

# NEWS

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G 14514 ● 7. Jahrgang ● Nr. 1 ● April 1999

## Research

# The Effects of Electromagnetic Fields on Health



**A survey by Dr. Otto Petrowicz**

So far a multiplicity of studies about „electrical smog“ have been carried out and published. In view of the abundant material it is not easy even for experts to keep an overview. A sifting of the published research reports and a critical discussion of the most important studies therefore proves to be essential.

Viewing the individual publications about the topic, a quite heterogeneous picture shows up. In principle each publication, which brings new research results to light, represents the current scientific status quo - at least in such a way, until it is obsolete or disproved by other investigations. The informative capability of the findings can be evaluated, however, only if one measures the underlying study according to clear, objective quality criteria. Among these criteria rank among others type and topicality of methodology, the number of cases, the biometric soundness as well as the plausibility and the reproducibility of the results. Of great importance are also the forums or the magazines, in which the work was presented or published, whose scientific level can be very different, and the fact whether the work is checked by independent consultants (distinguished scientists in this field) or not.

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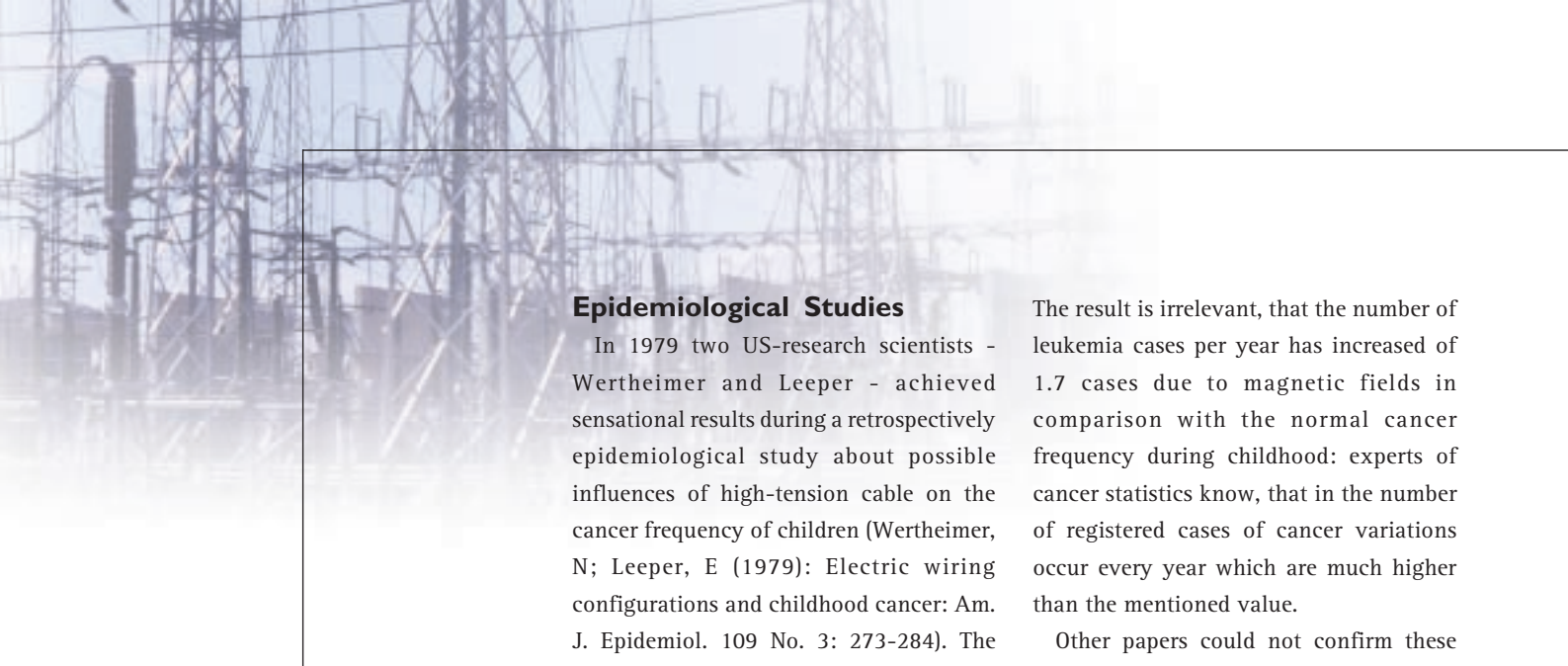
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### Epidemiological Studies

In 1979 two US-research scientists - Wertheimer and Leeper - achieved sensational results during a retrospectively epidemiological study about possible influences of high-tension cable on the cancer frequency of children (Wertheimer, N; Leeper, E (1979): Electric wiring configurations and childhood cancer: Am. J. Epidemiol. 109 No. 3: 273-284). The investigation is based upon 344 deaths caused by cancer during the period from 1950 to 1973 in the area of Denver, Colorado.

Accordingly, adolescents had a 2 to 3 times higher risk factor to be affected by leukemia or tumors of the central nervous system. Nevertheless, at a closer look some deficiencies occur, arising questions about the validity of these conclusions. A general problem of these „older papers“ is the approximate evaluation of the exposition by means of the „wire code“. Besides the researchers only insufficiently considered other scopes of influence (co-factors) such as, e.g., the smoke habits of the parents, other radiation levels, for instance, X-rays which can favor a disease, social conditions, the traffic situation in the surroundings and the current cable conduction inside the habitations themselves.

The same topic was subject of a case-control-study which was presented by Feychting and Ahlboom in 1992 (Feychting, M; Ahlboom, A. (1992): Magnetic fields and cancer in people residing near Swedish high voltage power lines: IMM report 6/1992, Stockholm). The authors also came to the conclusion, that the cancer risk increases especially during childhood due to current-conducting cables. And again we find arguments herein, which make the theory of the scientists seem to be doubtful.

Hence it is, for instance, not evident, why children in single-family houses are more endangered - according to the investigation - than those living in apartment houses. Likewise the number of „cases“ is too low and therefore the possibility of an error respectively high.

The result is irrelevant, that the number of leukemia cases per year has increased of 1.7 cases due to magnetic fields in comparison with the normal cancer frequency during childhood: experts of cancer statistics know, that in the number of registered cases of cancer variations occur every year which are much higher than the mentioned value.

