of the vagal tonus. Pflomm cites the following evidence for the correctness of his interpretation:

a) The vessels which have been dilated by short waves do not contract as a result of an adrenalin stimulus of the sympathetic nervous system.

b) The observed enrichment in pigmentation of the short-wave-irradiated hilus of the frog portal vein, a phenomenon which appears in the same manner after a separation of the sympathetic nervous system according to the studies of Else.

Cignolini[14] expanded Pflomm's experiments and found that the type of capillary reaction depends upon the dosage applied.

a) With a small dosage, a transient dilatation of the capillaries occurs.

b) With an intermediate dosage, the dilatation becomes more prominent and persists for a longer period of time. It assumes the form described by Pflomm, where the dilatation can become so extensive that a backflow into the capillary network takes place from the veins.

c) A further dosage increase results in a vascular constriction. An overdose can produce a paralysis of the capillary network with stasis.

Cignolini found that a low dosage stimulates the vasodilator nerves, while a strong dosage stimulates the vasostrictor nerves (i.e. sympathetic nerve stimulus).

Under the influence of intermittent short-wave energy (connection and disconnection of the current), the degree of influence on the vessels in considerably intensified, just as in the influence on motor and sensory nerves.

Arsonval[4] observed that a rapid dilatation of the ear vessels of the rabbit takes place when the current is connected. After the current is disconnected, a vigorous constriction of the dilated vessels takes place again.

Pflomm observed first a barely detectable constriction of all vessels for about a second when the current was connected, which disappeared rapidly, however, and changed to the inverse. It can be assumed, therefore, that an increased vagal tonus takes place under a small short-wave dosage with a resulting decrease of the tonus of the sympathetic nervous system while the sympathetic nervous system is stimulated by a strong dosage. This excitation can take place by a direct influence due to short waves as well as by stimulation of the higher autonomic centers in the diencephalon.

Short-wave energy influences not only the vessels but also the heart rate and does so not only by acceleration but also deceleration of the heart rate — a sign that an effect opposite to that of heat is involved in this case.

Pflomm, who exposed the hearts of frogs to the condensor field in Engelmann's suspension, observed a deceleration of the heart rate and a reduction of excursions. The deceleration takes place only when any thermal effect is avoided during irradiation, since heat is known to produce the opposite effect, i.e. an increase in the heart rate. This phenomenon can only be explained by an irritation of the vagus nerve by short waves. Together with an influence on the circulation by short waves, respiration is also influenced. Horten[45] found, that irradiation of the head produced a depression of blood pressure together with a decrease in the respiration rate. On the basis of these findings we can assume that the action of short waves influences the respiratory and circulatory center, the seat of which is known to be in the diencephalon. According to Hess, [38] activating and inhibiting centers for circulation and respiration are located in the diencephalon and the adjoining region, the function of which produce antagonistic effects. The excitation of the inhibiting center causes a depression of blood pressure and a slowing of the heart rate as well as a decrease in the respiration rate. A stimulation of the activating center, on the other hand, causes an increase in blood pressure and acceleration of the heart rate as well as an activation of respiration. We can assume, therefore, that a small dosage excites the inhibiting center of respiration and circulation, while the activating center is stimulated with a large dosage.

3) Influence on the EEG: — A certain relationship exists between the condition of the vessels and the EEG, i.e. during vascular dilatation, small, frequent elements appear in the EEG, while "slow" waves of high amplitude appear with vasostriction.

Hudson[46] investigated the relationship of the EEG to the blood pressure in cases of eclampsia. The author found that a high blood pressure corresponds to the "slow" waves of greater amplitude. With a blood pressure decrease, a clear increase in frequency and decrease in amplitude of the waves were observed. With high blood pressure and "slow" waves, traces of albumin were found in the urine.

Darrow, Green, Davis and Carol[18] observed frequent small amplitudes of the EEG waves during vasodilation. On the other hand, they were able to achieve vasostriction and the appearance of large-amplitude slow waves by hyperventilation.

Darrow and Graf[17] observed vascular changes photometrically in a parallel registration of the EEG and ECG. They found, that an increased activity of "fast" waves takes place with vasodilation, while vasostriction is connected with an activation of the slow waves.

Since a vasodilation or vasostriction takes place after short-wave irradiation, depending upon the dosage applied, the relationship between the state of the vessels and the EEG justifies the assumption that a small short-wave dosage results in an activation of β-waves, while a large dosage activates the slow waves.

This assumption has been confirmed in part by Hoagland. The author found a considerable frequency increase of the brain wave frequency after short wave irradiation of medium dosage.

The relationship between changes in vascular condition and EEG can be explained by the fact that brain waves as well as vascular function are controlled from definite regions of the diencephalon. This interpretation is in agreement with the hypothesis of Kornmueller, [55] according to which the potential fluctuations of the cerebral cortex originate from certain fiber systems, particularly from those of the thalamus.

The EEG changes after short-wave irradiation, incidentally, are identical to those of the EEG after stimulation with a low-frequency alternating current found by Rubinstein and Kurland. [82] The authors subjected cats to a minimal convulsive dosage of alternating current. The stimulation was repeated every 5 min. After the first stimulus, they observed an increase in the frequency and amplitude of the brain wave fluctuations. After the second stimulus, slow waves of large amplitude appeared.

4. <u>Influence on the temperature control:</u> — It has also been observed that the temperature control is influenced by short waves. In this case, as in the influence of the circulation, short waves have an inhibiting and activating action, i.e. they induce a decrease or increase of the body temperature depending on dosage. Groag and Tomberg reported on a surprising drop of fever after short-wave treatment. The treatment was given at a low dosage.

Schliephake[91] reported that the central temperature regulatory system of the brain is influenced under the action of short waves. In some of the animals, the body temperature increased several hours after short-wave treatment and remained at an elevated level. The animals which had a normal temperature of 38 to 38.5°, now showed a level with daily variations of 40 to 40.5°. This condition persisted for weeks and even months. In another group of the treated animals, i.e. after a particularly large dosage, a temperature decrease to 34-35° occurred which usually started about 2-3 hrs. after transmission and persisted for up to 24 hrs. All of these changes could be obtained only with a wave length shorter than 6 m. No results were obtained with longer waves even with a much longer and stronger field.

Ostertag investigated anatomical changes in the brain of the treated animals and found selective damage in certain cell groups; furthermore, he found that this selective damage increases as the wave length decreases. He found that all rabbits which were irradiated with a wave length of 3.2 m had developed a grave pathological condition of certain cell complexes. This pathological condition was observed in the caudal third of the medulla oblongata (in the so-called nucleus of the vagus), in the form of a grave vacuolous cell disease, in the course of which the reticular fibers are obliterated and the cells finally disappear themselves. This distinct effect on certain cell regions in the brain of the rabbit was observed only at wave lengths of 3.2 m, while longer waves, particularly those of 6 m, were less selective. Sometimes it was also possible to produce damage at the medulla oblongata with waves of 4.5 m and less, but this damage was far less extensive than that obtained with shorter waves. Longer irradiation periods produced more diffuse modifications, particularly in the region of the medulla oblongata, particularly the cells in the trifacial nucleus and regions laterally to the corpus striatum. These animals frequently developed pneumonia together with the disturbance in their temperature regulatory system. It is known that body temperature is regulated by the center of temperature control in the autonomic nervous system. It can be assumed, that this center is excited or inhibited by short waves, depending upon the dosage applied, and that this causes the increase or decrease in body temperature. This antagonistic effect of short waves depends extensively upon the dosage applied, so that a depression of body temperature takes place with a smaller dosage and an elevation with a larger dosage.

5. Influence on the water balance: — Horten[45] investigated the function of the water balance in sound human subjects after the action of short waves and first studied the problem of spontaneous diuresis. After irradiating 22 test subjects, spontaneous diuresis occurred in 20 cases. It frequently persisted for more than 2 hrs., resulting in quantities of 350-500 cc urine in 2 hrs. These involved quantities of urine which can hardly be produced in such a short time in healthy subjects; such values are only found after drinking or after the suggestion of drinking under hypnosis. Horten furthermore conducted drinking experiments. The test subjects were also in good physical condition. After voiding of the nightly urine accumulation and after another voiding two hours later, the test person drank 800 cc water at room temperature within 5-10 minutes. Immediately therefore, irradiation of the head was connected and continued for 30 minutes. Subsequently, the urine was collected for 4 hrs. at 30 minute intervals. A clear increase of the total quantity of urine was regularly found in 11 of 12 test subjects. In the majority of the test subjects, the increased diureses appeared only after 1.5-2 hrs., followed by another rise in diuresis between 2 and 3 hrs. after the water consumption. Such a course of diuresis in several surges can never be observed in healthy individuals. On the other hand, this course represents a characteristic disturbance of diuresis in patients with disorders of the hypophyseal region of the diencephalon. A urinalysis showed an elevated concentration after treatment, which can also be observed in cases of true disorders of the hypophyseal region. We can assume that short-waves influence certain centers in the autonomic nervous system, which regulate the fluid balance. According to Hess,[38] the fluid-regulating center is located in the supraoptic nucleus.

Diuresis could also be influenced by a direct stimulation of certain foci in the hypothalamus by means of alternating current.

Urnas[104] found that diuresis is activated when some nuclei in the hypothalamus are stimulated with an alternating current of 3-5 cps. A frequency increase up to 60 cps and more, on the other hand, produced an inhibition of diuresis. As we know, the physiological action of the low-frequency alternating current increases with an increasing frequency. so that a frequency increase is equal to a dosage increase. We can conclude, therefore, that when certain sites in the hypothalamus are subjected to electrical stimulation, an activation of diuresis takes place with the application of a small dosage, while an inhibition of diuresis is obtained with the application of a strong dosage.

These results are also in agreement with the findings of Kreienberg and Erhardt.[58] The authors observed an inhibition of diuresis for a period of 1.5-2.5 hours in 15 schizophrenics directly after shock treatment. The authors interpret this influence on diuresis as a consequence of a stimulation of the corresponding autonomic centers, perhaps of the hypophysis.

Since a certain parallelism exists between the influence on autonomic centers by direct electrical stimulation and short waves, we can anticipate an inhibition of diuresis with the application of a strong short-wave dosage.

6. Influence on the abduction phenomenon: — Abduction phenomena represent a further documentation of the influence of short waves on the central nervous system. Abduction phenomena refer to the phenomenon described by Fischer and Wodak, Barany and later by Hoff and Schilder,[39] in which the extended arms normally are abducted from their initial position when the eyes are closed. The influence of short-waves on this abduction phenomenon was described by Hoff and Weissenberg.[40] In the case of pathological processes in certain regions of the brain, the abduction reaction exhibits characteristic changes from normal. Thus, for example, the deviation is to the right in the presence of a tumor of the right frontal lobe and to the left with a tumor of the right cerebellum. With irradiation of the right cerebral hemisphere of the test

person showing a normal abduction reaction, both arms deviate to the right under a weak dosage, and to the left with irradiation of the right lobe of the cerebellum. Thus, pathological abduction reactions result in certain regions of the brain subjected to short-wave irradiation. The change in abduction reactions after short-wave treatment described by Hoff and Weissenberg persisted for up to 5 min. following treatment.

7. Influence on sleep: — Several authors reported that sleep can be induced by short-wave treatment. According to the report from the Institute of Physical Therapy in Nijmegen (Holland), a patient who was treated for occipital neuralgia, fell into a deep sleep, persisting for up to 1 hr., after each treatment. Zellner,[110] Kowarschik[56] were able to obtain good results in cases of insomnia (disorder of the central nervous system).

Weissenberg[108] reports that when patients were treated in the area of surgery, they fell into a deep and refreshing sleep soon after treatment. Treatment was carried out in this case by irradiation with electromagnetic waves generated by a portable transmitter of about 1 watt power.

Schliephake[91] also reports that a notable drowsiness is induced by the treatment of any part of the body in the condensor field. Many of the patients fall asleep during treatment. Horten[45] reports that a feeling of fatigue and drowsiness is sensed by healthy individuals receiving irradiations of the head. Treatment of the head had a sedative, mild sleep-inducing effect on the majority of healthy test subjects, leading to actual sleep in some individuals.

Short waves have a sleep-inducing action in all of these cases. Cases exist also where short waves have the opposite effect, i.e. inhibiting sleep. Schliephake observed that certain disturbances of sleep occur in the personnel operating the transmitter after their prolonged presence in the vicinity of the latter. Usually falling asleep at night is very difficult. The persons involved often sleep fitfully, with feelings of a lack of energy, exhaustion and apathy in the morning.

Similar sleep distrubances (inhibition of sleep) as a result of the action of electromagnetic waves are reported by d'Orville, Melland and Withney[72] as well as by Bell and Fergusson,[9] who observed these phenomena in radio amateurs and radio operators on ships.

These cases again represent the result of a direct influence of short waves on the autonomic nervous system. According to Hess,[38] a certain center which regulates sleep exists in the autonomic nervous system. According to his investigations, this center for sleep control is located on the floor of the third ventricle near its transition to the aqueduct of the midbrain. The presence of such a sleep center is also indicated by the findings of Förster.[23] Förster found that surgical intervention in the frontal zone of the floor of the third ventricle was accompanied by a lively increase in mental activity with an urge to talk, tell jokes and euphoric emotional states, while intervention in the region of the medulla oblongata and the posterior side of the ventricle resulted in dullness, fatigue and drowsiness. This, therefore, is in favor of two centers, one with a sleep-inducing and the other with a sleep-inhibiting action. This is in agreement with the results of studies of Hess and represent a complete analog to the functional structure of other regulatory centers in the diencephalon, which also have antagonistic functions.

8. Influence on conscious awareness: — In addition to the phenomenon already observed by us, various persons also observed phenomena which clearly indicate an influence of short waves on the conscious awareness. Thus, Michelson[64] observed an improvement of general condition (appetite, sleep) after a few treatments in the case of pulmonary abscesses. On the other hand, pathological changes could still be found for a long time in objective examinations, such as x-rays. The subjective complaints of the patients thus decrease much more rapidly than the objective symptoms. Similar phenomena were observed by other authors in the treatment of pain by short-wave irradiation. The pain abates much more rapidly than the objective symptoms. The fact that the focus of infection remains and the irritation produced by it (pain, etc.) is no longer perceived, clearly indicates an influence on conscious awareness. The focus of infection actually represents the cause for these subjective sensations or in other words, is a source which causes the irritation. This irritation is conducted via nerve fibers to the brain and is perceived, i.e. subjectively noted. The fact that this

source of irritation continues to exist after the first stages of short-wave treatment, but that the irritation produced by it is not perceived in the brain indicates that a change in perception takes place which evidently must be attributed to the influence of short waves on the brain.

Horn, Kauders and Liebenny[44] report that when schizophrenics are subjected to short-wave treatment of the brain, optical hallucinations appear in some cases and acoustic hallucinations in others. In the same manner as they existed at the start of his disease, they disappear promptly after the transmitter is disconnected. In some schizophrenics, irradiation produces tranquilization, elimination of inhibitions, an increased awareness of the environment, and a reduction of confused speech. After a few weeks, these phenomena disappear and the initial condition reappears.

