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Microwave Radiation Hazards from Radars and other High Power Microwave Generators

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ABSTRACT

Electromagnetic radiation, as a whole, effects the biological system. Microwave radiation produces heat due to its absorption by water and protein molecules present in the body. This effects the functioning of the body. The effect can be lethal also if the thermoregulatory system of the body fails because of the rise in body temperature. Microwave energy can leak through the couplers and from joints used in microwave systems. To detect the microwave radiation in working environment, it is essential to get the high power microwave generators and their transmission lines surveyed periodically. The results of a few surveys conducted by the author have been brought out in this paper.

1. INTRODUCTION

Microwave radiation demarcated in frequency range[1] from 300 MHz to 300 GHz on electromagnetic spectrum are very widely used in different areas of science and technology. These radiation are categorised as non-ionising radiation[2]. The radiation in frequency range of 300 MHz to 10 GHz can be easily absorbed in biological tissues. Due to this property, microwave radiations are extensively used in medicine where heating of the tissues is desired, specifically, in pasteurisation of foodstuff, medical diathermy[1] and hyperthermia of cancerous tissues for treatment, etc. While using high power microwave equipments, the safety of the operating personnel is a matter of concern.

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In view of the harmful effects of microwave radiation, microwave (MW) and radio frequency (RF) generators in several developed countries are periodically surveyed. The microwave radiation field as high as 180 mW/cm^2 around the FM station located on Mt. Wilson, California was recorded[3]. Similar results have been obtained in Sweden in and around the TV and FM broadcasting stations[3]. These fields are observed around the cables and wave guides carrying MW/RF energy to radiating antenna. In several places these cables and wave guides pass very close to the ladder used to climb the tower and could explain the high exposures received by the worker climbing the tower. Similarly some of the workers have recorded microwave radiation field as high as 70 mW/cm^2 leaking through conveyer slot from industrial microwave heating systems operating either at 915 or 2450 MHz. In some other industries using microwave power devices, the continuous exposure of the order of 1 mW/cm^2 to the workers have been reported. The survey of diathermy units has shown the microwave radiation of 16.6 mW/cm^2 field density falling on the operators from the applicators or RF cables.

2. BIOLOGICAL EFFECTS

Microwave can produce thermal and non-thermal effects in biological systems. The heating of tissues due to the absorption of microwave occurs due to the ionic conduction and vibration of dipole molecules of water and proteins present in the body[1]. The rise in temperature of the tissues depends up on the frequency and power of microwave radiation being absorbed and the cooling mechanism of the system. When the thermoregulatory capability of the body or parts of the body is exceeded, tissue damage and death can result. This occurs at absorbed power levels far above the metabolic power output of the body. Death usually results from the diffusion of heat from the irradiated portion of the body to the rest of the body by the vascular system. When the absorbed energy increases due to the prolonged exposure or increase in power of radiation, the protecting mechanism of heat control breaks down, resulting in uncontrolled rise in body temperature. At low power of irradiation, one usually gets headache, vomitting, intraocular pain, fatigue, nervousness, awareness of buzzing vibrations or pulsations and sensation of warmth. Most of these effects are not permanent.

The non-thermal effects[1] are not related with the increase in temperature. One of such effects is known as pearlchain effect. This effect occurs in the frequency range of 1 to 100 MHz. When suspended particles of charcoal, starch, milk, erthrocytes or leucocytes (blood cells) are placed in the RF field, the particles form the chains parallel to the electric lines of force. The other non-thermal effect is the dielectric saturation in the solution of proteins and other biological macromolecules in the presence of intense microwave fields. In this process the polarized side chains of macromolecules line up in the direction of electric field, which leads to the possible breakage of hydrogen bonds and to the alterations of the hydration zone. Such effects can cause denaturation and coagulation of molecules. Soviet scientists have reported direct and indirect effects on the central nervous systems (CNS) even at very low radiation field density of microwaves. They state that the CNS is the most sensitive of all body

systems to microwaves at intensities below thermal thresholds. Soviets have also reported non-thermal effects on the cardiovascular system, including decreased arterial pressure and heart rate.