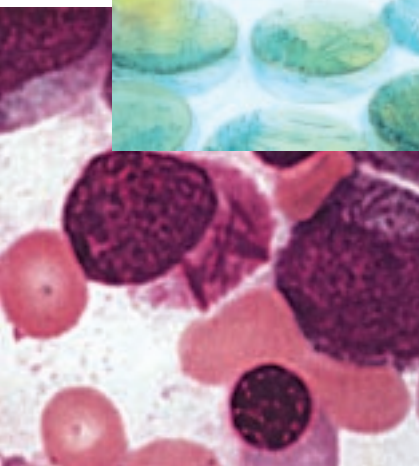
Other papers could not confirm these results. As a whole, large-scale epidemiological investigations refer only to vague correlations between EM-fields and cases of cancer, laying at the edge of significance. Apart from the mentioned weakness of the study other points of criticism are to be pointed out like the focusing on leukemia. Obviously, leukemia with its low latency and fast growth goes for a promising „nominee“ in the attempt to verify damaging environmental influences. Furthermore, it has not been taken into consideration, that „leukemia“ is a collective term for different symptoms which are quite different in their genesis and development. A separation into individual forms of leukemia has not or only insufficiently been made. The most important restriction is, however, the lack of knowledge about the exposition that was made in the past, which could only be roughly estimated and shows considerable mistakes.

### Melatonin

The effect of low-frequency fields on the human bio-rhythm has often been investigated. Thereby, a key role is assigned to the pineal gland in our brain. It produces the hormone melatonin, to which many functions, among others control functions of the day and night rhythm are attributed.

Some scientists fear that a decrease of the melatonin mirrors due to magnetic fields - especially at night - might lead to sleeplessness as well as immune weakness. Besides, it could nullify the protective function against cancer (radical scavenger) which is attributed to the hormone.

*Experimental investigations in cell cultures shall give further information about possible health effect of electromagnetic fields.*



*The fast growth of leukemia cells sometimes is put into a vague correlation with damaging environmental influences.*



*Possible health effects of high-tension cables had also been subject of a series of scientific investigations.*

In 1981 Wilson et al. had found a remarkable diminishing effect of electromagnetic fields on the melatonin production of male rats (Wilson, B.W.; Anderson, L.E.; Hilton, D.I. and Phillips, R.D. (1981): Chronic exposure to 60 Hz electric fields: Effects on pineal function in the rat. *Bioelectromagnetics* 2: 371-380). The results were rated as a weak chronic stimulation of the nervous system which influences the neuronal activity. Finally, the findings are, however, only relatively significant. A reason for that is the high individual variability of the melatonin concentration, which can make the results seem to be coincidental, since also malpractice in the use of biometric test procedures was recognized, which put the above mentioned significant differences into question.

Beyond, different investigations made in human medicine get contrasting results. Thus there is no evidence so far, for example, that humans are more sensitive to cancerous affection, if they are living against their bio rhythm.

In principle it should be noted that the extrapolation of findings from animal

experiments onto the human organism needs a detailed interpretation and is only permissible with considerable reservation.

### **EMF and Cancer**

The question after a possible cancer genesis or promotion due to electromagnetic fields is highly disputed in science. Beside the epidemiological studies also experimental investigations regularly deal with this subject. The investigations are made in vitro in cell cultures as well as in vivo in animal experiments - mainly on rats or other rodents.

A publication of Australian scientists from 1997 struck high waves (Repacholi, M.H.; Basten, A.; Gebski, V.; Noonan, D.; Finnie, J. and Harris, A.W. (1997): Lymphomas in E(-Pim 1 transgenic mice exposed to pulsed 900 MHz electromagnetic fields. *Rad. Res.* 147: 631-640). Michael Repacholi and colleagues had registered an increased Lymphoma-incidence with mice, which were exposed to high-frequency fields similar to mobile radio network for a longer time. However, the - quite essential - restriction has to be made, that the animals were genetically manipulated („transgene“)

and therefore had an enhanced predisposition for the development of spontaneous lymphoma anyway. At present several research institutions are trying to comprehend the experiments and to reproduce the results. It seems to be recommendable to wait for their results.

It is remarkable that short time later the same group made a similar study with 60 Hz magnetic field exposition, which did not show any differences between exposed animals and controls. This is an astonishing result, since effects could be rather expected at 60 Hz magnetic fields - if at all.

In 1993 Löscher et al. noticed symptoms of a causal connection between weak electromagnetic fields and the promotion of breast cancer (Löscher, W.; Mevissen, M.; Lehmacher, W. and Stamm, A. (1993): Tumor promotion in a breast cancer model by exposure to a weak alternating magnetic field. *Cancer Letters*, 71: 75-81). The scientists prescribed a breast cancer promoting carcinogens and then divided the animals into an exposition and control group. After several weeks of radiation with low magnetic field strengths, significant

differences appeared in number and size of the developed tumors.

The existence of a linear effect relation seems to be compelling if there were no contradictory findings. An element of uncertainty is at least the assessment of the tumor growth which has merely been determined by scanning. This appears to be the more important, as it was obviously no half-blind study. Therefore an important if not decisive influence on the findings has to be ascribed to the expectations of the experimentalist.

Considering the current discussion, it should be added that the results of the working group „Löscher“ are exposed to increased criticism of other teams being active in this area.

## EEG Modifications

Overwhelming resonance similar to the Feychting/Ahlbohm-study supplied an article of the medic Lebrecht von Klitzing from Lübeck (von Klitzing, L. (1993): In: Tagungsband (convention volume): Internationales Elektromog-Hearing (International Electromog Hearing), Niedersächsisches Umweltministerium (Ministry of the Environment of Lower Saxony)). Due to the long-term exposure to modulated mobile radio signals, the brain current diagram changed significantly with several test participants according to von Klitzing. The researcher assumes, that pulsed magnetic fields obviously led to a disturbance of the intracellular communication paths.

Among scientists, the results largely noticed by the public met an extremely

*Experimental setup and methodology are also decisive concerning the significance of research findings.*



divided echo. It was reproached to von Klitzing, that the signals generated by electromagnetic coils would not correspond to the GSM standards and a clear experimental description would be missing. Accordingly it was complicated or even impossible for other researchers to reproduce the presented findings.

Hence, for instance, Röschke and Mann (1997) could not verify the described effects. (No short-term effects of digital mobile radio telephone on the awake human electroencephalogram. Bioelectromagnetics 18: 172-176). In a placebo-controlled experiment the scientists could not verify an influence of GSM mobile telephones on the awake electroencephalogram. Here it has, however, to be considered that the probands were only exposed short time (3 1/2 minutes) to radio waves - different to the case of the Klitzing-study.

Besides it has to be regarded that the EEG is very receptive even to weak exterior stimulation. Therefore it can only in a restricted sense serve as an indicator for a possible electromagnetic interference potential. If the measurement results reported by von Klitzing were really confirmed, the findings would most probably be bioeffects without any health relevance.

Again it should be added because of the current scientific discussion that two further studies, both published in 1998, dealing with EEG modifications by weak GSSM and DCS signals and likewise could not reconstruct the EEG modifications postulated by von Klitzing.