Hallucinations can also be induced by a direct electrical stimulation of the focal area. Penfield[75] describes a case in which the patient had a focus in the right temporal lobe. In this patient, optical and acoustic hallucinations occurred repeatedly either at the start of or subsequent to an epileptic seizure. During surgery under local anesthesia, it was possible to induce hallucinations by direct electrical stimulation of the focal region.

It can be seen that positive or negative effects are obtained depending upon the applied dosage. Since every individual has different sensitivity to short waves, dosage cannot be defined as a physical quantity but rather as a relative value which produces a given reaction of the central nervous system.

The above-described symptoms can again be explained by temporary changes of conscious awareness due to short-wave effects. From the influence on sleep it can also be concluded that the conscious awareness is influenced by short waves.

The influence on conscious awareness by short waves can be controlled particularly clearly by the psychogalvanic phenomena which represent an image of the state of conscious awareness in the same manner as the EEG. The analgesic action of short waves, which incidentally occurs analogously to hypnotic analgesia, also is to be attributed to a change in conscious awareness. As we know, the change of conscious awareness of the environment can be the result of suggestion in hypnosis. Thus, similar phenomena are produced by short waves and hypnosis. When we consider that the process which takes place under the influence of short waves is the same as in hypnosis, i.e. the somatic nervous system is influenced by central autonomic centers in the brain stem and not by the sensory organs of the cortex, the parallelism between the phenomena induced by short waves and by hypnosis becomes clear.

The parallelism between the mechanism of short-wave effects and hypnosis and the phenomena resulting from these extends also to the other physiological symptoms which have already been considered above and which can also be produced by hypnosis.

9. General influence of the short electromagnetic waves on the central nervous system: — The first data concerning the general condition of individuals working near a short-wave transmitter originated from American radio amateurs. These data are reported by d'Orville, Melland and Withney.[72] Similar phenomena have been described for radio operators by Bell and Fergusson.[9] The nerve disturbances differ individually and appear particularly clearly at wave lengths of less than 6 m. In persons which exhibit this individual sensitivity, these disturbances are expressed by nervous overexcitability, psychologically increased irritability, general fatigue, and in some persons tremors of the hands and disturbed sleep can be observed. Liebesny[61] has reported on nervous symptoms and great fatigue and high irritability in the proximity of short-wave transmitters below 6 m. As such, Liebesny could observe such symptoms only when the head was kept near the condensor field. This indicates the individual difference in the sensitivity of the test subjects with respect to the influence of short waves. The electromagnetic wave transmitted through an antenna can produce certain biological effects, as recognized first by Lakowsky[59] in carrier pigeons. In this manner, general nervous symptoms of irritation can appear in animals and man, which appear to be the more intense, the shorter the applied wave length.

Schliephake states that when human subjects work near short-wave transmitters, disturbances in the general condition appear with time, which can only be explained from the influence of the electromagnetic effects. The individual disturbances differ individually: In some cases, unpleasant sensations appear immediately when the transmitter is switched on, while in others these sensations occur only after staying several hours near the transmitter. In some cases this sensitivity is so great that they can easily report whether the transmitter is switched on or not when they enter the treatment room, where any acoustic or optical appearance of the transmitter naturally must be ruled out. The nervous disturbances are the more intense, the shorter the applied wave length. Thus, for example, in the operation of a 400 W transmitter on wave lengths of 3 m, intense reactions appeared immediately, while nervous disturbances appeared only after several hours in the closest vicinity of a 5000 W transmitter with a wave length of 15 m.

The type of influence on humans in the transmitter field depends extensively upon the exposure time. On the basis of the observations of Schliephake, three different degrees of this influence can be distinguished:

a) Extensive fatigue appears first, which is aggravated to apathy with continuation of the irradiation;

b) With longer exposure to the proximity of the transmitter, the symptoms characteristic of neurasthenia appear: restlessness, excitation, sometimes anxiety and pessimism, disturbed sleep (difficulties), extensive fatigue, debility and feeling of inactivation.

c) With continued irradiation, a dull pressure sensation in the head and headache appear, which can become aggravated to the extent of intolerability. Psychologically, feelings of depression and inferiority are observed, with an inclination to complaints and argumentative disposition, as well as a certain amount of uncertainty in dealing with others.

Roth[81] reports that persons working near a short-wave transmitter complain of excitability, psychologically increased irritability, general fatigue, etc. All of these symptoms disappeared promptly when the corresponding persons were removed for some time from the field of the transmitter radiation. These symptoms are in agreement with those cited in (b) and observed by Schliephake. It can be concluded from all of these findings that the degree of influence depends upon the irradiation time, in addition to the wave length and the sensitivity of the test subject. Since the dosage = dosage rate x time is determined by the irradiation time, it can be said that the degree of influence on humans by electromagnetic waves depends not only upon the particular wave length applied and the sensitivity of the test subjects, but also upon the applied dose. It is apparent from the observations of Schliephake that the small dosage causes tranquilizing and the large dosage irritating effects. Naturally the concept "small" and "large" is referred strictly to the sensitivity of the test subject. It can be assumed, therefore, that an influence on the central nervous system in the manner of a vagus stimulus occurs with a small dosage and in the sense of a stimulation of the sympathetic system with a large dosage. It can be assumed that the irritation of the parasympathetic and the sympathetic system is the result of a direct short-wave effect on the corresponding control centers of the diencephalon. This assumption is also confirmed by other symptoms, such as where the electromagnetic waves, which can also have antagonistic effects on sensory nerves depending upon the applied dosage and the sensitivity of the test person, are manifested by different pain symptoms.

Weissenberg[108] has reported on the disappearance of pain in the region of the central nervous system, while other authors report on the appearance of pain under the influence of electromagnetic waves. These symptoms can be explained by the irritation of the sympathetic and the parasympathetic systems, respectively. With a particularly high dosage, symptoms appear which indicate pathological changes in the brain.

Thus, electromagnetic waves influence the central nervous system of humans exactly as the high-frequency current in the condensor field, except that in the case of this second high-frequency effect, larger quantities of energy are transmitted to the test subject per unit of time than in the first form of application, i.e. the only difference consists of the different dosage rate. In this context one can consider electromagnetic waves as a form of treatment with smaller dosage rates.

10. Chemical-physical effects of short waves: — (a) Influence on the total albumin and sugar concentrations in the cerebro-spinal fluids and blood under the effect of short waves: — Horn, Kauders and Liebesny,[44] reporting on cases of paralysis and schizophrenia subjected to repeated treatments of the skull in the condensor field, found a notable increase of the total albumin level in the cerebro-spinal fluids as well as a temporary increase in the cell count, which subsided only slowly in the course of months. No heat sensation was observed during treatment. In spite of the extensive meningitic changes in the cerebro-spinal fluid, the patients exhibited no subjective signs of meningitis or symptoms (headaches, high fever) of meningitic irritation and their subjective feeling of well-being also remained undisturbed. This illustrates again that short waves influence conscious awareness.

Haug[36] also found an increase in the total albumin in the cerebro-spinal fluid of patients after short-wave treatment. As in the case of Horn et al., Haug[36] employed a small dosage. Glauner and Schorre[33] also reported on changes in the cerebro-spinal fluids after short-wave treatment of the rabbit brain. The treatment was conducted with a small dosage at a wave length of 6 m with no significant evolution of heat. They found that a total albumin increase of 1.66% and an increase in the cerebro-spinal fluid sugar of up to 220 mg% occurs, while an increase in the cell count was not observed. Perhaps this is due to the fact that they experimented with a healthy brain in contrast to the other authors. In later investigations, the authors have confirmed their findings concerning the increase of albumin and sugar in cerebro-spinal fluid.

Schiersman,[89] in contrast to the findings of other authors, determined a moderate drop in the total albumin and the albumin ratio in 22 mental patients subjected to short-wave treatment of the cerebrum. An influence on the sugar level by short waves occurs not only in the cerebro-spinal fluids but also in the blood. Schliephake and Weissenberg[94] obtained a doubling of the initial value of the blood sugar and more already after a few minutes of irradiation of the brain. The drop is not as steep and often extends to far below the initial value within 4 hours. Glauner and Schorre[33] also found an increased blood sugar upon irradiation of the brain of a rabbit. However, the increase in blood sugar does not exhibit a parallel increase with cerebro-spinal fluid sugar.

Schliephake and Wuest[95] were able to attain a considerable increase in the blood sugar levels in healthy test subjects upon irradiating the head and cervical region with short waves. After the irradiation of the extremities, in contrast, a drop in blood sugar was obtained.

In contrast to healthy test subjects, quite different blood sugar curves are obtained in patients with diabetes, hypophyseal obesity and emaciation, myxedema, Basedow's disease, after irradiation with short waves.

In all of these diseases disturbances of the autonomic nervous system are involved, which have resulted by organic damage to the diencephalon. According to our interpretation the centers in the diencephalon are influenced by short waves; therefore, the differences in the sugar level curves after short-wave irradiation of healthy and pathological subjects with diseases of the autonomic nervous system become understandable.

Pflomm[76] assumes that the albumins in blood and serum undergo a change in the direction of a shift in dispersity from the coarsely dispersed to the finely dispersed state under the influence of short waves. Since defibrinized serum was used in the serum experiments, fibrinogen cannot be involved, but the globulin/albumin ratio might have been displaced in the direction of the albumins. The latter assumption can be supported by the findings of Kauders, Liebesny and Finalli.

Since the regulation of the total albumin as well as of the sugar concentration takes place from the autonomic nervous system, these phenomena can again be explained by the influence of short waves on the autonomic nervous system. Contradictory results — reduction in albumin levels (Schiersmann[89]) and increase (other authors) can be explained by differences in the applied dosage. The autonomic nervous system is known to carry out antagonistic functions, and one or the other of these functions is stimulated or inhibited depending upon the applied dosage.

(b) Influence on leukocytes by the action of short waves: — After a general irradiation of the rabbit with a high dosage, Oettingen and Schulze-Rhonoff[70] were able to find a pronounced drop in the leukocyte count. After 1-3 hrs., a hyper-leukocytosis occurred and the initial state was reattained after 24 hrs.

Jorns[53] investigated the action of short waves on the phagocytosis of leukocytes and found that a moderate dosage stimulates this process, while a high dosage attenuates it.

Schliephake and Nöller[93] found a drop in the leukocytes after the irradiation of the extremities and trunk of human subjects which occurred immediately after irradiation, while a pronounced hyperleukocytosis was produced after irradiation of the head.

Horten[45] arrived at similar results as Oettingen[70] and Schliephake[91] in the irradiation of extremities. In 20 test subjects, a drop of the leukocyte values occurred in 11 cases, while irradiation was in progress (5-8%). In some instances, the leukocyte number even increased beyond the initial value after 30 minutes of irradiation. The results of Schliephake obtained with irradiation of the head could not be confirmed by this author. Since the leukocyte count is subject to control from the central nervous system, the influence of short waves on the central nervous system is again confirmed by this finding. Here, as well as in the influence on the total albumin antagonistic effects are produced depending upon the applied dosage (increase-decrease in the leukocyte count).

(c) Hydrogen ion concentration by the influence of short-waves: — Pflomm[76] found that an increase of the hydrogen ion concentration occurs in the venous blood of the irradiated arms or legs as well as in the serum in an irradiated test tube. Schlag[90] found in his studies that a greater acidification occurred after the short-wave irradiation. With the application of the shortest wave lengths, where heating was at a minimum, the highest degree of acidification was found. A pure heat effect in a heat treatment with a Solux lamp had no effect on the course of the acidification curve.

Nordheim and Schliephake[69] were unable to determine an acidification of the serum after short-wave irradiation. The serum was obtained from one part of the body before and after short-wave irradiation. In vivo measurements conducted with human subjects and animals, an acidification also occurred, which might not be caused solely by the temperature increase. The authors believe that this acidification in the short-wave field is related to electrical and physical processes at the cell surface and cell membrane.

11) Interpretation of the processes with different forms of application of short-waves: — A direct influence of the autonomic nervous system takes place by the action of short waves. Depending upon the applied dosage, this influence is expressed by the stimulation of the sympathetic or parasympathetic systems. Consequently, it is understandable that antagonistic phenomena appear depending upon the applied dosage of short waves: promotion and inhibition of sleep, increase and decrease of body temperature, aggravation and inhibition of pain, increase and decrease of the galvanic skin resistance, dilatation and constriction of the vessels with a consequent drop and rise of blood pressure, acceleration and deceleration of the heart rate, increase and decrease of the respiration rate, increase and decrease of the total albumin concentration in the cerebro-spinal fluids, increase and decrease in the leukocyte count. It is known that all of these phenomena represent the expressions of the double-function of the autonomic nervous system. These phenomena occur by the direct action of short waves on the vegetative nervous system, which take place without any participation of the sensory organs. This influence can be attributed to the stimulation of nucleus of origin of sympathetic and parasympathetic systems or their control centers, which are known to be located in the diencephalon. This stimulation of the ganglion cells can result from their absorption of a high-frequency energy. This absorption of high-frequency energy is entirely possible, since a certain percentage of the high-frequency energy permeates all tissue layers and cell membranes into the interior of the ganglion cells and stimulates the latter. This stimulation is due to the pronounced drop of the dielectric constant and an increase of the conductivity of body tissues in the very high frequency range. The stimulation of the ganglion cells can be explained by the fact that they are subjected to a direct flow of the high-frequency current. But this is only possible when they are located between the applied electrodes.

The method of Hunecke proves that the high frequency can be supplied to the ganglion cells without passing a direct high-frequency current through them. Thus, it can be assumed that the high-frequency energy in this case is conducted to the ganglion cells through peripheral nerves. Usually, when various physical stimuli act on the human body, these stimuli are received by the sensory organs and transformed into electrical energy forms — action currents — and these action currents are conducted to the ganglia, resulting in the stimulation of the latter. Hunecke's[47] method allows to influence the autonomic nervous system by means of high frequency energy without participation of the sensory organs as well as without direct flow of high-frequency current through the ganglion cells. Therefore, we can assume that electrical pulses are conducted to the ganglion cells in their original shape along the peripheral nerves.

The phenomenon of a vibration of the hand in the condensor field observed by Schliephake (see p. 4) can also be explained as in the case of Hunecke's findings. The short-wave energy flows centripetally via peripheral nerves to the ganglia without transformation in the sensory organs and excites the ganglia. The resulting excitation flows centrifugally over motor nerves and produces muscle contractions. Here, a special form of reflexes appears again, which differs from the known reflexes by the fact that — as mentioned before — the stimulus producing the reflex (short waves) is conducted to the ganglion cells in its original form without transformation in the sensory organs.

12) Dosage: — The methods of determining dosage utilized at the present in short-wave therapy are based mainly on the principle of measuring the energy conducted to and absorbed in the body. Before we turn to an investigation of these methods, we should define accurately the concepts of "dosage rate" and "dosage." According to Schafer[87], the dosage rate is the quantum of energy absorbed per unit of time in the individual treatment and the dosage is the entire quantum of energy absorbed during the entire period of treatment.