3. SAFETY LIMITS

In view of harmful biological effects of microwave radiation several countries have adopted a safety limit for microwave radiation exposure. American National Standard Institute (ANSI)[4] has recommended a maximum limit of 5mW/cm^2 microwave radiation exposure for 6 minutes period in one working day for whole body exposure. The exposure can be prolonged by reducing the power density of microwave radiation to less than 1 mW/cm^{2}and in same way the exposure can be increased up to 50 mW/cm^2 provided the time of exposure is reduced to less than one minute in whole working day. But some of the East European countries[5] have put a maximum limit of 10 mW/cm^2. Under any circumstances this limit should not be exceeded. Soviet[6] block countries have put more stringent limit of exposure. In 10 μW/cm^2 power field one can work for full working day. As the power density increases the time of exposure is to be reduced as followed by other countries. When microwave field density reaches 1 mW/cm^2 the period of exposure is restricted to 15–20 minutes. In India no such limits have been set for safe microwave radiation exposure. Since India is a tropical country, extensive research work is required to know the biological effects in such climatic conditions before setting any safe exposure limits. However, the author feels that till safe exposure limits are formally decided, it will be safe to follow the Soviet standards for summer and ANSI standards, which are more liberal for winter[5] For the measurement of microwave radiation field, a microwave radiation monitor[7] has been developed and for the safety of working personnel, microwave radiation surveys of radars and other high power microwave generators operating in India have been carried out.

4. PROTECTION SURVEY OF MICROWAVE INSTALLATIONS

Microwaves are generated by Klystron or Magnetron. This microwave energy is transferred from the generators to the required place either through coaxial cables or through waveguides or both. In the process, the microwave energy is transferred several times from waveguide to coaxial cables or coaxial cables to waveguides. Microwave radiation can be released to the open atmosphere either by dipole antenna or by horn antenna. When parallel beam of microwave radiation is required, a parabolic reflector with dipole or horn is used. In all these microwave instruments, couplers are very frequently used. There is a possibility of microwave radiation leakage[2] from the coupling joints and from badly designed parts. Author has carried out microwave radiation protection surveys to find the radiation density in working environment. The results of the first survey have been reported earlier[8]

A few radar stations have also been surveyed. Two types of radars are commonly used, stationary radars mounted in immovable structures and mobile radars[9] mounted on van. Most of these radars are imported. In the stationary radars surveyed no

measurable microwave radiation field was found anywhere inside the working places. Only at the roof of the radar station and below the antenna, radiation fields of varying power density ranging from 5 mW/cm^2 to more than 20 mW/cm^2 were observed. These radiations were detected only when antenna faced the measuring position during its rotation. This dose not normally pose any health hazards as operating staff is seldom required to be present there under operating condition.

The situation is somewhat different for mobile radars because their height is low. Some of them are used for surveillance while others are for flight guidance. The flight guidance radars are mostly operated near or at the aerodromes. In several cases, a number of mobile radars are installed in close vicinity as shown in Fig. 1. Microwave radiation field was measured on the top of one mobile unit due to the other. On occasions, the operating personnel have to climb on one unit for maintenance work while the other unit is operating. The microwave radiation fields of 10–15 mW/cm^2 have been measured. In the communication units also, microwave radiations were leaking from the coupling joints of microwave transmission lines. The highest microwave power was radiated from the coupling used for changing the direction of microwave power transmission line from the antenna to dummy load and vice versa. Near the coupling, the radiation power density was more than 20 mW/cm^2. At about

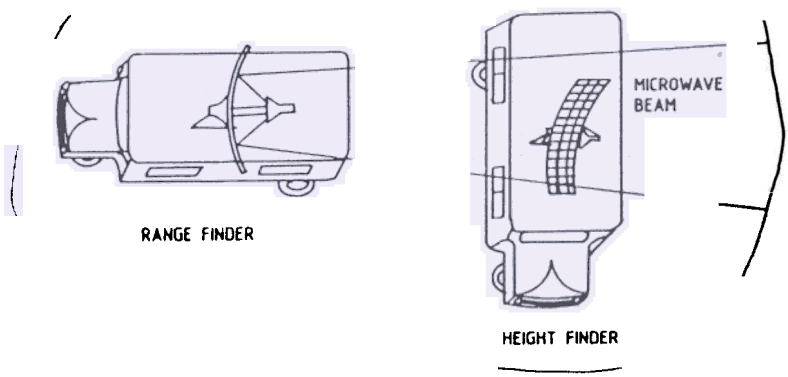

Figure Mobile radar units.