## Solid Evidences are Scarce

At a closer look almost all investigations suggesting a potential health risk due to EM-fields cannot convince in the end. There are often striking deficiencies of methodical, biometric or dosimetric type, which make the validity of the test results appear doubtful. It is true that the repetition of tests to achieve positive effects is not always easy. Nevertheless, they are absolutely necessary and again they indicate that even spectacular findings can not be reconstructed and

therefore have to be questioned. Unfortunately people often overestimate such findings as clear statements about a real health relevance or the results are only valid for the used model and its close packed conditions. It must absolutely be differentiated between biological effects without health consequences and such, which favor or cause the emergence of serious illnesses. Environmental attractions such as light, sound, warmth etc. cause biological effects and reactions in us, which are harmless below a threshold value, above a certain threshold level, however, they are impairing and even lethal. With low-frequency electric and magnetic fields and high-frequency electromagnetic radiation it is the same way. The existence of harmful athermal effects of such fields below or even far below such thresholds, respecting the relevant recommendations and regulations (limit values), have not been proved and are unlikely due to the present research findings. Obviously the accusing party makes it sometimes easy for itself to represent unwarranted risks by EM-fields as given in a doubtful manner. For objective researchers it is growing more difficult to treat the suspicion meanwhile deeply rooted in the population with strictly scientific arguments.

The task gets even more complicated by the fact, that scientists can only prove the harmfulness of a matter. A „zero-proof“ - i.e. the guaranty, that an agent under no circumstances produces detrimental effects - is, however, an unattainable ideal.

The presented survey is an extract from an extensive assessment of altogether 20 selected, much quoted scientific publications about the subject „Do electric, magnetic and electromagnetic fields have a health relevance?“ of March 1998.

The unabridged text can be seen or downloaded over the Internet supply of the Forschungsgemeinschaft Funk e.V. (Research Association for Radio Applications) under <http://www.fgf.de/Forum> of topics.

*Written by Priv.-Doz. Dr.-Ing. Dr. med. habil. Otto Petrowicz, scientific employee at the Institut für Experimentelle Onkologie und Therapieforchung der Technischen Universität München (Institute for Experimental Oncology and Therapy Research of the Technical University of Munich).*

# EEG Modifications And Sensitiveness to Changes in the Weather



**General indisposition, headache, phantom or scar pain - the range of weather-related („meteorotrop“) complaints could be extended at will. Indeed some people seem to be especially receptive to the caprioles of the weather. But what is it, that makes the affected persons react as a living „seismograph“?**

A possible solution could be supplied by the biometeorology, which in the weather forecast and its effects on the organism does not only consider visible quantities such as the cloud configuration, but also diverse physical phenomena. Revealing indicators for a forthcoming change in weather are the so-called Very Low Frequency (VLF-) Sferics - extremely short-lasting electromagnetic pulses which develop from lightning discharge.

Due to their expansion at speed of light, Sferics already announce a thunderstorm before it reaches the region concerned. Apart from their meteorological importance, Sferics have already been tested several times for their biological effectiveness.

Numerous correlation studies suggest the connection of natural Sferics activity and physical complaints such as headaches and sudden hearing losses and in individual cases even heart and epileptic attacks. The previous studies could, however, not prove a direct causality.

As the discharges have the signal characteristics of a potential biotrop stimulus, their role as a possible cause of complaints about sensitiveness to changes in the weather was investigated within the scope of two double-blind studies. In the first experiment two groups similar of age and sex with comparable sensitiveness to changes in the weather were at first formed out of 20 female and male test persons.

After a baseline phase of ten minutes the researchers exposed the first test group to the pulses of an especially developed Sferics simulator for the same period of time. For this test the magnetic component of a representative pulse with an amplitude of 50 nT and a duration of 0.5 milliseconds was selected, which was generated during the exposition period with a randomized pulse frequency between 7 and 20 Hertz. To register longer lasting effects, the

**S** After a previous  
**C** pilot study had  
**U** already shown  
**R** modifications in  
**I** the alpha band of  
**R** the EEG as a  
**E** result of a  
**F** Sferics exposition,  
**F** this time the  
**S** researchers  
**S** have been  
**S** successful again.



Schematic depiction of the Sferics-test setup



Data of the general sensitiveness of the test persons to changes in the weather had been recorded additionally to the EEG.

proband afterwards passed a 20 minute control phase without stimulus application. The second test group was not exposed to any stimulus.

After a previous pilot study had already shown modifications in the alpha band of the EEG as a result of a Sferics exposition, the researchers succeeded again this time. The brain current activity of the test group reacting with an increase of the alpha power differed from that of the non-stimulated control group which showed a „contrary reaction tendency“. Only near the end of the test the spectral power level of both groups approached each other again.

In a questionnaire the test participants had to specify from which meteorotrop complaints they usually suffered and how distinctive the correlative symptoms were. In a comparison with the results of measurements in the EEG it manifested, that the test persons sensitive to changes in the weather showed a stronger alpha power in certain parts of the brain under

the influence of Sferics than their less sensitive test fellows.

A second test series entered into the question whether the observed EEG modifications were a repeatable reaction pattern. For this study the scientists selected 32 women aged 19 to 76 years, who according to their own statements suffer regularly from migraine or tension headaches. The patients had in common, that they put down their complaints to the influence of meteorological factors. The most frequently mentioned causes were sudden changes of weather with 79 percent, changes of temperature with 48 percent and thunderstorms with 21 percent.

The test sequence as well as the results of measurement of the second experiment were otherwise identical to those of the first one: while the control group only showed minimal EEG modifications, the exposition group indicated an analogous increase of the alpha power. Physical complaints of the participants could, however, not be registered by the scientists. The experiments suggest, that the used Sferics exposition is a biologically effective stimulus which can release changes of the spectral composition of the spontaneous EEG. This means, that the human organism reacts more sensitive to low-amplitude magnetic fields in the low-frequency range than assumed so far. Whereas, in view of the results it is still unanswered whether Sferics can lead to marked changes in health in the sense of complaints about sensitiveness to changes in the weather. The scientists, however, do not exclude, that the observed EEG modifications might be a preliminary stage of a meteorotrop reaction. Further research is indispensable in any case.

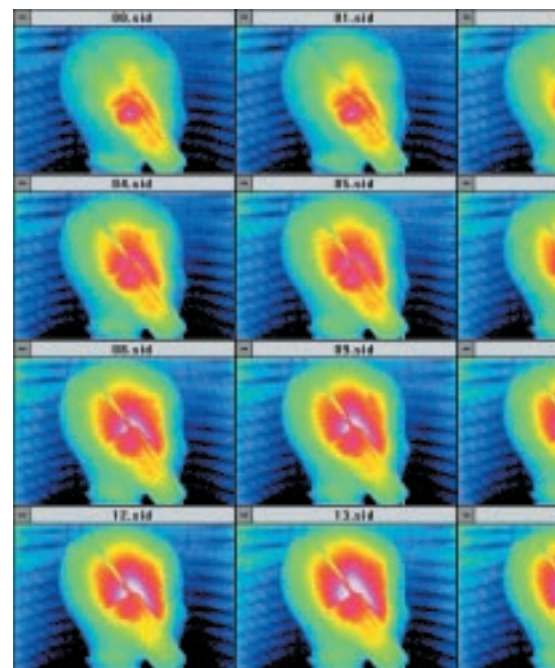
Written by Dr. Anne Schienle, Gießen

# Use of The For

**All handheld radios or those carried on the body such as radio-telephone systems, report senders and mobile telephones a high near field exposure is caused by electromagnetic fields due to the antennas operating close to the body. The strongly increasing use of mobile telephones contributes to the fact, that those fields more and more occur in daily life.**

**For an assessment of the biological effect and for the control of the respecting of limit values the energy absorbed by the human body has to be determined.**

**For this purpose numerical methods as well as methods for the measurement of the specific absorption rate (SAR) have been developed, having reached a high technical standard.**



# Thermographic Methods

## the Depiction of Absorbed HF-Energy on Surfaces

With the portable radio frequencies the energy absorption basically occurs in areas close to the surface of the body. We therefore investigate in how far thermographic methods, which generally register surface temperature distributions, are suitable for the visualization of the HF energy absorption.