Innumerable methods have been proposed, all of which were based on the above-mentioned principle, but none could achieve a satisfactory solution of the dosage problem. In the irradiation with short-waves, however, the current intensity is not a relative measure of the absorbed power. The current is composed of the resistive current and the reactive current and the measuring instrument connected into the secondary circuit indicates only the resistive current. Therefore, the energy absorbed in the body can change extensively while deflection of the galvanometer needle remains the same. The determination of the dosage rate by a measurement of the field strength with a thermocouple also could not provide a satisfactory solution, since a local increase in density of the field takes place, which causes a pronounced heating of the thermocouple and consequently leads to considerable measuring errors.

A somewhat better solution of the dosage problem was obtained by the so-called method of decrements. The principle of this method is based on the measurement of the absorbed energy in the patient by means of an equivalent circuit with the same electrical data as the patient-condensor field. A consumption resistor is connected into the equivalent circuit and the output converted in it is determined by calorimetry or photoelectrically by measurement of the light emission of a filament. This method is complicated and requires the use of special auxiliary equipment between instrument and treatment electrodes, and it is not universally applicable, i.e., it cannot be built into any desired instrument. Furthermore, this method only furnishes the absolute quantities of energy which are absorbed in the body. The specificity of this energy is neglected altogether. Consequently, in order to compare the test results obtained with this method, the type, size and distance of the electrodes, the separating material and, in the case of bioassays, the material of the vessel in which the experimental object is placed, must also be taken into account. We have already demonstrated in the preceding paragraphs that the effective action of short waves on the human body is also influenced extensively by the wave length as well as by the shape of the pulse. Thus, the effective action is magnified with a decrease in the wave length; a damped as well as a modulated pulse causes a much more pronounced effect than an undamped or unmodulated oscillation. In a comparison of the test results, therefore, the wave length, type of transmitter (quenched spark transmitter, oscillator), current supply of the anodes (AC or DC), as well as modulation, if it is unitized, must be taken into consideration. Since accurate data on the above-cited factors usually are absent in most reports, no comparison of the treatment results is possible. The numerous contradictions in the question of the so-called specific short-wave effects (as is apparent from our investigations — influences on the central nervous system), are to be attributed to completely different, physical causal factors for their origin.

As we have already shown, the effect of short waves has a special influence on the autonomic nervous system. Depending upon the applied dosage, sympathetic and parasympathetic centers are influenced, which is expressed by the physiological and physicochemical symptoms (see table).

	Dose	
	Small	Large
Galvanic skin resistance	Increases	Decreases
Blood pressure	Decreases	Increases
Vessels (capillaries)	Dilated	Constricted
EEG	High-frequency oscillations	"Slow" waves
Muscle tone	Decreases	Increases
Diuresis	Promoted	Inhibited
Pain symptoms	Reduced	Enhanced

Table 1. — Indications of the reactions of the autonomic systems with short-wave irradiation.

It is apparent from Table 1, that contrary effects of short waves are the result of the particular applied dosage: A small dosage produces an increase in the tonus of the parasympathetic system, while a strong dosage results in an increase in the sympathetic tonus. We have already mentioned that the reaction of the patient's organism with respect to short waves differs highly. Therefore, the dosage cannot be simply determined even under completely identical physical conditions (wave length, type of transmitter, type of electrodes, etc.), since one and the same dosage under otherwise equal conditions can cause parasympathetic reactions in one patient
and sympathetic reactions in another. According to the observations of Weissenberg, 108
the effect even differs in one and the same patients at different times (perhaps in accordance with his particular psychological state). Consequently the dosage cannot be based on the principle of measuring the energy absorbed by the body, but must also be based on the principle of measuring the reaction of the body to the absorbed energy.

The measurement of the reaction of the organism on the effect of short waves, however, may not be based upon the subjective sensation of heat of the patient and it is entirely impossible with a treatment given with a low power supply, where such small quantities of energy are furnished to the body (0.1 to 0.000001 W-sec/cm^3), that no measurable heat is generated. Since short waves influence the autonomic nervous system, the reaction of the organism to this influence can be controlled by recording the different symptoms compiled in Table 1, which are an expression of function of the autonomic nervous system. Schliephake has already made reference to the possibility of such dosage determinations by the control of the expressed function, of the autonomic nervous system, i.e., by vascular controls. The individual reactions of cutaneous capillaries can be observed with the capillary microscope and the dosage can be adjusted accordingly. However, due to its unwieldiness, this method cannot be applied in practice for a dosage determination.

An objective and much more convenient and accurate dosage measuring method is represented by the measurement of the reaction of the organism on the effect of short waves by means of a control of the galvanic skin resistance. It is known that changes in galvanic skin resistance represent the expression of the function of the autonomic nervous system and its variation takes place parallel to the other symptoms listed in Table I.

I have carried out such a control of the galvanic skin resistance in healthy test subjects, in patients with diseases of the liver, kidneys, gall bladder, and in mental patients. The studies took place at the Municipal Hospital, Hans Sachs Haus, Stuttgart (Medical Director: Prof. Dr. Roemer) and later in the hospital for nervous diseases of Stuttgart (Medical Director: Dr. Gundert). The galvanic skin resistance measurement took place with the use of a Wheatstone bridge with a sensitive galvanometer $1^{o} = 2 \cdot 10^{-7}$ A. A polarizing effect was prevented by the use of unpolarizable electrodes (zinc-, zinc sulfate-NaCl solution). The leads usually were placed at the fingertips. It has been found, incidentally, that the same curves are obtained by placing the leads on the toes. In the course of the investigations, 114 curves were recorded with 30 test subjects. The measurements were carried out directly before short-wave irradiation and 24 hours after short-wave irradiation. Short-wave irradiation took place with the "Ultratherm" short-wave transmitter of the Siemens-Reiniger Werke with a high-frequency output of 400 W and a wave length of 6 m as well as with the "Roehren-Erbotherm" short-wave transmitter with a high-frequency output of 400 W and a wave length of 6 m. The electrodes were placed on different parts of the body in the different cases: at the head, epigastrium, knee, shoulder, etc.

It was found that the curve prior to short-wave irradiation exhibits an exponential course in healthy test subjects as well as with most patients suffering from organic internal diseases, and that it shows the superposition of irregular fluctuations (isolated Veraguth's reflexes).* In these test subjects, the absolute galvanic skin resistance values (measured at the instant of connection of the auxiliary current) are found in the range of 15-45 kilo-ohm. Fig. 2 shows a typical course of the galvanic skin resistance with time in a healthy test subject.

After the short-wave irradiation (measurement took place 24 hours after irradiation), a considerable increase of the galvanic skin resistance occurred in all patients. This increase is extensively dependent upon the particular short-wave dosage applied, referred to the individual sensitivity of the test subject. The increase of the galvanic skin resistance occurs with irradiation of any part of the body. With the same short-wave dosage, the effect is most pronounced when the current flows through the head, and at a minimum with current flow through the extremities. Depending upon the applied dose, a 3-7-fold increase of the galvanic skin resistance was obtained and absolute galvanic skin resistance values of more than 100 kilo-ohm and at times even above 200 kilo-ohm were attained. Fig. 3a shows the course of the galvanic skin resistance with time in a patient prior to the short-wave irradiation. The patient complained of pain in the left shoulder joint and neck and exhibited increased nervousness. After short-wave irradiation of the left shoulder joint, carried out with an electrode distance of 2 cm for a period of 7.5 min., a considerable increase of the galvanic skin resistance resulted, as shown by Fig. 3b. Twenty-four hours after the first treatment, this patient was exposed to a second short-wave treatment, in which current was passed through the neck for a period of 5 min. with an electrode distance of 15 cm. Fig. 3c shows the course of the galvanic skin resistance determined 24 h after the second treatment. The curve is characterized by unusually high galvanic skin resistance values, which otherwise are found only in mental patients. A particularly even course of the curve, without typical fluctuations, which normally are superimposed on the curve, is also worthy of note.

*Veraguth's reflex is defined as a rapid reduction of galvanic skin resistance, which usually is followed by a gradual recovery to its initial value.

An increase of the galvanic skin resistance also occurs by the action of electromagnetic waves with longer exposure to the vicinity of a short-wave transmitter. Fig. 4a shows the galvanic skin resistance curve of a healthy test subject before the influence of the short waves. Five hours after the subject was exposed to the vicinity of the short-wave transmitter, a notable increase of the galvanic skin resistance was observed in this person, as shown by Fig. 4b.

In mental patients under no influence of short waves, the curves exhibit no continuous exponential course; rather the shape of the curves for the same patients varies spontaneously with time and assumes very irregular forms. In most mental patients, the Veraguth's reflex is weak and often is entirely absent. The curve consequently has an "even" course without the superimposition of "rapid" fluctuations. The absolute galvanic skin resistance values are sometimes very high (more than 100 kilo-ohm). Fig. 5 shows the galvanic skin resistance curve in a patient with melancholia hypochondriaca; curve shows high resistance values and a continuous irregular shape, which has no similarity at all to the typical exponential course of normal healthy subjects. The measurements after short-wave irradiation of mental patients showed no clear picture, since very pronounced spontaneous fluctuations of the galvanic skin resistance take place in these cases, as noted above.

13) Summary. — On the basis of the above-cited data we have demonstrated that high-frequency energy has a special influence on the central nervous system, which by no means can be attributed to the effect of heat, or to the effect on the sensory organs. Under the influence of short-waves, the central autonomic system is affected without participation of the sensory organs, and the influence on the somatic nervous system takes place by the control of its readiness to function from the autonomic sector. Thus, a process takes place which otherwise occurs only under hypnosis. This effect is manifested by the psychological, physiological as well as physicochemical symptoms: promotion and inhibition of sleep, increase and decrease of the galvanic skin resistance, drop and rise of blood pressure, increase and decrease of total albumin, etc. This influence on the autonomic nervous system can take place by the action of the high-frequency current as well as of electromagnetic waves. This energy, which acts on the autonomic nervous system, can be produced

by a short-wave transmitter as well as by a d'arsonvalization instrument. The effect of this energy on the central nervous system increases with the decrease of the wave length. Furthermore, it has been found that the action of intermittent high-frequency currents and waves has a much greater influence on the autonomic nervous system than the action of continuous currents and waves. The fact that an influence on the autonomic nervous system is produced by the action of high-frequency energy, offers the opportunity for the application of a new dosage method, which is based on the principle of measuring the reaction of the organism to the quantity of energy absorbed by it. It has been found that the control of the galvanic skin resistance can be used as an indicator in the determination of the dosage.

II. ELECTRICAL PROCESSES IN THE HUMAN BODY AND ITS ENVIRONMENT

1) Electrical phenomena in the human body as well as its environment as a function of the emotional state: — From the electrical phenomena of the brain in the cortex and the stem of the brain it can be concluded that an energy is produced in the ganglion cells by a certain process. Some investigators assume that brain waves have their control centers in the central autonomic system of the diencephalon. Thus, Kornmüller[55], on the basis of his observations of the various time relationships between the potential fluctuations from different leads, arrives at the hypothesis that the fluctuations in voltage of the cerebral cortex originate from certain fibre systems, primarily those of the thalamus. Schäfer[86] also agrees with this concept.

A part of the energy generated in the ganglion cells radiates through all tissue layers and appears in the form of electrical pulses on the surfaces of the skull. The frequency, amplitude as well as the shape of the curves of these pulses are extensively dependent upon the emotional state of the subject.

a) In the state of complete mental passivity, when the influence of sensory stimuli is avoided, the voltage pulses appear in the form of α-waves, the amplitude of which amounts to 20-40 μV with a frequency of 8-12 cps. In spite of the complete relaxation of the test subject, the α-waves are always superimposed by waves of higher frequency. These superimposed waves can be clearly observed with the use of an amplifier with a sufficiently broad frequency spectrum and broad time recording (see Fig. 6). The amplitude of this higher harmonic is relatively large and has a rather great influence on the fundamental oscillation. The curve is consequently distorted, showing clear deviations from the sine shape. The deviations of the curve from the sine shape can only be recognized with the use of an amplifier with a sufficiently broad frequency spectrum. An amplifier with a narrow frequency spectrum, on the other hand, produces very regular, nearly sine-shaped curves. With the use of an amplifier with an extremely narrow frequency spectrum of 5-20 cps, Rohracher[80] was able to completely eliminate the influence of a higher harmonic on the fundamental oscillation. The result obtained by him that the α-waves form a completely sine-shaped wave, can therefore be attributed not to their nature but to the narrow frequency range of the amplifier. With the use of an amplifier with a broad frequency spectrum and a broad time recording, Rohracher was also able to observe that the α-waves obtained in the state of complete mental and physical relaxation are always superimposed by the spikes of rather frequent (higher than 100 cps) higher harmonics. (See Fig. 7). These higher harmonics cause a distortion of the fundamental oscillation. In the state of mental activity, the higher harmonics have a larger amplitude than in the state of mental relaxation and therefore a greater influence on the fundamental oscillations. Due to the greater influence of the higher harmonics, the curve is distorted more extensively, showing much greater deviations from the sine form than the curve obtained in the state of emotional rest (see Fig. 8).

In states of reduced consciousness (unblocking of the cortex), the amplitude of the waves occurring in this condition amounts to 100-250μV and the frequency of the fundamental oscillation drops to 7-0.5 cps.

On the basis of the curve analysis of these waves, Franke and Koopman[24] found that the amplitude of the higher harmonic is very large and can have a far greater influence on the fundamental harmonic than is the case in a state of full consciousness. Consequently a pronounced distortion of the curve results, which assumes a characteristic, paroxysmal form of a relaxation oscillation. The electrical potentials on the surface of the skull produce electromagnetic waves which propagate in space. According to physical laws, these waves should form an accurate picture of the potential pulses which are derived from the skull and which have their origin in the ganglion cells. Consequently, this electromagnetic energy radiated from the surface of the skull is to attain its highest values in the states of reduced consciousness. Since we wish to formulate a hypothesis for the explanation of extrasensory perception by the transmission of this energy from brain to brain, we must take into account that this wave energy is attenuated with propagation into space in a ratio equal to the square of the distance and consequently we must assume that the human brain contains such a hypersensitive receiver organ which reacts to these minute energies.

The further phenomena, which can also be explained by the transmission of brain waves, are those of mass psychology, in which the effective excitation appears to take place not via the cortex but directly from brain stem to brain stem.

Rohracher has reported that large numbers are not even necessary for many subjects in order to produce such an excitation. In the proximity of an excited subject, the nervous system of another begins to oscillate to such an extent with the excited one that it itself is excited. We do not know the manner in which this transmission originates; if at all, we must think of a direct effect of the electrical potentials produced by the event in the brain.

The higher harmonics superimposed over the brain waves have a striking similarity to the muscle tone (compare Figs. 6 and 9).