1 m distance the power density reduced to 1 mW/cm . This power density is low, but if someone has to work in this power density continuously for 8 hrs daily, it may reduce the efficiency of the worker.

Survey was also carried out in an industry designing diathermy units. In the diathermy instruments the microwave energy from Klystron or Magnetron is transferred to dipole parabolic antenna through a coaxial cable. The working of the instrument was tested in a small room. During the operation of diathermy instrument, there should not be any microwave radiation at the back side of parabolic reflector.

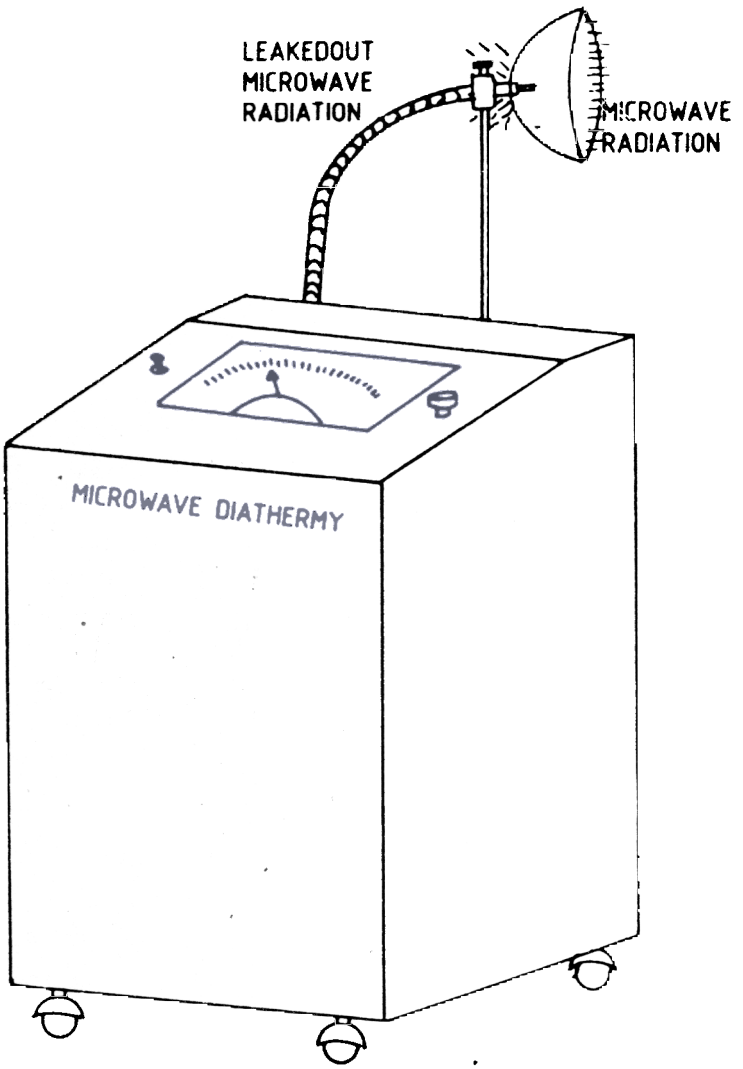

Figure 2. Microwave diathermy unit

However, microwave radiation field of more than 20 mW/cm^2 power density at 2 m distance at the back side of the reflector antenna was observed (Fig. 2). Such an instrument can be harmful to the operator. Instructions were given to change the design of coupling and that of parabolic reflector.

5. CONCLUSIONS

High power microwave generators are increasingly used in India. It is desirable that users should be made aware of the possible microwave radiation hazards. The users should also know the possible sources of microwave radiation leakage during the operation of the system. Users of high power microwave generators are advised, therefore, to get their installations surveyed for microwave radiation levels.

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