Hereafter the results of thermographic measurements on head models and living tissue (skin surface) are described.

### The Thermographic Method

In the established mobile radio SAR measuring methods the electric field strength in sphere phantoms filled with tissue-equivalent liquid is measured with robot-piloted field probes. The thermocamera on the other hand supplies a temperature distribution of the surface. In fact the SAR cannot be determined directly, but with some experience conclusions can be drawn

on the quantity of the SAR. As, however, a substantial part of the energy is absorbed close to the surface of head areas, the surface approximation which is necessary for the SAR measuring methods can be checked for plausibility. During the investigations the reproduction of a mobile telephone with a blade antenna served as HF radiator. The electrical characteristics of the blade antenna approximately correspond to those forms of blade antenna, which have often been used with mobile telephones up to now.

The use of this method is not restricted to definite forms of antennas. The HF radiator formed as a mobile phone was fed by the Rhode & Schwarz signal generator SMT 03 with a postconnected band amplifier. The output signal of the measurements at the phantom-head was in accordance with the GSM standards for the D-system (average HF power 0.3 W).

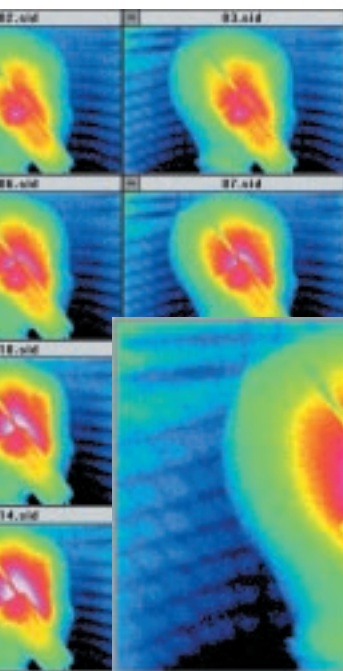


Figure 1: Delineation of the warming up process in a series of 15 single photos with intervals of 20 sec  
( $P_{HF} = 0,3 \text{ W (rms)}$ ,  $f = 916,2 \text{ MHz}$ ,  $d = 1 \text{ cm}$ )

Figure 2: Temperature distribution on the surface of the head model after 300 seconds  
( $P_{HF} = 0,3 \text{ W (rms)}$ ,  $f = 916,2 \text{ MHz}$ ,  $d = 1 \text{ cm}$ )

### Correlation between Specific Absorption Rate and Thermographic Pictures

The specific absorption rate (SAR) is a measuring quantity which gives the absorbed power referred to the body mass (W/kg). All presently existing limit values for personal security and recommendations for limit values for electromagnetic fields in high- and highest-frequency range ( $f < 10 \text{ GHz}$ ) have underlying knowledge about the thermal effects. The correlation between SAR, tissue parameters, field quantities and thermal quantities is given by formulas 1 and 2:

$$SAR = \frac{\sigma}{\rho} E_i^2 \quad (1)$$

$$SAR = c \frac{\Delta T}{\Delta t} \quad (2)$$

- with
- SAR specific absorption rate in W/kg
  - $\sigma$  electric tissue conductivity in S/m
  - $\rho$  tissue density in kg/m<sup>3</sup>
  - $E_i$  effective value of the electric field strength in the tissue in V/m
  - $c$  specific heat constant of the tissue in J/kg (K)
  - $T$  temperature increase during warming up period  $t$  in K
  - $t$  Warming up period in sec

In investigations with absorber or phantom materials their material parameters have to be used.

The thermocamera supplies a distribution of the surface temperature based on formula 2.

With the portable radio frequencies the energy absorption basically occurs in areas close to the surface of the body.

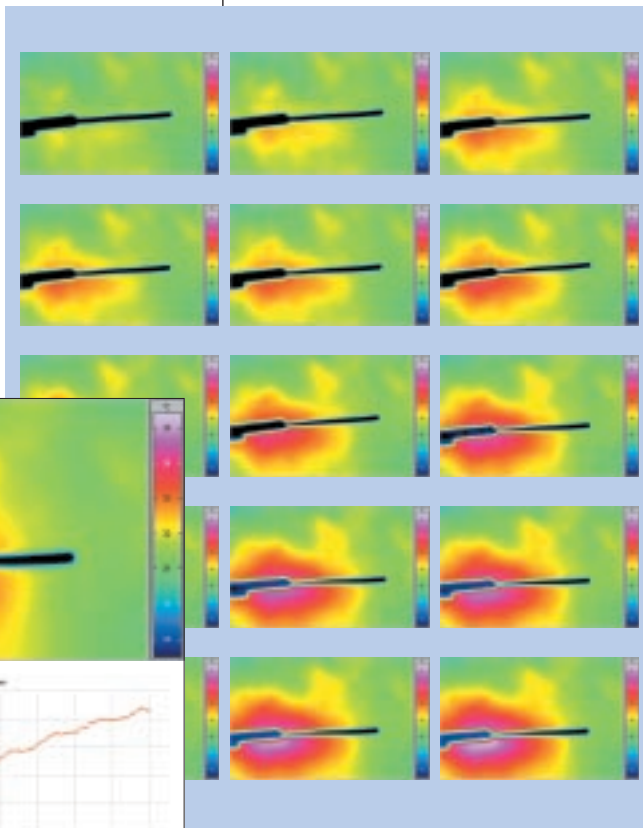


Figure 3: Development of the temperature distribution on human skin during a 15 minute exposition with PHF = 5 W (rms), antenna distance  $d = 1$  cm

Figure 4: Final picture of the photo series with graph of the temperature increase measured at the hottest spot

All figures clearly show, that the maximum energy absorption with a blade antenna form happens in the range of the antenna nadir (antenna current maximum), i.e., that the magnetic field of the antenna essentially determines the energy entry. The distribution of the surface temperature corresponds to the surface SAR calculations and measurements of analogue antenna forms. First publication in: EMC Kompendium 1998, pp 298-300.