It is evident from the studies of Davis and Bagchi that the amplitude of the muscle tone as well as that of the higher harmonic of brain waves depends upon the emotional state of the subject. Thus, with mental activity, and especially with a mere conceptualization of observation, the amplitude increases extensively.

This parallelism between muscle tone and the higher harmonic of brain waves indicates that the muscle tone originates from the central nervous system and that it actually represents the higher harmonic of the brain wave transmitted to the peripheral system. Since the brain waves of the cortex, as mentioned above, have their origin and control centers in the central autonomic system of the diencephalon, the muscle tone, on the basis of our assumption, should also be controlled by the autonomic nervous system. This is supported to some extent by the observations of Schäfer[86], that human subjects with a high heart rate have a particularly elevated muscle tone. It can be assumed, therefore, that a part of the energy produced in the ganglion cells flows through all tissue strata and appears in the form of electrical potentials at the surface of the skull, while the other part of this energy is propagated in the form of muscle tone over the nerve fibers to the periphery. According to physical laws, the currents should be reflected by the nerve endings and after flowing through the tissues, they appear at the cutaneous surface in the form of electrical potentials. These potential pulses as well as those at the surface of the skull should produce electromagnetic waves which propagate in space. These should represent an image of the muscle tone as well as the higher harmonic of brain waves. In a model concept, this process can be simulated by a simple connection of a power source to a line with an open end. Consequently, the pulses or transient waves can be generated in this line and by reflection at the end of the conducting line, these transient waves can be propagated in space. Such a reflection of the muscle tone should be found primarily at the finger tips. By this reflection, the Veraguth's as well as the Tarchanoff* reflexes can be explained. It is known that the psychogalvanic reflex depends upon the emotional state of the subject. In the state of psychological relaxation, the galvanic skin resistance is particularly high, while it drops in the state of psychological activity and reaches its lowest values in the state of reduced consciousness. The galvanic skin resistance, therefore drops with the increase in amplitude of the higher harmonic superimposed over the brain waves. Since the muscle tone according to our assumption represents the higher harmonic of brain waves transmitted to the periphery, we can conclude that the galvanic skin resistance decreases with the increase in amplitude of the muscle tone. We can assume that the current reflected by the nerve fibres produces a change in membrane potential and thus in the galvanic skin resistance as it is transmitted through the skin. Since the polarization in the living tissue is known to be located at the interfaces, and is the result of ionic displacements, a more pronounced irradiation thus can also cause prominent changes in concentration and thus in the permeability of the membrane and therefore to a decrease in polarization. After flowing through the skin, the muscle tone reflected at the nerve endings appears at the skin surface (inferior zone of the finger tips) in the form of electrical potentials. This phenomenon is known as Tarchanoff's reflex. The changes of these potentials may be the result of changes in membrane potential as in the case of the galvanic skin resistance changes and thus are dependent upon the emotional state of the subject.

According to physical laws, the potential charges formed at the surface of the body should be propagated in the ether in the form of electromagnetic waves. On the basis of the above, changes in the energy emitted from the finger tips should take

* Electrical potentials at the inferior zone of the finger tips.

place in parallel with the changes of the higher harmonic superimposed on the brain waves. In other words, the fluctuations of the waves radiated from the human body should be the result of the emotional state of the subject: in the state of mental passivity, these waves should have their minimum magnitude while their amplitude should increase in the state of mental activity and they should reach their highest magnitude in the state of reduced consciousness.

The existence of electrical waves in the vicinity of the human body has been objectively confirmed by various means. The first method for the verification of these waves is based on their property to increase the conductivity of various media (air, mica, etc.).

The indicator of these waves built on the basis of this principle was developed by E. K. Müller[68] in two different designs and was called the electromanoscope. In its first design, mica was connected in a DC circuit as the medium with a variable resistance. In the second design, the DC was chopped by an oscillator and the air gap between two electrodes was used as the resistance-variable medium. With the approach of the finger tips to the instrument, a considerable rise in the current was produced, which could be observed by the deflection of the galvanometer. In the interpretation of the author, this change in current due to the change of resistance of the indicator medium is to be attributed by the effect of the energy emitted by the finger tips. It resulted from Müller's experiments that this change in resistance depends upon the emotional state of the test subject, where the resistance decreases in the state of mental activity compared to its value in the state of mental inactivity. We can conclude from this that the resistance change of the insulating media under the influence of the energy emitted by the finger tips exhibits a parallel behavior to the changes in galvanic skin resistance, which appear when this oscillatory energy flows through the skin. In some subjects, this radiation attains such a magnitude, that it can even influence a photographic emulsion.

Bradoc[12] was the first who attempted to photograph this radiation. The process is based on the same assumption as in radiography, i.e. that the corresponding radiation passes through paper, wood, etc. Accordingly, the photographic plates are exposed to this radiation in their cases or paper wraps without light exposure or directly in the darkroom. In the first case, they are pressed against the body, held in the hand, etc., and in the second the hands or fingers are pressed on the emulsion or more rarely on the glass cover of the plate.

Aigner[1] found that the hands of some subjects placed with the fingers spread on the glass of a photographic plate for 15 min. in the absence of light, clearly produce a shadow image: The areas which are not covered are affected into the corners of the plates in the manner of a light exposure. The finger tips appear to be the origin of this active energy. The magnitude of the influence decreases towards the center line. However, this effect was obtained only with some individuals and in these cases in a very intermittent manner: Any effect may remain absent for a period of days and then may return for a longer or shorter time; this was also found by experiments conducted in clinics and hospitals. In Berlin, Nuremberg and Munich, these experiments were carried out with positive results, so that a common source of error could hardly be assumed.

The change of the energy emitted from the finger tips takes place parallel with the changes of the higher harmonic superimposed over the brain waves as well as with the changes in muscle tone. Since the brain waves are controlled by the autonomic system, we can assume that the radiation emitted by the finger tips also originated from the autonomic nervous system.

2) Electrical phenomena in the human body as well as in its environment during muscle contractions: — Various investigators have reported that a relationship exists between the potential fluctuations of the cortex and muscle contractions. On the basis of his experiments, Kornmüller[55] arrived at the conclusion that movements of the extremities cause an amplitude decrease of α-waves in the central motor area.

Jasper and Andrews[51] report of a clear agreement in the frequency of a finger tremor and cortical potential fluctuations.

Dawson[20] recorded the potential fluctuations of the cortex simultaneously with the muscle action current during certain seizures in a test subject. He found that a good agreement exists between the course of the EEG and the muscle action current curves, particularly in grave pathological conditions. It can be concluded that a relationship exists between the potential fluctuations of the cortex and the fluctuations of the muscle action current, thus that the amplitude of the muscle action current appears to increase with the increasing excitation of the corresponding motor centers. We have already referred to a similar dependency between cortical potential fluctuations and the muscle tone in the first part of this chapter.

A part of the energy discharged with the stimulation of motor ganglion cells flows to the periphery in the form of action current. In flowing through motor nerves with the action current, a reduction of its galvanic threshold of excitation is produced and when a certain value is exceeded, muscle contraction results. It is obvious that a further increase in muscle contraction is produced with a further increase of the action current strength. We can also assume here that a further reduction of the threshold of galvanic excitation takes place. The latter assumption has been confirmed by the findings of Bourguignon and Haldane. They reported at the Twelfth International Congress of Physiologists that in order to produce a contraction during a seizure with hyperventilation, it is necessary to increase the current, as the intensity of the seizure increases. Thus, the excitability of muscles and nerves is reduced by hyperventilation, even though they are hyperstimulated. The reduction of the threshold of galvanic stimulation can be explained by the reciprocal influence of the excitation waves when they encounter each other. The process of interaction of excitation waves was experimentally analyzed by P. Hoffmann[42]. The author was able to observe the process of suppression of voluntary excitation waves by the opposite artificial stimulation in the axons of motor nerves and inversely, the suppression of the artificial stimulation by intense voluntary innervation. This explains the phenomena observed by Bourguignon and Haldane as well as by Audiat[5] and Dalton[16] (see p. 5).

Analogously to the phenomena described in Section 1, we can assume that the action current flowing along the motor nerve fibres during the muscle contraction is also reflected at the myoneural junction, passes through the tissue strata and causes the electrical potential fluctuations at the surface of the body. According to physical laws, these potentials should produce electromagnetic waves, which are propagated in space.

The existence of such electromagnetic waves in the vicinity of the human body during muscle contraction was confirmed experimentally by Sauerbruch and Schumann[85]. The authors were able to demonstrate the electrical fields in the vicinity of working muscles in vivo by means of a very sensitive amplification equipment with a string galvanometer as indicator. Furthermore, they found that the deflection of the galvanometer depends upon the work output, i.e. it increases with an increase in muscle contraction. Such a characteristic of this wave corresponds to the properties of the action current and is entirely understandable when we consider that these waves are to form an accurate image of the action current.

Grünewald[35] was able to produce electromagnetic induction effects in an induction coil by moving the hand through it. He made use of a mirror galvanometer as indicator together with the recording instruments registering the deflections. Evidently, energy emitted by the hand was considerably amplified due to the muscle contractions during its movement, since he was able to observe only very small deflections of the galvanometer while the hand was at rest.

Hoffmann[41] was also able to observe a current induced in the coil when the hand moved through it. However, no current was induced when the coil moved through the resting hand. This again is proof that the electromagnetic energy produced in the human body and propagated in the space is subjected to a considerable amplification during the muscle contraction.

If we wish to explain the telepathic transmission of movement by the transmission of these waves, then the amplification of these waves, and thus the amplification of the action current, should considerably improve this transmission. This means, that with a mere imagined movement, in which only weak action currents and weak waves are produced, the transmission should be less effective than when this movement is performed. This is entirely in agreement with the observations of Babaks[6] and Joire[52]. These authors conducted innumerable experiments with a telephatic transmission of movements and found they are more successful when the agent at the same time performs it himself. "At times, when a mere imagined concept of the movement to be performed was not sufficient, I was able to induce the correct movement when I gradually actually realized it myself (without noise, without being seen)." (Babak).

3) Amplification of the electrical phenomena in the human body and its environment by artificial means: — Under normal conditions, the electrical potentials occurring at the surface of the body can flow into the surrounding atmosphere as well as through the lower extremities directly into the ground without inhibition. For this reason only very small potentials can be found on the surface of the body. By a suitable insulation of the body, the flow of electrical potentials away from the body surface can be prevented or reduced and thus a considerable increase in the electrical potentials can be obtained. With a suitable insulation of the feet, the action current of considerable magnitude flows into the finger tips and causes detectable voltage discharges. Thus, Spitzer[100] reports that he observed when wearing shoes with heavy rubber soles that an audible and perceptible, and very rarely also a visible spark is discharged from his hand when he touches a patient or opens an instrument case. Together with these phenomena, the following symptoms of general irritability appear: migraine headache, perspiration, especially of the hands, and oppression. These symptoms, known to be an expression of the function of the central nervous system, ceased abruptly after the electrical discharge. Similar symptoms are also observed under the influence of short waves (see pp. 22, 23). With the action of short waves, the electrical energy, furnished to the body from external sources, charged the body, and as a result, a stimulation of the central nervous system occurs. In the phenomena observed by Spitzer, a charge of the body with the electrical energy produced in the ganglion cells of the body takes place. This charge is increased by prevention of the flow of electrical potentials from the surface of the body. With an increase of the charge, the central nervous system is stimulated, with the manifestations of the above-cited symptoms. A still higher voltage discharge from the surface of the body can be attained when not only the feet but the entire body is insulated with a suitable material. These voltage discharges receive a further amplification during the muscle contractions. Under such conditions, Oppenheim[71] was able to demonstrate the electromagnetic waves, forming by the voltage discharges on the body surface, up to a distance of 3 m with a neon lamp. When Oppenheim grounds one pole of the neon lamp and connects the other with the body, he obtained a synchronized lighting of the lamp with every jump from the floor, raising and lowering of the feet, i.e., with every strong muscle contraction with a simultaneous insulation of the body from the floor. Under particularly favorable circumstances,

he obtained lighting of the neon lamp up to a distance of 3 m. In this case, the lamp was grounded on one pole, while the other was connected to a small antenna. Only weak phenomena could be detected with the neon lamp without insulation of the body with the latter completely nude. Thus, the voltage discharges as well as the resulting electromagnetic waves produced during the muscle contractions at the surface of the body are considerably amplified by insulation of the body. Similar electrical phenomena in the proximity of the human body could be demonstrated by Wüst and Wimmer with a vacuum-tube voltmeter. The deflections were produced with rapid walking or jumping with rubber soles. Even a rapid stroking with the finger or with bare feet over a good dielectric, e.g. celluloid, hard rubber and the like, sufficed in order to obtain the deflection of the voltmeter.

4) Resonance phenomena during transmission of nerve energy in the human body as well as its environment: — On the basis of Weis's[106] resonance theory, specific nerve impulses and specific myoneural junctions should exist which latter respond only to the stimuli adequate for them. Thus, an entirety of different specific stimuli should flow through one fiber, which are distributed into all ramifications of the fiber. The myoneural junctions of these ramifications then select — in a manner of speaking — the stimulus adequate for them and allow the muscle to function only when this stimulus was contained in the total stimulation.

The Weiss resonance theory corresponds completely to modern communication technology. Several messages can be transmitted to different stations over a single conducting wire. Every transmitting and receiving station is adjusted to a certain frequency range and a mixture of frequencies flows through the common line, each of which has a specific frequency.

This resonance theory was based on experimental results of Weiss. Weiss grafted a fifth leg on salamanders anywhere on the body by bringing a part of the nerve fibres of the closest leg to the grafting site, so that these nerve fibres grew into the grafted fifth leg. The subsequent microscopic examination show that these nerve fibres, branched into the most diverse fibres and formed connections with the existing fibres of the grafted leg. More frequently, a single fibre developed a number of terminal branches, which passed into the various muscles of the grafted leg. In one case, for example, almost the entire grafted leg was supplied by the ramifications of a single nerve truni, which previously had passed only to the plantar muscle of the normal leg. These knee-bending fibres thus were connected with nearly all muscles of the grafted leg after healing had taken place, i.e. with muscles of entirely different functions. The additional leg was dragged along for a few weeks as a passive appendix, then it began to perform weak movements and soon it functioned as a normal leg. The fact that a correct total function results with the existence of a single nerve fibre, which splits into several rami only in the periphery which then pass into different muscles, proves the correctness of the Weiss resonance theory. It would be impossible that each stimulus flowing through the individual neurite would produce the correct function of all muscles supplied by its rami, for this could only result in a disorganized spasm.

We have already seen that on the basis of the Weiss resonance theory, specific action currents as well as specific myoneural junctions must exist which respond only to adequate action currents. Since the electromagnetic waves, formed as a result of the reflection of the action currents, form an accurate picture of the action current, these waves should also be specific. Thus, we can imagine the electromagnetic waves in the vicinity of the human body to be a mixture of impulses, each of which has a specificity, i.e. has a certain frequency.

Since the action currents are produced in the ganglion cells, every certain type of ganglion cell should produce specific action currents. Thus, each ganglion cell should produce a specific frequency impulse.