## Summary and Results

The influence of antennas operating close to the body can be quickly and clearly delineated by means of thermography and hence also be used, e.g., for the optimization of antennas. As the results of the head model show, thermographic methods can also be used in the range of low HF power under adequate prerequisites. The thermography completes established SAR measuring methods which cannot enable a straight determination of the surface absorption due to the finite peel thickness of the phantom models, the only restricted reducable E-field probes and the measurement inside the model. The use of thermographic systems in connection with high-frequency absorber materials can be extended to many fields of the high- and highest-frequency technology to realize intended or unintended energy absorptions and to arrange appropriate countermeasures.

Written by Dipl.-Ing. Sigurd Goltz and Dr.-Ing. Siegfried Eggert, Berlin

With the measurements on living tissue a mean power of 2 W or 5 W respectively was chosen. In the investigations a head model made of foam polystyrene was used. In the area of the mobile telephone position it was covered with an absorption layer of about 1 mm thickness, which shows electrical characteristics copied from human skin and a high HF absorption grade.

To measure the surface temperature distribution of the human skin, the transmitter was fixed onto the back of a test person so that the distance of the antenna from the skin came to 1 cm.

In the process the antenna ( $\lambda/2$  wave trap antenna) was pulled out a bit from the case to be able to better delineate the temperature distribution in the area of the antenna nadir. The thermographic system was the system VARIOSCAN 3011 with a frequency range of 8...12 (m of the Jenaoptik L.O.S. company. The investigations took place in a temperature stable room.

Eike Bär  
(chairman)

# Seventh General Meeting of the FGF

The Research Association for Radio Applications (FGF) has a new chairman: Eike Bär from Motorola was elected during the seventh general meeting of the FGF in Frankfurt/Main on 28 January 1999.

Bär took up the succession of Georg Langheld who managed the FGF for six years and turned down a re-election for vocational reasons. Due to his merit he became honorary chairman of the FGF.

In the name of the previous committee Dr. Christian Payer / Bosch thanked the separating chairman for his work. Langheld essentially contributed to the FGF being a forum of scientific research.

Langheld on his part expressed his thanks for the confidence and the good cooperation during the last six years. He hoped, that the good work of the last years had „contributed a little bit to the enrichment of the knowledge in EMF research“.

In his report Langheld struck a positive balance of the year 1998. The FGF played a Europe-wide innovator's role in the support of research for „Electromagnetic environmental compatibility“.

To the highlights of the year Langheld counted the dialogue with the EU in the run-up of the fifth framework for the support of research and technological development, the participation at the 20th world congress of the BEMS in St. Petersburg Beach/USA and the WHO conventions in Geneva as well as the active involvement in the COST 244bis program and also the diverse activities of members at CENELEC.

## Research Projects

As Langheld explained, at present 13 research projects are in the project or assessment phase. Six projects are to be continued this year. The remaining seven projects have been scientifically completed, but detailed final documentation or the assessment within the scope of a presentation are still missing. Altogether 1.3 million marks have been spent on research during the last year. Since the foundation of the FGF in 1993 all in all 72 single projects have been supported with an amount of altogether 6.76 million marks.

Beside the continuation of the six current projects the FGF wants to realize a new call for bids on the subject „Electrosensitivity“. Additionally, in cooperation with the carriers and manufacturers the large EU projects shall be supported which are to be started this year within the scope of the fifth framework of the EU.

## Public Relations

Also in the field of public relations the FGF can look back to a successful year. Target group-orientated public relations could be further extended. The internet offer was extended by a forum of topics where authors can give their opinions about certain subjects. The „calendar of events“ gains increasingly positive response as well as the newly offered possibility to request all articles in English.

Beside the internet offer, which is exceedingly successful with about 20,000 accesses per month, the publication series have also proved efficient. During the last year three issues of the „Newsletter“ and

## FGF with new committee

Eike Bär/Motorola (chairman)  
Klaus Hummel/T-Mobil (vice-chairman)  
Horst Ehmsperger/BMWi  
Dr. Christian Payer/Bosch  
Herbert Tillmann/  
Bayerischer Rundfunk  
Peter Zapf/Siemens  
Dr. Horst Lennertz/E-Plus  
Dr. Wolf R. Haas/  
Mannesmann Mobilfunk

one edition of the „Edition Wissenschaft“ in German as well as two English editions were published.

## Finances

The FGF has gained international reputation to handle its disposable financial means quite efficiently. The receipts of 2.45 million marks of the last year were faced by expenditures of 2.37 million marks, the outweighing proportion has been spent on research projects. For the current financial year a budget of 2.7 million marks is available, 1.6 million marks of it shall be spent for research of third parties. ■

# Influence of pulsed electromagnetic waves On the Electrical Act

**The Federal Office for Radiation Protection (BfS) has recently dealt with possible EEG modifications due to microwave exposition. The main interest of the investigation, which was carried out together with neurologists of the Großhadern University Clinic, was exclusively focussed on such effects that occur in direct and simultaneous connection with the microwave radiation.**

The possible effect of high-frequency electromagnetic fields on the human organism is discussed controversially time and again. But only serious scientific studies can illuminate the real risk potential. In this context it is necessary to determine possible effects of the electromagnetic fields used in mobile communication under reproducible and realistic experimental conditions. In accordance with these research findings, institutions as the WHO or the ICNIRP recommend limits for the protection of the public, which are subject to constant revision and adequately adapted if needed.

Yet the test results are often incoherent and partly contradictory, for instance, in the question about the effect of pulsed high-frequency electromagnetic waves on the electrical activity of the human brain. In 1992 the medical physicist Lebrecht von Klitzing from Lübeck observed direct as well as long-term effects on the electroencephalogram (EEG) of several test persons and he therefrom concluded a detraction from brain capacity.

In contrast, the psychiatrists Joachim Röschke and Klaus Mann from Mainz found no effect on the EEG in the awake state when they in 1997 exposed 34 test persons to the field of a D-system mobile phone for several minutes. An overview study about neurological effects of high-frequency electromagnetic waves of the same year concludes that neither the exposure to continuous nor pulsed fields constitutes an increased health risk in the non-thermal area to the brain.

The Federal Office for Radiation Protection (BfS) has recently dealt with possible EEG modifications due to microwave exposition. The main interest of the investigation, which was carried out together with neurologists of the Großhadern University Clinic, was exclusively focussed on such effects that occur in direct and simultaneous connection with the microwave radiation. However, it cannot finally be said by means of an EEG investigation, whether a measurable effect means a health risk, though its occurrence would at least suggest extrapolating studies.

The electroencephalogram records the chronological development of the electric processes which accompany the cerebral activity and are measured by means of electrodes in the head area. The waves generated by the brain are divided into five frequency ranges according to their wavelength: delta waves (0.5 to 3.5 Hz), theta waves (3.5 to 7.5 Hz), alpha waves (7.5 to 12.5 Hz), beta-1 waves (12.5 to 18 Hz) or beta-2 waves (18 to 30 Hz).

Each frequency represents a characteristic reflection: some waves correlate to certain states of consciousness as, for example, tiredness or sleep, some correlate to pathological changes such as coma, brain injury or poisoning. The analysis of the diagram therefore enables conclusions to the present state of health and efficiency of the test person. As the „conventional“ EEG is in the end a „summation“ of simultaneously occurring processes, the scope of any statement as the condition of individual, functionally connected areas of the brain, will be limited. This limitation can only be overcome by measuring so-called evoked voltages where a test person

# Activity of the Human Brain

is repeatedly exposed to a specific, e.g., optical or acoustic stimulus.

39 healthy test subjects - of whom 21 were women, aged between 16 and 58 years took part in the BfS study. In the test usual mobile phones of the D-system (frequency 902.4 MHz, tested on 23 subjects) and the E-system (1760 MHz, tested on 16 subjects) were used. The phones were placed directly against the right ear of the subject. Even at maximum transmission power none of the limits was exceeded.

In several test procedures first an EEG at rest and afterwards evoked voltages were recorded. For this purpose, the test persons had to watch alternating patterns and listen to audible clicks. Simultaneously, the electrical activity of the brain was measured. The acoustic stimulation served as a test for the reaction time. The test procedures were repeated several times whereat in one of the tests the pulsed field was switched on undisclosed to the test subject.

In the D-system field at the EEG at rest two of the 23 test subjects showed a reaction in the alpha band. One of the test subjects showed an increase in activity during the exposition, all other conditions (evoked voltages) were not noticeable. Another test subject showed a marked increase in activity already before the exposure phase, so that an effect due to the influence of electromagnetic waves can be excluded (see graphics).

In the E-system field three of 16 test subjects showed reactions in the alpha band of the EEG at rest. Two persons showed an increase, one a decrease in activity, the other conditions showed no response again.

The evaluation of the evoked voltages gave no indication of a change in EEG activity. The same picture appeared in the context of the measurement of the reaction time, in which the test subject had to respond to an acoustic impulse by pressing a button.

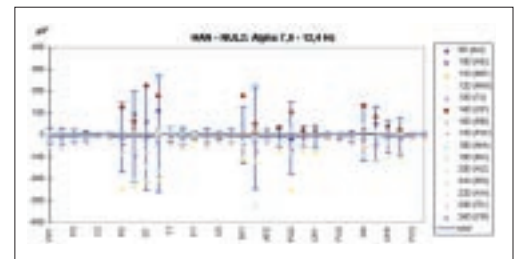
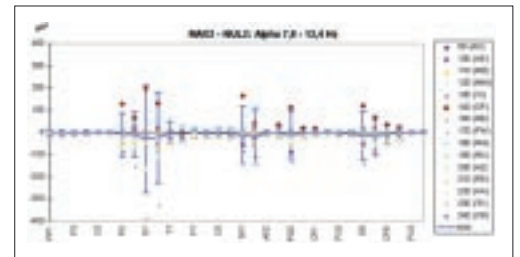
## Conclusion

The current study neither indicated, that the electromagnetic high-frequency waves transmitted by mobile phones modify the activity of EEG at rest, the electric activity of the brain under the influence of optical and acoustic stimulus nor that they influence the reaction time.

It has, however, to be noted, that in the interpretation of the results of neuro-physiological tests in connection with electromagnetic fields, the extreme variation within and between the findings must be taken into consideration. At long last the measured EEG activity results from the interaction of a series of factors, which partially can neither be found in the basic conditions of the experiment nor be controlled within its course. A considerable influence on the shaping of the EEG have, for instance, variations in concentration and degree of relaxation of the test subjects.

Written by Dr. S. Krafczyk, Munich

For 15 test subjects (test sequence II) it is shown in the following figure (difference diagram of the exposition and placebo conditions of the EEG at rest in the alpha band). The line pulled through represents the average value of all single differences above the 32 test electrodes. The scattering bars show the double standard deviation (confidence interval) of the test collective. If the difference line of the average value strongly deviates from the zero line (more than the double standard deviation), a significant difference is present above the corresponding electrode. As the difference line of the average value does not deviate from the zero line, it is already observable from the graphics, that the electromagnetic field of the hand-held mobile phone (emitted with a power of 2 W) has no measurable effect on the EEG at rest. The difference between exposition and placebo condition remains near the zero line.



The line of the average value does not deviate from the zero line, no effect can be recognized. The electromagnetic field of the hand-held mobile phone - emitted with a power of 2 W, or the car telephone (8W) - has no measurable effect on the EEG at rest.

# Unified Jurisdiction

High-frequency systems do not require official approval in the sense of the immission protection law. The Federal German Immission Protection Act (BImSchV) obligates to set up and operate such systems so that damaging environmental effects, which could be avoided according to the standard of technology, are prevented. Unavoidable environmental effects have to be limited to a minimum. The BImSchV authorizes the Federal Government to define requirements for such systems by means of statutory orders. Requirements in this sense could for example be limiting values for electromagnetic fields. Only with the regulation on electromagnetic fields (26th BImSchV) such a legal order was coming into force on 1 January 1997. It puts the BImSchV into concrete form and defines limiting values, whereat it differs between high-frequency and low-frequency field with regard to potential health risks. Besides the carrier of a high-frequency system is obliged to indicate the installation at least two weeks before commissioning to the appropriate authorities. The same applies to fundamental changes on already existing systems.

According to the BImSchV, electromagnetic fields caused by high-frequency systems in principle have to be assessed as immissions. This was also confirmed for low-frequency systems by the Federal Administrative Court in 1996. The law determines the measure of what has to be subjected as environmental effects due to electromagnetic fields. However, the health protection conveyed by the

immission protection law only starts where human medicine can make sufficiently reliable predicates about the risk of emissions. Therefore with systems, which do not need official approval according to the immission protection law, only the protection against verifiable damaging environmental effects can be demanded. Statutory safety precautions against damaging environmental influences do not exist in contrast to the systems requiring official approval according to the immission protection law.

The regulation on electromagnetic fields is restricted to the construction, constitution and operation of stationary systems that generate high-frequency or low-frequency electromagnetic fields. Additionally, the systems have to serve commercial purposes. Transmitting radio communication systems of the public broadcasting corporations are not affected by the regulation, as the carrier does not practice a commercial occupation.

## **Limiting Values of the 26th Federal German Immission Protection Act**

The immission limit values defined in the 26th BImSchV are based on the recommendations of the International Radiation Protection Association (IRPA) and the International Non-Ionizing Radiation Committee (INIRC), the International Commission on Non-Ionizing Radio Protection (ICNIRP), which continues the work of IRPA/INIRC, as well as on the recommendations of the Commission on Radiation Protection.