It is known that in addition to ganglion cells which fulfill the function of a transmitting organ, there are ganglion cells which represent receivers, responding to the action currents conducted to them by the sensory organs, the sensory cells and the other ganglion cells. If the Weiss resonance theory is to be applied also to these centripetal action currents, then we should assume that each specific type of ganglion cell responds only to action currents adequate for it.

As we have shown in chapter I, certain types of ganglion cells can be influenced directly with high-frequency energy and can thus be excited, i.e., resonance oscillations can be produced in them. Since every ganglion cell responds only to the frequencies adequate for it, we should assume that short waves contain components, the frequencies of which coincide with the fundamental frequency of the ganglion cells.

The hypothesis for an explanation of the mechanism of the divining rod can also be based on such resonance phenomena. It is evident from the investigations of Wüst and Wimmer[109], that the rod reacts to short waves in the wave length range between 1 and 70 cm. Different chemical elements, magnet poles as well as human hands serve as the source of these short waves. The operating mechanism of the rod can be interpreted in the following manner. The short waves produced by test compounds are received by the peripheral nerves of the hand of the diviner, without participation of the sensory cells. These nerve impulses flow along the nerve fibres to the central nervous system and stimulate certain groups of ganglion cells, which produce fundamental oscillations, the frequencies of which coincide with those of the short waves generated by the test compounds. As a result, resonance frequencies are produced in these ganglion cells. Every type of ganglion cell produces specific resonance oscillation, which results in specific action currents. These specific action currents flow centrifugally along the nerve fibres and induce changes in potential at the surface of the diviner's two hands, producing a flow of current through the rod. There are indications that the deflection of the rod results from this current flow. The mechanism of the rod seems to be similar to the operation of an electromotor. In this connection, rod shapes which proved to be most informative were those with a structure symmetrical to the axis of rotation (see Fig. 10). These rods require less holding effort in any position than any other rods.

The symmetrical rods differ from each other by the fact that in the rod f the parts adjacent to the medial margins of the fists have a uniform current sense for the particular side, while this is not the case for g and h. It is worthy of note that the flow of current in f corresponds to that in the coil of an electric motor or an electrodynamometer. The experiments have shown that the deflections can be obtained only with the use of the rod shape f, while shape g and h proved to be completely useless. A further confirmation of the assumption that the rod deflection is to be attributed to the flow of current through the rod is provided by the findings of Wüst and Wimmer[109], that the deflections remain absent with resistances of less than 5000 ohm as well as condensors of more than 30 cm connected in parallel to the rod and with grounding of the rod.

The hypothesis formulated by us which explains the operating mechanism of the rod by resonance phenomena is in agreement with the findings of Wüst and Wimmer. The latter found that when the diviner touches a certain pure element, which emits the radiations of a certain wave length, the rod operator will have a specific sensory perception, i.e., his nervous system is tuned to the frequency by this element. As a result, the deflection of the rod occurs only via this pure element, or a compound in which this element is a constituent. These findings of Wüst and Wimmer represent an expansion of the Weiss theory. While Weiss was able to demonstrate resonance phenomena between transmitting and receiving stations connected by a conductor, Wüst and Wimmer have demonstrated resonance phenomena in the wireless transmission of bio-electrical energy.

The hypothesis for the explanation of hypnosis and suggestion can also be based on the resonance phenomena in the transmission of energy produced in the ganglion cells. In order to hypnotize the subject successfully, the hypnotist must produce a sufficiently strong nerve energy. Furthermore, the central nervous system of the subject must be tuned to that of the hypnotist, i.e., resonance must be established between the two. This resonance in hypnosis is known by the name of "rapport." Hypnosis can be defined as a variable, sleep-like state in which the subject and the hypnotist are in resonance. As a result, every voluntary change of state in the nervous system of the hypnotist produces an adequate involuntary change in the nervous system of the subject, resulting in corresponding psychological or physiological reactions. To establish resonance and produce an hypnosis it is necessary to: a) eliminate active function of the central nervous system of the subject, which is independent of the hypnotist and therefore represents an interference, b) replace this active function by an artificial function of the central nervous system, which is induced by and dependent upon the hypnotist. Hypnotist, in order to successfully influence his subject, should be in a state of emotional activity, since this results in the amplification of the bio-electrical energy produced in his nervous system. On the other hand, the subject should be in a state of emotional passivity, in order to facilitate the influence of the hypnotist. The entire process of inducing a hypnotic trance is characterized by the change in the psychological state of the subject from a state of psychological activity to inactivity (state of fatigue) and then to the state of reduced consciousness, which is called hypnosis. Under the continued influence of the hypnotist, further degrees of reduction of consciousness of the subject up to somnambulism can be achieved. In the EEG, the process of inducing hypnosis is expressed by the displacement and annihilation of the cortical brain waves of the subject which are independent of the hypnotist. Fig. 11 shows this curve which was obtained directly prior to the start of hypnosis, which incidentally exhibits a striking similarity to the curves prior to the appearance of natural sleep as well as a hypoglycemic coma (compare Figs. 12 and 13).

These EEG's incidentally refute the claim of Rohracher[80], that the α-waves are particularly clearly evident prior to falling asleep and that their amplitude attains a maximum magnitude. The curves (Figs. 11, 12, 13) show exactly the opposite. After the achievement of hypnosis, the potential fluctuations of increasing amplitude and decreasing frequency occur, which are controlled by the hypnotist; they are highly distorted by the higher harmonics and consequently assume the shape of relaxation waves (see Fig. 14).

The brain waves are known to be influenced in the alert state by the psychological activity and also due to sensory stimuli. Therefore, these two factors should be eliminated in order to suppress the brain waves. Under the influence of greater energies, for example, with short-wave treatment, the inhibition of brain waves of the test subject takes place by the electro-magnetic energy acting directly on the ganglion cells. This direct action of the electro-magnetic energy produces more intense reactions in the ganglion cells than those induced by the sensory stimuli and mental activity. The effective short-wave action on the central nervous system depends extensively upon the emotional state of the test subject. In the state of psychological inattention, this effect is most pronounced, while it is reduced in the state of mental activity. Since the bio-electrical energy produced by the hypnotist is too weak to achieve a simple displacement of the brain waves of the test subject, the autosuggestion plays a very important role in the process and is enhanced by a number of artificial means.

While the elimination of sensory stimuli takes place by a suitable appointment of the room, various artificial aids must be applied by the hypnotist in order to eliminate psychological activity of the subject. These artificial means are (a) fixation according to Braid's method. This diverts the attention of the subject from his own thought processes as well as from the perception of the sensory stimuli acting on him. Fatigue is produced by the intense concentration of the subject. (b) Verbal suggestion based on modern suggestion methods. In this case, the diversion of the subject's attention from his own thoughts as well as from the perception of stimuli acting on him by concentration of his attention on the concepts transmitted to him by verbal suggestion. (c) Fascination-affect — by means of which a state of mental relaxation is obtained and is further maintained by fixation. All of these techniques serve only to displace the subject's own brain waves and thus to enhance the effective influence of the bio-electrical energy produced by the hypnotist and transmitted to the subject. Therefore, each of these techniques is effective without the other. The bio-electrical energy produced by the hypnotist in all cases is the only indispensable factor for the achievement of hypnosis. For this reason, hypnosis can also be achieved without the above-mentioned techniques when relatively strong bio-electrical energy is produced or when the sensitivity of the subject is very high. The method of the action of so-called "magnetic passes" introduced by Mesmer represents the case of a direct influence on the subject ("magnetizing individual") by the impulses emitted from the finger tips of the hypnotist ("magnetist"). We have seen in the above paragraphs that the finger tips emit more bio-electrical energy than the other parts of the body. This energy decays with the square of the distance as it is propagated in space. When we condiser that the manipulation of the "passes" is performed at a small distance from the body, the relatively pronounced effective influence of this method is entirely understandable. The process of transmission of this bio-electrical energy to the brain of the subject exhibits a similarity with that under the influence of short waves as well as of the emitting substance on the diviner.

The second method of obtaining an effect with the energy produced by the hypnotist and transmitted to the subject represents mental suggestion. The process of mental suggestion, where it is possible to "influence the subject without his knowledge, out of his immediate sight, at a certain distance and through closed doors and to produce in him a complete somnambulent state and arouse him again" (Husson[48]), can only be explained by teletransmission of the bio-electrical energy, from the brain of the hypnotist to the brain of the subject. This, of course, is the highest achievement and can only be accomplished with particularly favorable disposition of the agent and receiver; in order to obtain a desired effect in the subject by transmission of this bio-electrical energy, the latter not only have to be of sufficient intensity (corresponding to the sensitivity of the subject), but also must consist of certain specific frequency components. These frequency components represent certain concepts. With the stimulation of a complex of ganglion cells of a certain type in the cortex of the hypnotist, specific oscillations of certain frequency are produced and transmitted to the subject. Consequently, resonance oscillations are produced in the ganglion cells of the subject. As a result, the transmitted concept is perceived by him. Consequently, the desired suggestion is successful only when the hypnotist concentrates on this suggestion. The correctness of this conclusion can be confirmed by the experimental results of various hypnotists and "magnetists."

Janet[50] was able to induce sleep in his test subject by touching him with the fingertips, but this was successful only when contact was accompanied by the will to produce sleep.

Townshend[103] observed mesmerized persons who performed the funniest grimaces at the same time, although the mesmerizer was standing behind them, but he adds, that this pehnomenon occurs only when the mesmerizer concentrates his attention and his will in this direction.

Gibert[29] was able to put his test subject to sleep in another room, even when Janet was sitting next to the subject, but had no desire to induce sleep. That the hypnosis actually originated from Gibert was clearly evident from the fact that the test subject had established rapport only with him. If sleep had been the consequence of suggestion due to the mere proximity of the person involved, it should have been induced by Janet.

Gerster[28] found in his hypnotizing experiences that therapeutic results occurred more rapidly and more reliably the more intensively he concentrated his entire thought to the therapeutic suggestion. Once, when he had a patient under hypnotic treatment, he was called away and was given the report that he should visit another patient at place X. He interrupted the treatment, but subconsciously was occupied with the new task. After he had left, the patient suddenly found himself on another street than he had originally intended to use, and finally arrived at the place X, which was quite out of the way for him, before the same house where his doctor was to be.

Wetterstrand[107] recommends for a successful hypnosis that the hypnotist must concentrate on the suggestion.

5) Physical characteristics of the energy emitted by the human body as well as by various inorganic and organic substances: — Wüst and Wimmer proved with the aid of the divining rod as indicator, that pure chemical elements as well as various inorganic and organic compounds exhibit fundamental oscillations. Measurement with a Lecher system* showed that the wave length of these oscillations are found in the range, between 1 cm and 70 cm. They found that every pure chemical element is characterized by a specific wave length and that chemical compounds, in contrast, exhibit compound oscillations. The individual components of compounds have the wave lengths of the pure chemical elements constituting the compound. On the basis of our interpretation of the operating mechanism of the divining rod, these oscillations should induce the resonance oscillations in the ganglion cells of the diviner. So that we can assume that the oscillations produced in the ganglion cells will also be found in the range between 1 cm and 70 cm. This assumption was confirmed by further findings of Wüst and Wimmer[109]. They found that the impulses emitted by human hands exhibit a series of peaks which are in the above-cited spectrum and that the maximum energy corresponds to a wave length of 7 cm. Furthermore, human hands exhibit a reverse polarity. This reverse polarity is caused by the rectification of the action current by passage through the skin.

* Parallel wire system which is used to produce the standing waves.

Human hands have a behavior similar to the poles of a magnet. The radiation emitted by magnetic poles also exhibits complete identity to the radiation emitted by human hands. The maximum energy of the radiation of a magnet also corresponds to a wave length of 7 cm.

The physical characteristics of the waves which are emitted by the human body are only partially identical to those of electromagnetic waves in the radiofrequency range. The identity of these waves with such radiowaves is supported by the following: They can be reflected on smooth surfaces and they can be refracted at edges and diffracted by prisms. They can be conducted over wires and form standing waves. Self-induction-free resistances of 5 MΩ as well as condensers of 15 cm do not represent a hindrance when they are connected into the line. On the other hand, these waves cannot be conducted over inductive impedances of certain dimensions. Furthermore, these oscillations can be conducted by vacuum tubes as well as by crystal detectors. They have the property that they increase the conductivity of insulating materials. Furthermore, they can be polarized on bias grids. The transmission of these waves takes place more advantageously at night than during the day, in winter than in summer, in dry air than in humid; the effect of the waves is attenuated by thunderstorms, rain and snow. If waves in the decimeter range are contained in the electromagnetic field surrounding the human body, then action currents should also contain such high-frequency waves. It can be assumed, therefore, that the "specificity" of stimulation is caused not by chronaxy (Bourguignon) but by these high-frequency oscillations.

The measurable low-frequency action-current waves as well as low-frequency electromagnetic fields around the human body can be represented as a resultant oscillation formed from a mixture of the high-frequency elementary components of the oscillation. Presumably, the objectively detectable electrical phenomena in the vicinity of the human body are produced by these resultant low-frequency electromagnetic waves. On the other hand, any direct influence on the central nervous system by short waves and suggestion appears to be attributable to the transmission of the high-frequency oscillation components. These high-frequency waves can be separated from the low-frequency waves by certain devices (see chapter 3).

The following factors refute the identity of these high-frequency waves with electromagnetic waves of radio-frequency: (a) Their propagation velocity (measured during conduction along wires) amounts to 42-45 m/sec, which is in agreement with the propagation velocity of the action current; (b) by means of certain magnetic devices they are prevented from propagation; (c) they can be transmitted through excellent electrically conducting metals, and on the other hand, excellent dielectrics, such as celluloid, galalith, bebrit, silk, and rayon, are impermeable to them; (d) in the same manner, these waves cannot be transmitted through diaphragms consisting of impermeable materials which have an aperture which is smaller than $\lambda/4$ of the corresponding wave. These specific properties of these waves, which refute their identity to radiofrequent electromagnetic waves, do not permit us to arrive at a more or less explicit interpretation of their physical nature. Perhaps these results which diverge from our present knowledge, especially the propagation velocity of these waves, can be attributed to the indicator utilized. Consequently, in order to solve this question — whether these oscillations represent electromagnetic waves or a special form of bio-electrical energy — the investigations must be carried out with an objective indicator suitable for the decimeter wave range.

6) Summary: — In this chapter we have shown that the human subject proves to be a generator of a bio-electrical energy which propagates into the surrounding atmosphere in the form similar to electromagnetic waves. These waves, when transmitted to other human subjects, influence their central nervous system in a manner similar to radiofrequent electromagnetic waves. These waves act on the central autonomic system directly without participation of the sensory organs and consequently produce different psychological, physiological and physicochemical symptoms. The amplitude of these waves depends extensively upon the emotional state of the subject — i.e. it has its lowest values in the state of psychological inactivity, increases in the state of psychological activity and is subjected to further considerable increases in the state of reduced consciousness. Body movements also have a certain influence on these waves. Every muscle contraction is accompanied by a local increase in the intensity of these waves. Thus, the amplitude of the waves increases parallel with the increase in muscular contraction. This explains the finding that subjects in a state of trance exhibit considerably increased muscle contractions compared to those in the normal state.