The regulations are orientated on the realization prevailing in science, that the main effect of high-frequency fields is the heating up of tissue. For the protection of the population an SAR basic limit value (Specific Absorption Rate SAR) was internationally determined on 0.08 W/kg, on which also the limit value determination for high-frequency systems in appendix 1 of paragraph 2 of the 26th BImSchV is based. By the adherence to this limit value thermal effects in the human body can be excluded. By the definition of the immission limit values the legislator made a definite regulation about the electromagnetic fields which are binding to the public. The courts are bound to the limit value definition in the regulation. Something else could only apply if the legislator had misjudged the yardstick resulting from article 2 paragraph 2 Basic Law in the definition of the limit values. The state is in principle obligated to protect its citizens against potential health risks. This protection obligation not only intervenes if lives and health are concretely endangered. In addition, it cannot be expanded into the „scientific ignorance“ concerning possible damages. The right of the public and the neighborhood to physical soundness is protected if indications for a health risk do not exist according to the status of science and technology.

## **Court Decision concerning Potential Health Risks due to Electromagnetic Fields**

Although only verdicts by the supreme court do exist so far concerning the influences of low-frequency electric and

*on electromagnetic fields (26th BImSchV)*

# on

magnetic fields on health, those decisions are essential for the assessment of the health effects of high-frequency systems in jurisdiction and literature. In a judgement concerning the construction of a 110-kV railroad conduction, the Federal Administrative Court acknowledged that the rights of third are protected according to the present state of knowledge, if the limit value recommendations of the IRPA are kept. In the adherence to these limit values a health risk of the residents is impossible. Transferred to high frequency systems, this would mean that on observance of the limit values determined in the appendix of the 26th BImSchV health risks by thermal effects on the human body are impossible, because these limit values correspond to the international recommendations. In a resolution from 17 February 1997 about the operation of a transformer station next to a house the Federal Constitutional Court determined that electromagnetic fields can impair the human state of health in principle. However, according to the present state of knowledge a health risk would only occur with effects, which were situated clearly above the determined limit values. In further proceedings, which also dealt with a study of the American National Council for Radiation Protection (NCRP), the Federal Constitutional Court acknowledged the limit values of the 26th BImSchV for low-frequency systems, as they were determined according to international recommendations. Since this applies also to the limit values of high frequency systems, the decision of the Federal

Administrative Court from 17 February 1997 might be applicable to high frequency systems as well.

Beside thermal effects also so-called athermal effects are discussed in science. The influencing of the human EEG, the melatonin secretion of the pineal gland as well as a cancer-promoting effect are after-said to high-frequency electromagnetic fields. However, first results of such diseases can - according to the probably unanimous jurisdiction - neither be consulted for the evaluation of harmful environmental effects in the sense of the BImSchG nor for the reason of a violation of fundamental rights according to the Basic Law. For an endangerment in the sense of right rather a state of affairs must exist, which in foreseeable time would lead to a damage with sufficient probability.



# REGULATORY JURISDICTION

**The right of the general public and the neighborhood to physical soundness is protected, if there is no evidence for a potential health risk according to the standard of science and technology.**



Such a probability of damage is not given with electromagnetic fields. None of the effects described in science so far could be determined again with comparable tests. Accordingly the Administrative Court (VG) Osnabrueck determined in a judgement of 26 April 1996 that athermal effects could not be verified scientifically at present. The most provable biological effects due to high-frequency fields rather correspond to the reactions as they are caused by a tissue heating up (recommendation of the ICNIRP, Edition Wissenschaft, Research Association of Radio Applications, April 1996, p. 6/8).

The protection from any health risks due to electromagnetic fields is therefore ensured by the adherence to the limit values of the 26th BImSchV, because this regulation is just to prevent effects due to an increase of the body temperature. On adherence to the limit values the rights of the public and the neighborhood to physical soundness in the sense of article 2 paragraph 2 rate 1 Basic Law are thus protected.

In this sense also the Higher Administrative Court (OVG) Lueneburg expressed itself to a judgement announced on 26 March 1998. Accordingly an infringement of the law of the plaintiffs by the operation of a portable radio base station in a distance of approx. 140 m is not recognizable. According to the court, it cannot be ascertained that pulsed electromagnetic fields of high frequency systems produce health impairments in the population of the closer vicinity of transmitting plants by athermal biological effects.

The court neither sees a basis for the necessity of an expert evidence. It relies on the fact that the plaintiffs themselves could not bring a concrete proof for the existence of the athermal health-impairing effects maintained by them. The court sees,

however, still research requirement here, since the status of science is „still just as unsatisfactory today as five to ten years ago“.

Altogether the jurisdiction of the higher administrative courts and administrative courts come to the corresponding result that athermal effects on health are not proven.

The OVG Lueneburg neither sees a legal base for the fact that the criterion of precaution could oppose the construction and operation of radio transmitting installations, which are actually in agreement with the 26th BImSchV. The BImSchG does not designate such a precaution precept. The precaution in the area of the systems that do not require official approval is rather transferred to the legislator who is entitled to have further clearance in estimation, evaluation and organization according to the already quoted decision of the Federal Administrative Court from 17 February 1997.

According to the judgement of the OVG Lueneburg, the limit values determined in the 26th BImSchV are important for the evaluation of the legal validity of the system also in the relation to the neighbors. The limit values concretize the request for the protection of the public and the neighborhood from harmful environmental effects. These requests are now defined normatively. Thereby they obligatorily and sufficiently determine the measure, in which protection and precaution are required against endangerment of the health. The legislator thereby acts in practice of the national protection obligation. His decision concretizes the necessary measure of protection and precaution.

Regarding the non-thermal effects, the OVG Lueneburg decides that the legislator

before the decree of the 26th BImSchV dealt with the question, whether precaution requests are to be placed on the high frequency systems for the consideration of non-thermal effects. However, he decided against it, because it „missed any scientific basis“. This normative decision is relevant for the judicial evaluation.

In the same sense the Administrative Court Munich had already expressed itself before in its resolution of 8 July 1997. It also deems the adherence to the determined limit values sufficiently. Regarding potential health risks due to so-called athermal effects of electromagnetic fields on biological systems like humans, the Munich judges noted that this was just a bare first suspicion, which is not sufficient anyhow to „lift out“ the obligatory limit value definition. The limit values, which were determined on the basis of the natural body stream and were based on the recommendations of the International Radiation Protection Association (IRPA) as well as the World Health Organization (WHO), reliably protected against irritations and thermal damage. In fact, health-relevant effects, which cannot be led back to irritation and warming up, were also discussed underneath these limit values. Concrete evidence for possible health risks would not be available according to the present status of science.

Also the Administrative Court Schleswig determined in a judgement of 22 August 1997 that with adherence to the limit values a health risk can be excluded both by thermal and by possible athermal effects of electromagnetic fields according to the present status of science. In this sense also the Higher Administrative Court Bautzen expressed itself in the resolution of 17 December 1997. It decided that with a system, which does not exceed the limit

values, a deviating evaluation of the possibility of harmful environmental effects is basically excluded in the sense of the BImSchG. Also regarding the so-called athermal effects, a comprehensible risk potential does not exist in the opinion of the OVG Bautzen.