It has been found that a mixture of waves is produced in the human body. Each of these is specific, i.e. has a certain frequency. These specific waves presumably are in the decimeter wave length range. From the mixture of these high-frequency waves, the low-frequency electrical waves, which are objectively detectable, are formed in the proximity of the human body.

Every ganglion cell produces specific oscillations and responds only to the oscillations specific for it. This means that every ganglion cell can act as a transmitter as well as a receiver for its specific oscillations.

The operating mechanism of the divining rod as well as the mechanism in hypnosis and suggestion can be explained by the resonance phenomena in the transmission of these high-frequency waves. The effect of short waves on the central nervous system can also be explained by such a resonance. It can be assumed that the short waves contain the frequency components which are identical with those of the high-frequency waves emitted by the human body. The physical properties of these waves for the most part are identical to those of electromagnetic waves of radiofrequency. Only some of the properties of these waves, and particularly their propagation velocity, do not agree with those of the radiofrequent electromagnetic waves.

III. ABSORPTION OF ELECTROMAGNETIC ENERGY IN GANGLION CELLS

1) The relationship of absorption to the emotional state of the subject: — We have already shown in chapter 1, that a direct influence on the central nervous system takes place by short waves. We assume that this influence is the result of the absorption of a part of the electromagnetic energy in the ganglion cells.

Schliephake[91] was able to determine an absorption of the wave energy transmitted between transmitter and receiver dipole, if a human subject was present near the transmitter or the receiver. In order to prove this, it is only necessary to connect a measuring instrument into the circuit of the receiver dipole and to observe the decrease in the current. This phenomenon also takes place with a rather large distance between subject and receiver which proves that it is not due to a simple capacitive grounding of the receiver by the subject.

Cazzemali[13] also found that the subject located between transmitter and receiver dipole absorb a part of the electromagnetic energy and that this absorption depends upon the emotional state of the test subject, i.e., it decreases with an increase of his excitation. In states of reduced consciousness, this absorption even attains negative values. Thus, for example, in the case of neurasthenia, during hypnotic hallucinations, an amplification of electromagnetic energy takes place. This amplification can be observed by a current increase at the receiver. These facts are also in agreement with the findings of Sherrington[99], that when a cell complex is in a state of excitation, it will no longer react to additional stimuli transmitted to it. This also explains that the effective influence of short waves on the central nervous system depends upon the emotional state of the test subject.

2) Resonance absorption: — This relationship of absorption to the emotional state of the test subject as demonstrated in the first section refutes the assumption made by Schliephake as well as by Holzer[43], that the human body simply acts as a dipole receiver. Rather, we can derive a hypothesis for the explanation of such absorption phenomena from the microscopic vibrational processes in the ganglion cells.

We assume that the microscopic components of Nissl bodies (protein molecules and their building blocks, respectively) exhibit fundamental oscillations, the frequencies of which depend extensively upon their size and are found in the range of short radio wave spectra. In this case, each of the vibrating particles represents a vibrator, which generates oscillations, which wave length depends upon their size. The latter assumption is in agreement with the finding of Wüst and Wimmer[109], that the wave lengths of the energies emitted by the human body as well as by various chemical elements depend upon the atomic volume of the chemical element producing this wave length (compare Figs. 15 and 16). In the model concept, such a process can be simulated by the so-called "mass radiator." The frequencies generated in the mass radiator also exhibit an extensive dependency upon the size of the vibrating particles. As a result of the vibrational process, energy is produced in the interior of the ganglion cells, which causes the charging of the cell membranes. When a charge exceeds the capacity of the cell, a voluntary discharge results. On the basis of our assumption that microscopic component particles of the Nissl bodies exhibit fundamental frequencies, we can explain the influence of the central nervous system by the short waves by the resonance vibrations in accordance with Drude theory. This refutes Debye dipole theory, which explains the effect of short waves of the orientation of miscroscopic particles inside the cell as a result of the applied electrical fields. The existence of the molecular fundamental vibrations in the radio band of the spectrum was confirmed by experimental data of Weichmann[105], Rukop[83], Iwanow[49] and Colley[15], who found dispersion bands in water in the wave length range between 20 and 70 cm.

Mobius[66] found a dispersion band in water, which has a wave length between 3.5 and 1.7 cm.

Tear[102] was able to find three bands of abnormal dispersion in water in the range of 2.7-0.4 cm.

All of these studies were conducted with damped waves. Frankenberger[25] found that dispersion bands can only be observed when silicates and sodium hydroxide are dissolved in the water, which are always contained in the water when it is stored in vessels of soluble glass. When distilled water is stored in containers of insoluble

Jena glass, such water no longer exhibits dispersion bands. An addition of sodium silicate to distilled water again results in dispersion bands. For these reasons, Frankenberger attributes the dispersion bands not to the water but to the dissolved salt. Thus, dispersion bands can form only when the material constants of the vibrating particles differ from those of their surrounding medium. Frankenberger also conducted these studies with damped waves. In a later study, he operated with weakly damped waves and was unable to confirm his earlier results obtained with silicate solutions in water. In contrast to his earlier studies, he was unable to find dispersion bands. Girard also was unable to detect dispersion bands either in pure water or in silicate solutions in investigations with undamped waves in the range of 20-70 cm. It can be assumed, therefore, that resonance absorption occurs only under the influence of damped waves.

Iwanow[49] investigated the relationship of dispersion to the temperature in the wave length between 60 and 120 cm. He found that the dispersion bands disappear gradually with heating of the water and can no longer be observed at 60°. Eckert also investigated the relationship of absorption to temperature for the wave length of 3.7 cm and found that a very pronounced reduction of absorption occurs with heating. This phenomenon of the decrease or disappearance of the dispersion band during heating can be explained by the fact that the frequency of the fundamental vibrations of the heater particles is increased and consequently is no longer in resonance with the applied electrical field.

The assumption that the frequency of the heated particles is increased is also in agreement with the observations of Wüst and Wimmer. The authors found that the wave length of the oscillations investigated by them decreases with an increase of temperature. (see Table 2).

	Mn	Cr	Sn	Zn	Pb	Ni
$t_o = 40^o$	7.4	6.3	10.0	8.0	14.0	11.2
$t_o = 18^o$	13.4	15.2	16.1	17.0	18.2	22.2

Table 2 — Dependency of the wave length of fundamental vibrations of pure chemical elements upon the temperature.

We can conclude, therefore, that resonance absorption takes place in the decimeter wave length band:

a) When the material constants of the vibrating particles differ from those of the surrounding medium;

b) Under the influence of damped oscillations of the applied electrical field;

c) When any heating is avoided.

In a model concept, we can replace the brain compounds by salt solutions. Brain compounds and salt solutions have identical values of conductivity and dielectric constant in the decimeter wave length band. This supports our hypothesis concerning resonance absorption of short waves in the brain compounds. This can explain (a) that an extremely small dosage of a short-wave application (with prevention of any heating) and particularly with the application of intermittent energy (damped waves, current impulses) results in phenomena (reduction of the threshold of the galvanic stimulus, slowing of the heart rate, etc.), which are even transformed into their opposite under the influence of heat.

d) In short-wave hyperthermia (high dosage diathermy) in which an extensive generation of heat is produced in the body, so-called specific short-wave influences are no longer observed.

Aside from the phenomena of resonance absorption of short electromagnetic waves, certain indications exist that an electrical AC or DC field produces the mechanical vibrations and deformations of the droplets of an emulsion, milk or latex particles. This was pointed out by Rayleigh and Welb[79] as well as by Kirchoff. Such phenomena were also observed by Boedeker[10] with microscopically visible droplets. This author found that the resonance frequencies occur only for particle radii of 1 μ in the wave length range of 300 m. For very high frequency waves, the particles involved must therefore still be considerably smaller. Presumably they are in the order of magnitude of the microscopic components of Nissl bodies (protein molecules or their building blocks).

Similar phenomena were observed by Dixon and Bennet-Clark[22] in the microscopic particles of an emulsion of water and oil. The particles are subjected to mechanical deformations in the direction of the electrical line of force.

Rajewsky[78] reports on characteristic phenomena in the influence of an electrical field on emulsions. In a DC field of sufficient intensity, the particles are arranged in chains in microscopically visible manner, which reduce the resistance of the emulsion. After disconnecting of the field, the chains gradually disintegrate and the resistance of the emulsion rises again.

Similar phenomena were investigated by stalagmometry by Schliephake and Compere[92]. They found that water and homogeneous liquids exhibit no changes in the number of droplets in a condensor field at a wave length of 6 m, while pronounced changes in the form of an increase in number of droplets appear in colloidal systems of certain composition. These changes are particularly striking in blood and serum. The authors state that the phenomenon of an increase in number of drops, i.e., a decrease in drop size, can be explained according to the Gibbs-Thomson theory only in such a manner that the surface-active materials must have migrated from the surface into the interior. It must be assumed, therefore, that local concentration changes occur under the influence of short waves, which have their effect in changes of the interfacial potentials in the human body. Since such changes in interfacial potential are the cause of changes in the galvanic skin resistance, we can confirm our interpretation of the changes in galvanic skin resistance under the influence of short waves on the basis of the observation of these authors.

Krasny-Ergen[57] has made a detailed investigation of similar phenomena. He started with the assumption that the electrical field induces dipoles and multipoles of higher order on the colloidal particles and that with sufficient particle concentrations, forces of attraction act between these particles. As a result of this force effect, the formation of "strings of beads" of particles and plate formation takes place again. Such processes have been observed repeatedly in experiments with suspensions. Fundamentally, they occur with direct current ("chain formation") as well as in AC fields of different frequencies. In the opinion of Rajewsky, a possibility of a specific assignment to the ultra-high frequency range could be furnished only by special resonance oscillations which are related to the particle size and their mechanical properties.

A considerable contribution for a further explanation of the oscillation processes in the ganglion cells is represented by the concept developed by Hausser[37] concerning electrical vibrations of molecules. The investigations of the aminophosphatides of the brain (lecithin, sphingomyelin) were carried out by Hausser. He found that lecithin and sphingomyelin exhibit regions of abnormal dispersion in the wave length range of 4 m in alcoholic solutions. In this dispersion region, the solution exhibits no relationship to viscosity. The dielectric constant increases approximately continuously with the wave length in the entire temperature range, so that internal friction, i.e., the relaxation effect according to Debye, does not cause this dispersion field. According to the interpretation of the author, only the greatest part of the large molecule vibrates as a rigid body under the influence of the AC field. The long fatty acid chains act rather like a float in the solution and only the short highly polar arm of the choline-phosphoric acid vibrates under the influence of the electrical field. This polar arm vibrates like a pendulum about its rest position due to the orienting force of the resting fatty acid chains. Consequently, the observed dispersion region which is dependent of viscosity is caused by the resonance position of this pendulum and not by the relaxation effect.

3) Relationship of absorption to the frequency of the high-frequency energy acting on the human body: — According to our hypothesis, the excitation of ganglion cells is the result of a resonance absorption. This resonance absorption forms in the decimeter and centimeter wave lengths band. As we know, however, the central nervous system is influenced by wave lengths band between 3 and 15 m. Consequently,

it can be assumed that resonance absorption is attributed to the higher harmonics of the fundamental frequency.

Consequently, the relative energy absorption in ganglion cells should increase in the very high frequency range and the effect of the energy influencing the central nervous system should be amplified with the decrease of the wave length. Since the absorption coefficient of human tissue increases with the increase of their conductivity, the relative absorption of electromagnetic energy in the brain depends upon the conductivity of the brain substances as well as the tissue layers enveloping the brain.

It is apparent from the studies of Osswald[73] that the conductivity of adipose tissue remains constant with a decrease of the wave length of from 12 to 3 m and that the conductivity of the brain, in contrast, increases. Since the absorption coefficient increases with an increase in conductivity, the distribution of absorbed energy between adipose tissue and brain tissue changes, i.e., the relative energy absorption of the brain increases with the decrease of the wave length from 12 to 3 m. Parallel to the increase of absorption, the effect on the ganglion cells is enhanced, which is apparent from the subjective reactions as well as from objective findings — pathological changes in ganglion cells. No data are available to me concerning the change of the relative energy absorption in the brain with a further decrease of the wave length. Since the conditions in the irradiation of adipose brain tissue are approximately similar to those with the irradiation of the fat-muscle tissue, certain indications can be obtained in first approximation concerning the course of the absorption change in the brain in the region of less than 3 m on the basis of the studies of Pätzold and Osswald[74]. In accordance with natural conditions, the authors have irradiated muscle tissue through the adipose tissue. Irradiation was carried out with a reflector at a wave length of 107 cm. The investigation showed that the energy absorbed in the muscle tissue at this wave length is greater than that in the adipose tissue. Thus, a further increase of the relative energy absorption in inner tissue layers also takes place at a wave length of 1 m. For this reason we can assume that the relative energy absorption in the brain is still in the process of rising at a wave length of 1 m.

4) "Filtration" of the higher harmonics of the fundamental frequency influencing the ganglion cells: — A direct confirmation that the central nervous system is influenced not by the entire electromagnetic field but by the higher harmonics is offered by the findings of Wüst and Wimmer[109]. The authors were able to demonstrate the direct influence on the central nervous system already in the electromagnetic field of an ordinary electrical line (50 cps). They used the divining rod as indicator. Authors showed that it is not the entire electromagnetic field around an electrical line which acts on the nervous system but only the higher harmonics contained in this field. This is evident from the fact that shielding of the wire with various metals suppresses the effect of the electromagnetic field on the vacuum-tube voltmeter but not on the divining rod. On the other hand, in the case of shielding with a magnetic screen, the effect of the radiation is suppressed for the divining rod but not for the vacuum-tube voltmeter. As we have already seen in chapter 2, the high-frequency waves detectable in the vicinity of the human body have the same behavior and we can therefore assume that the same vibrational components are contained in electromagnetic waves. According to our hypothesis, the higher harmonics, which are in the decimeter and centimeter band, act on the ganglion cells. From the fact that the influence on the central nervous system is retained with metal shielding, while the electromagnetic field (low frequency) is suppressed, it can be concluded that a "filtration" of the higher harmonic of the fundamental frequency takes place due to the metal shielding. Such a "filtering" action of metals for very short electrical waves has been confirmed by the experimental results of Glagolewa-Arkadjewa[32]. The author made use of a mass radiator for the production of very high frequency waves. As an indicator, a thermocouple with a galvanometer of a sensitivity of 3×10^{-9} A/mm was utilized. It was found that the amplitude of the lower frequencies is decreased, while the amplitude of the higher harmonic is increased with shielding of the thermocouple by means of a metal plate (see Fig. 17). A harmonic analysis of the curves showed that the displacement of the energy maximum in the shorter-wave region changes from $\lambda = 4$ cm $\lambda = 1.2$ cm. The proof that, a biological effect on the cells is produced by this higher harmonic, which is "filtered" by the metal shielding, and not the "slow" fundamental frequency, can be derived from the experiments of Denier[21]. He exposed white beans to the radiation with a wave length of 80 cm. The transmitter utilized by him had an output of 50 W

and the radiation was oriented on the test object by means of a reflector. The irradiated beans were placed under bells of glass, porcelain and iron. The author found that no influence occurs in the case of glass, a moderate influence in the case of porcelain, while a three-fold growth took place compared to the controls in the case of iron bells. No measurable heating could be detected. We can conclude from this, that the amplitude of the higher harmonic influencing the cells is reduced more or less during propagation through glass and porcelain, while it is increased in propagation through metal.

5) Summary: — An absorption of a part of the electromagnetic energy takes place in ganglion cells. This absorption exhibits a relationship to the emotional state, i.e., it decreases with an increase of excitation. This dependency can be explained by the resonance vibrations formed under the influence of electromagnetic waves in accordance with the Drude theory. Since the brain compounds have identical electrical data as salt solutions in the band of very high frequency waves, they can be replaced by such salt solutions in model concepts. Similar to the behavior of salt solutions, the resonance absorption in ganglion cells should be promoted by the increased damping of electromagnetic waves and inhibited by heating. The resonance absorption in the ganglion cells exhibits a relationship with the applied frequency, i.e., in the very high frequency region, the absorption increases with the increasing frequency. The resonance vibrations in the ganglion cells are to be attributed to the effect of the higher harmonics superimposed on the fundamental oscillation. These harmonics exhibit a similar behavior as the vibrations emitted by the human body as well as by chemical elements. Metals prove to be permeable to these vibrations, while magnetic shielding planes are impermeable. It can be assumed that the higher harmonics in band of the electromagnetic waves are identical with the high-frequency waves which are detectable in the vicinity of the human body.

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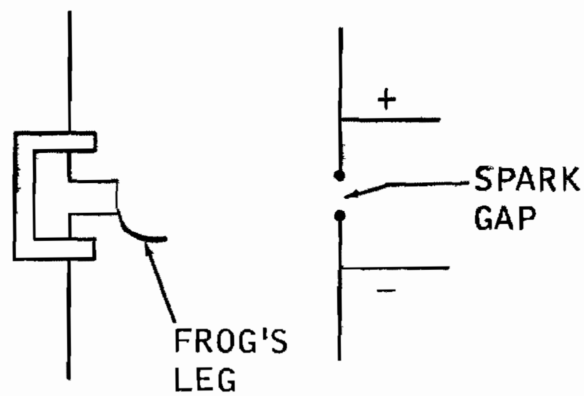

FIGURE 1 – EXPERIMENT OF GALVANI (FROM POHL)

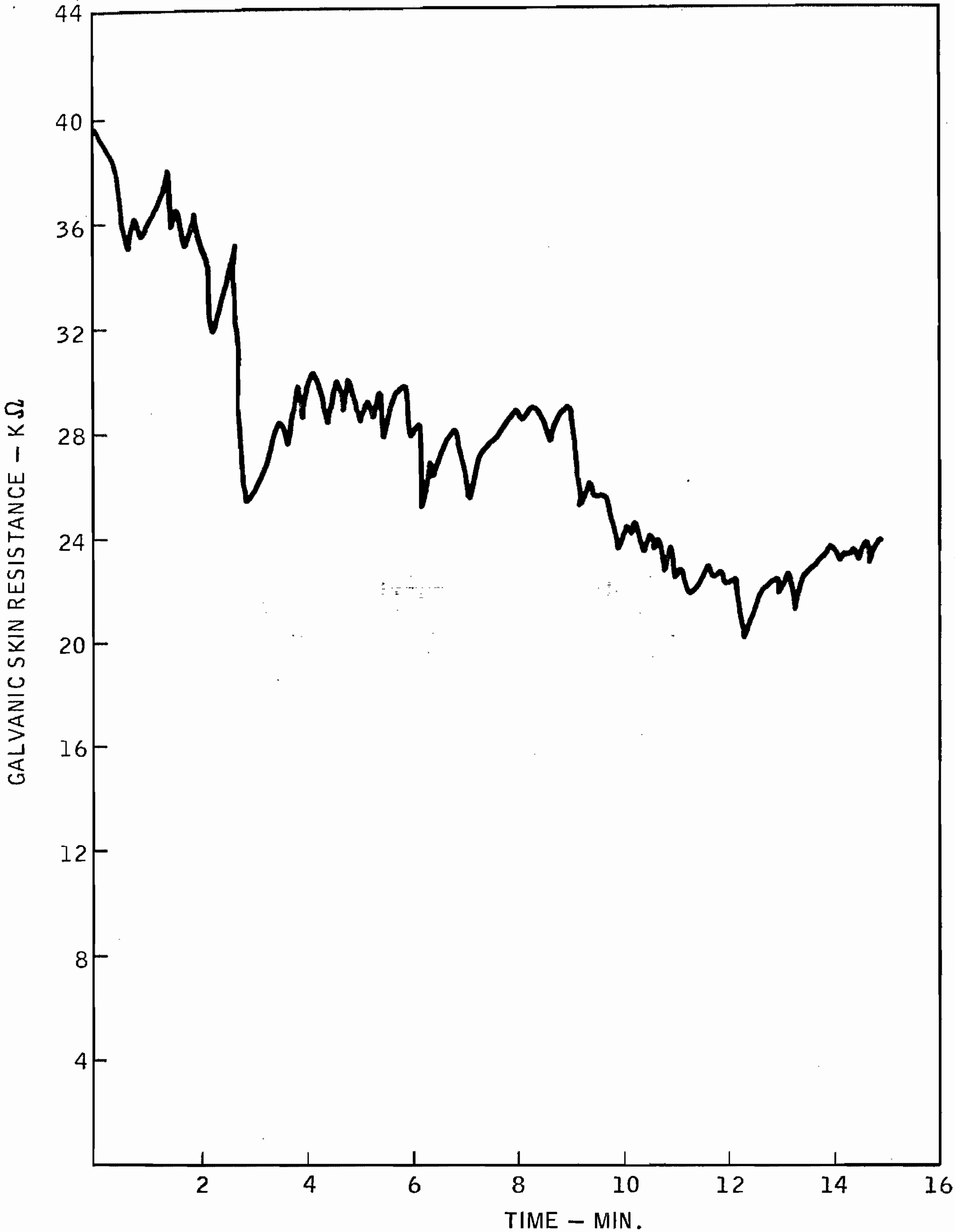

FIGURE 2 — TYPICAL GSR CURVE OF A HEALTHY SUBJECT

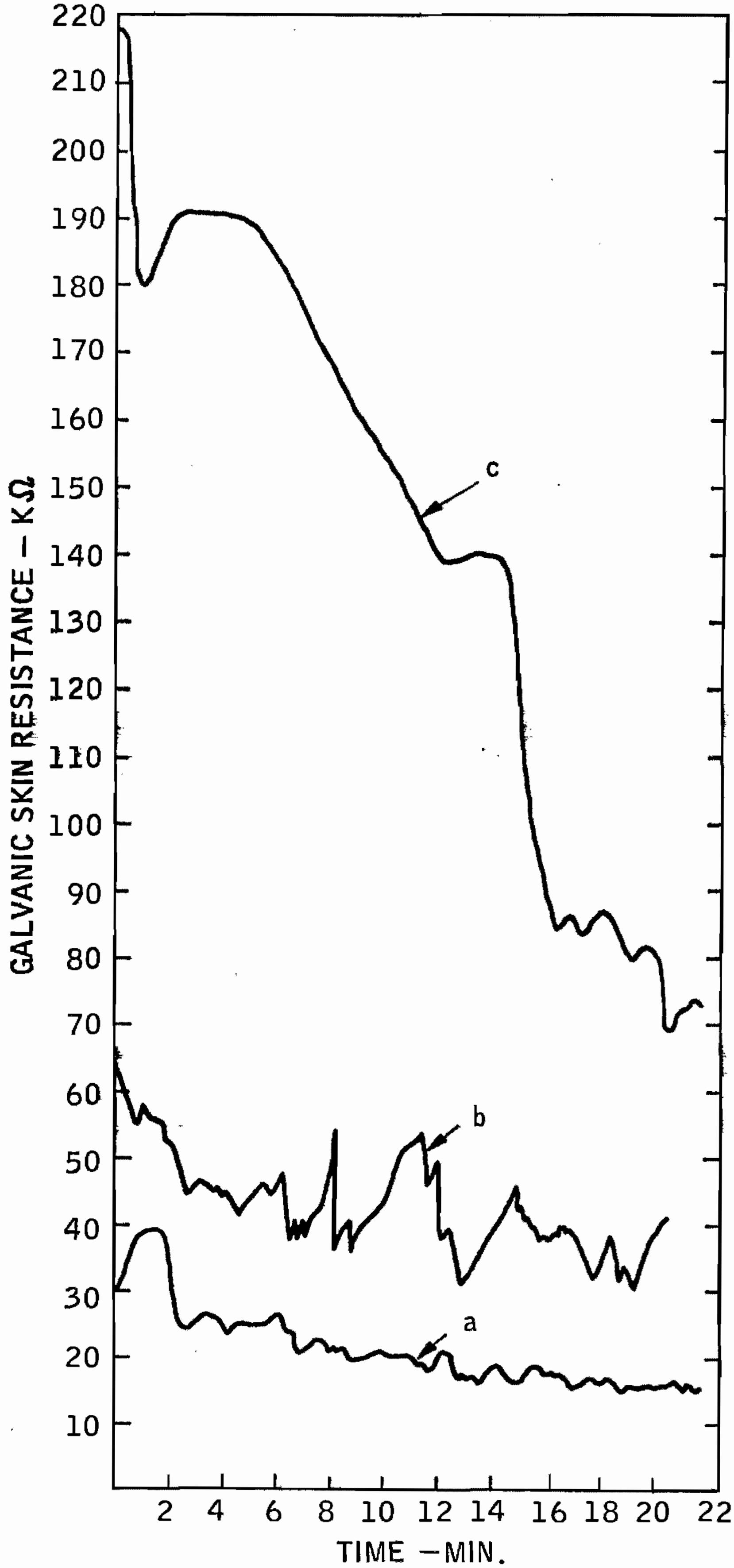

FIGURE 3 — EFFECT OF SHORT WAVES ON GSR. a) PRIOR TO IRRADIATION. b) 24 HOURS AFTER THE FIRST TREATMENT. c) 24 HOURS AFTER THE SECOND TREATMENT

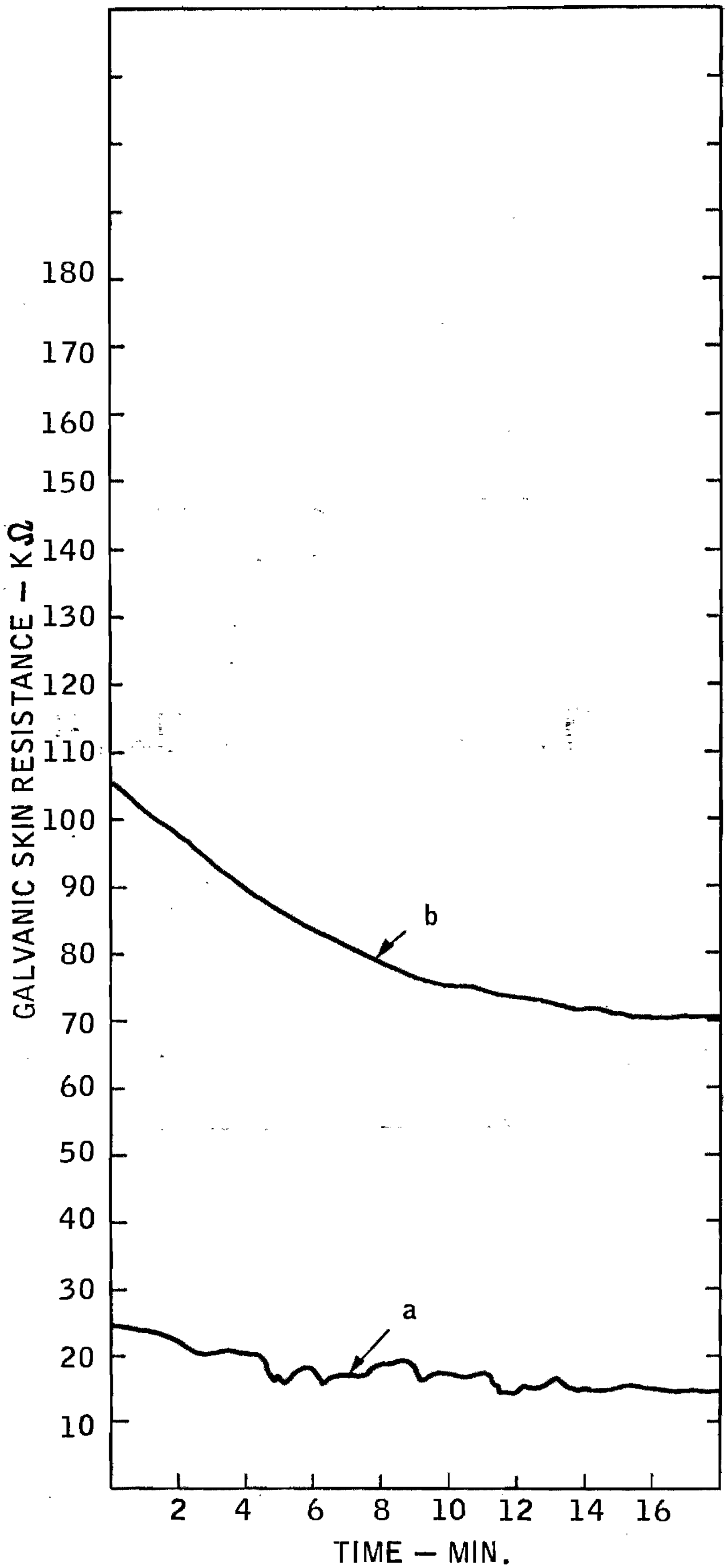

FIGURE 4 — GSR CURVE OF A HEALTHY SUBJECT. a) PRIOR TO EXPOSURE TO SHORT ELECTROMAGNETIC WAVES. b) AFTER 5 HOURS EXPOSURE TO SHORT WAVES.