The Bautzen judges besides expressly refused granting special protection to one of the plaintiffs who had fallen ill with a brain tumor. It is not evident that the limit values could not offer sufficient protection considering particularly sensitive states of health. Regarding the heating up of the body tissue, sufficiently conservative values might insofar have been determined in the 26th BImSchV. After a rise in temperature negative effects were basically only determined during a continuous influence of SAR values of above 2 W/kg. With an SAR of 0.08 W/kg the limit value offers an extensive safety margin. The risk of health consequences due to a high frequency system could hence be excluded even with a markedly increased health sensitivity of residents.

A resolution of the Administrative Court (VG) Hamburg from 24 April 1997 is based on the statement that at the present state of science there are no realizations about so-called athermal or non-thermal effects, which would have the character of harmful environmental influences in the sense of the BImSchG. Many predicates existed about the fact that particularly low-frequency pulsed high-frequency fields can cause biological effects, which are not based on a heating up of the body. These findings are, however, disputed. It is just as disputed whether such athermal effects are harmful to the organism. This uncertainty in the scientific evaluation of the athermal effects of portable radio systems does not lead to the consequence that the legal evaluation

has to assume a risk situation, which is different from atomic energy law. Under no circumstances it can be spoken of concrete or provable risks for life and health at the present state of knowledge. The causative and damage profile of such effects is theoretically as well as empirically vague and may become recognizable in its individual effects only after a further, longer observation phase. Only then necessary preventive measures could be evaluated. Finally the VG Hamburg decided that the limit values determined in the 26th BImSchV ensure the protection against health risks, considerable disadvantages and irritations.

The Administrative Court Munich determined in the judgement of 11 November 1997 that the limit values defined in the 26th BImSchV do not offend against higher-ranking right and have to be regarded as obligatory. In case of adherence to the intended limit values health damage is impossible - anyhow according to the present state of knowledge.

### Summary

The 26th Federal Immission Protection Act specifies obligatory values for the authorizing bodies and the courts with the evaluation of the effects of electromagnetic fields. In most cases no more doubts might therefore exist against the approvability of antenna carriers for portable radio. However, this does not mean that the carriers can „lean back“ calmed. It is rather important to research furthermore about possible health risks due to electromagnetic fields. As long as research does not reveal any contradictory recognition, the keeping of the limit values ensures sufficient protection against the possible endangerment of third.

*Written by lawyer Dr. Claus-Peter Martens, Berlin*

## Judgements for Rereading

- Federal Administrative Court (BVerwG), resolution from 02-09-1996 - 11 VR 46.95, published in the German Verwaltungsbblatt 1996, 682
- VD Osnabrueck, judgement from 04-26-1996, AZ. 2 A 34/94, not published
- OVG Lueneburg, judgement from 03-26-1998 - 1 L 1796/97, not published
- VG Schleswig-Holstein, judgement from 08-29-1995 - 1 L 143/93, not published
- VGH Mannheim, resolution from 01-02-1997 - 8 S 3396/96, published in Neue Zeitschrift für Verwaltungsrecht 1997, 704
- Federal Constitutional Court (BverfG), decision from 02-17-1997, published in Neue Juristische Wochenzeitschrift 1997, 2509
- VGH Munich, judgement from 07-08-1997, published in Neue Zeitschrift für Verwaltungsrecht 1998, 419/420
- VG Schleswig, judgement from 08-22-1997, published in Neue Zeitschrift für Verwaltungsrecht 1998, 434
- OVG Bautzen, resolution from 12-17-1997 - 1 S 746/96, not published
- VG Hamburg, resolution from 04-27-1997 - 13 VG 127/97, not published
- VG Munich, resolution from 11-11-1997 - M 1 K 95.927, not published

Further information is available in the FGF-Hotline from 04-08-1999. The article can be called or downloaded in an unabridged version under <http://www.fgf.de/forum>

## Call for bids of the FGF

Within the scope of its research program for the scientific investigation of possible influences of electromagnetic fields on human beings, the FGF intends to implement a provocation study about the electro-sensitivity (ESV) of human individuals. More information can be gathered from HYPERLINK <http://www.fgf.de> <http://www.fgf.de>. Applications should at latest arrive on 30 April 1999.

## Call for bids of the EU

The head office XII of the European Commission invites scientists and scientific institutes to tender applications for listing experts taking over the assessment of the proposals to the specific programs. The application form is available at HYPERLINK <http://www.cordis.lu/expert-candidature> <http://www.cordis.lu/expert-candidature> or can be requested at the European Commission, GD XII - SDME 5/20, 200 rue de la Loi, B-1049 Brussels. The text of the invitation and the „Guidelines for the Completion of the Application Form“ are available under code HOT 1575 at the FGF's office.

## Appliances against Electrosmog?

Beware of sales offers that are supposed to avoid or reduce electrosmog. As the Öko-Test magazine reports in this year's third edition, that - according to investigations of the medical physicist Lebrecht von

Klitzing - only two of the 22 tested products actually can reduce electrosmog. The complete article can be obtained from the FGF's office under code HOT 1624.

## Annual Meeting of the BEMS

The 20th annual meeting of the „Bioelectromagnetic Society“ (BEMS) takes place in Long Beach, California, from June 20 to 24, 1999. Application forms for the conference and hotel accommodation are available under code HOT 1617 at the FGF's office.

## Fifth RTD Framework Program

From February 25 to 26, 1999 the European Commission held a conference to introduce the „Fifth Framework Program for Research and Technological Development“ in Essen. Beside the new research programs already successfully realized research projects were also presented among other things. Further information is available at HYPERLINK <http://www.cordis.lu> <http://www.cordis.lu>.



## Switzerland lowers Precaution Values

The Swiss Upper House of Parliament published the draft of a new regulation about the protection against non-ionizing radiation (NISV). The precaution values given there are approximately around the factor 10 below the values recommended by the ICNIRP and apply to places, where persons regularly stay for a longer period of time. The documents can be obtained under: HYPERLINK <http://www.admin.ch/buwal/buwal/presse/1999/d9902161.htm> <http://www.admin.ch/buwal/buwal/presse/1999/d9902161.htm>

## Imprint

Newsletter of the FGF

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### Conception and Editing:

Gerd Friedrich (responsible)  
Kesberg, Bütfening & Partners, Bonn

### Copyright:

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### Design, layout, graphic art:

Setz it, Sankt Augustin

### Fotos:

P. 2 Bayer, p. 3 Kruse, p. 6 Schienle, pp. 6-9 Goltz, p. 16 EU-commission, p. 1/p. 5/p. 11, pp. 12-15 archive

### Mode of publication:

Quarterly

### Edition:

1000 copies

### Reprint and reproduction welcome

ISSN 0949-8745