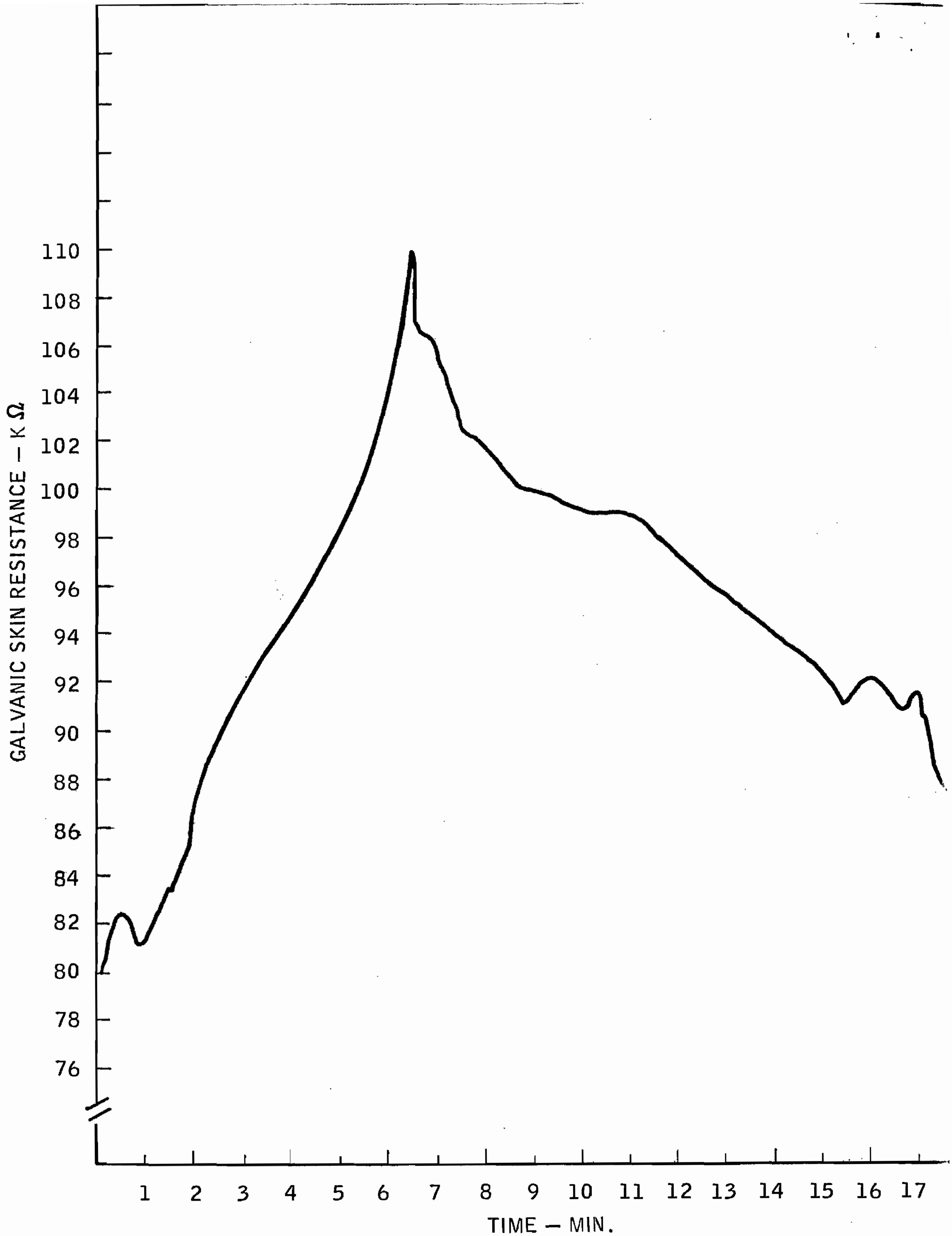

FIGURE 5 — GSR CURVE OF A PATIENT WITH HYPOCHONDRIAC DEPRESSION

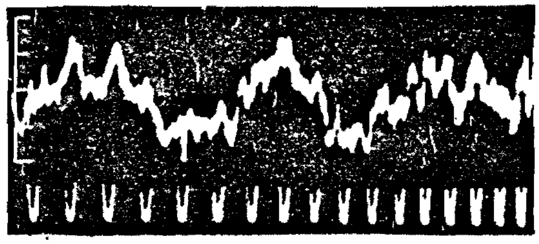

FIGURE 6 — EEG OF HUMAN SUBJECT, OCCIPITAL DERIVATION TOWARD EARLOBE, UNIPOLAR. ORDINATE SCALE IN 20 V; TIME SCALE IN 50 CPS. (FROM SCHÄFER, ELEKTROPHYSIOLOGIE, II.)

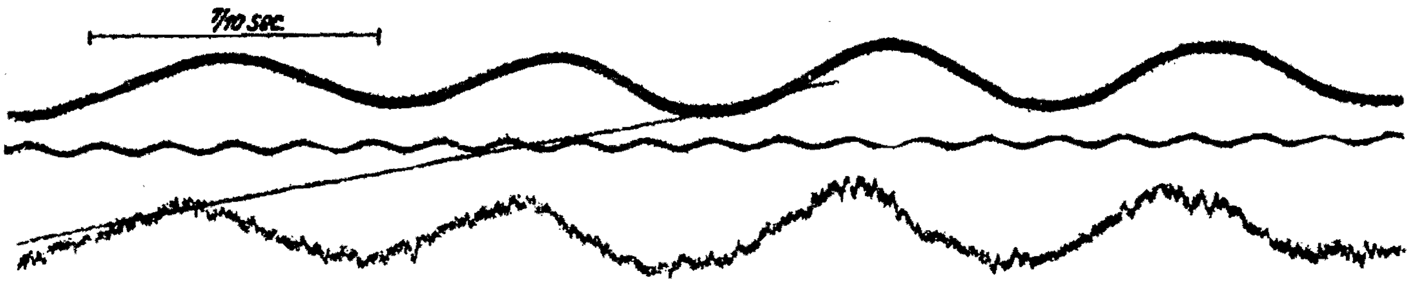

FIGURE 7 — -WAVES WITH A HIGH SPEED OF THE PAPER OF 36 CM/ SEC. THE CENTER CURVE SHOWS THE AC OF 42 CPS USED AS THE TIME MARK. (FROM ROHRACHER, ELECTRICAL PROCESSES IN THE HUMAN BRAIN, 1942.)

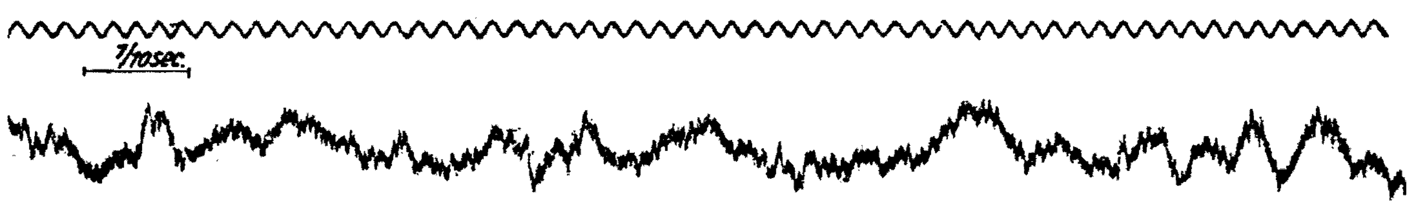

FIGURE 8 — EEG FROM AN EXPERIMENT WITH MENTAL CALCULATION; AT THE TOP EDGE, THE AC OF 42 CPS USED AS A TIME CONSTANT. (FROM ROHRACHER, ELECTRICAL PROCESSES IN THE HUMAN BRAIN, 1942.)

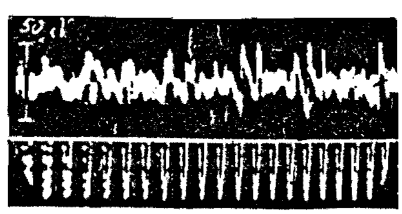

FIGURE 9 — MUSCLE TONE WITH ABSOLUTE RELAXATION OF TEST SUBJECT. (SCHÄFER, ELEKTROPHYSIOL., II, 1942.)

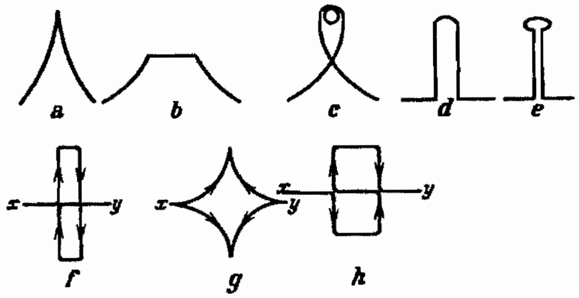

FIGURE 10 — DIFFERENT FROMS OF DIVINING RODS. FROM WÜST AND WIMMER, ROUX' ARCH. F. ENTWICKL. MECH. DER ORGANISMEN, 1931.

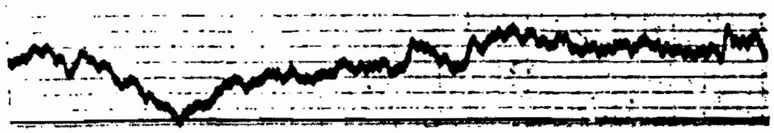

FIGURE 11 — EEG PRIOR TO START OF HYPNOSIS. TIME SCALE IN 20 CPS. ORDINATE SCALE 100 V = 23 MM DEFLECTION. (FROM FRANKE AND KOOPMANN, Z. F. D. GES. NEUROL. U. PSYCHIATR. 162, 1938.)

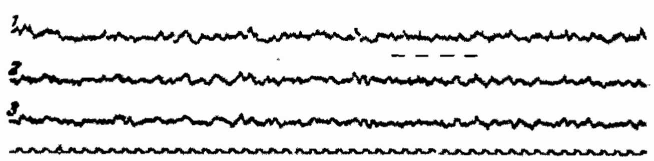

FIGURE 12 — EEG PRIOR TO NATURAL SLEEP. SIMULTANEOUS UNIPOLAR DERIVATIONS FROM POINTS 1 (FRONTAL), 2 (CENTRAL) AND 3 (OCCIPITAL) AGAINST EARLOBE.

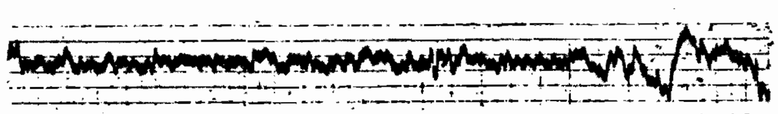

FIGURE 13 — EEG PRIOR TO START OF HYPOGLYCEMIC COMA (FROM FRANKE AND KOOPMANN.)

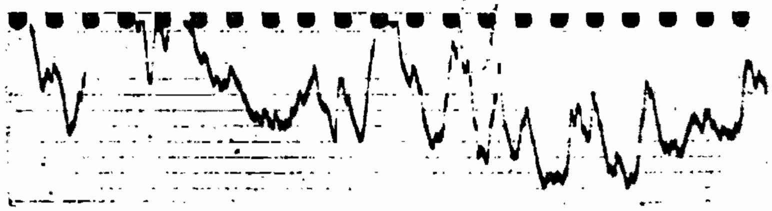

FIGURE 14 — EEG IN HYPNOSIS (FROM FRANKE AND KOOPMANN).

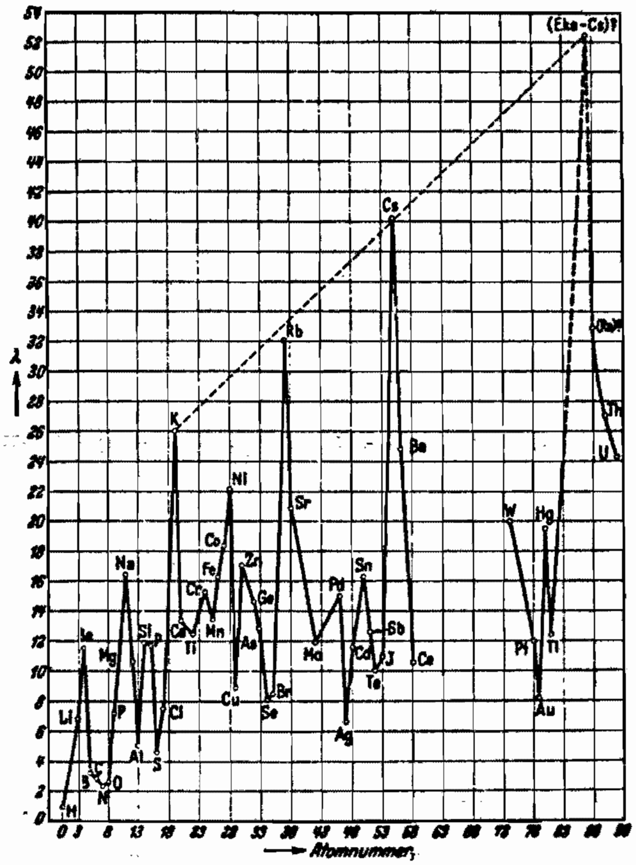

FIGURE 15 — RELATION OF THE WAVE LENGTH OF FUNDAMENTAL VIBRATIONS OF PURE CHEMICAL ELEMENTS WITH THEIR ATOMIC NUMBER (FROM WUST AND WIMMER).

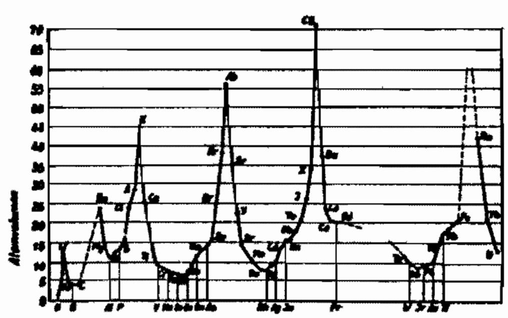

FIGURE 16 — RELATIONSHIP OF ATOMIC VOLUME TO THE ATOMIC NUMBER.

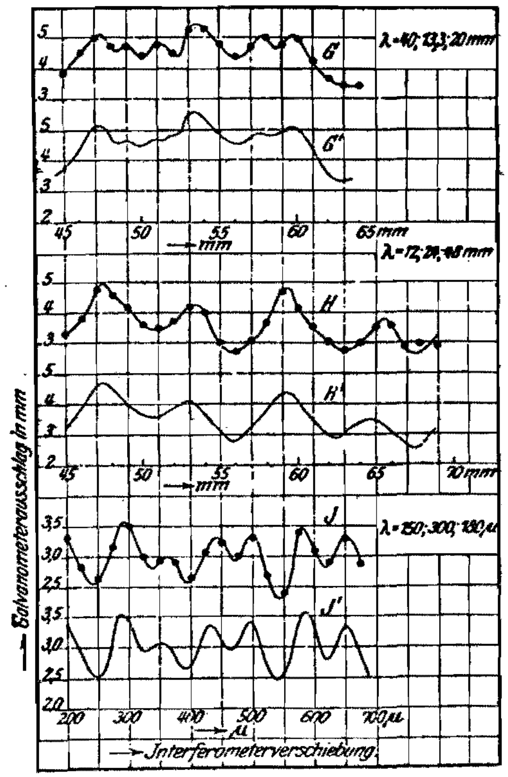

FIGURE 17 — INTERFERENCE CURVES RECORDED WITH THERMOCOUPLE WITHOUT METAL PLATE (G) AND WITH METAL PLATE (H). FROM GLAGOLEWA-ARKADJEWA, Z. F. PHYS. 24 (1924).