Glaser

Cardiac and Neural Effects of Radar Wavelengths

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Summary

This report is a brief review of our experimentation on the cardiac effects of UHF energy. of three experiments are reported, the first two experiments used isolated frog hearts and the used intact frogs. The UHF energy was synchronized with events in the ECG in an attempt to dri heart. Synchronization with the R wave had significant effects.

The gross heating effects of radar wavelength energy at high power density are well understood. Data on these effects form the basis for our present hazard limit.

But ground and airborne personnel are frequently exposed to radar wavelength energy of low power density. The physiological effects of low power densities energy at certain carrier frequencies and modulations have only recently been recognized. This recognition of the physiological effects at low incident powers, e.g. uw/cm^2, has led to the current discussions on revision, downward, of the present hazard limit. In fact, for one application, the hazard limit has already been reduced an order of magnitude.

We have carried out an extensive series of experiments on the neural, behavioral, and to a lesser extent cardiac effects of UHF energy. Today, I will briefly review our experimentation on the cardiac effects.

Our cardiac work began as a result of discussions in the lab of our nervous system data and because of a scattering of reports in the literature that suggested that the heart could be affected by rf energy, possibly via nervous system mediation. These reports include clinical observations such as that of Drogichina, Konchalovskaya, Glotova, Sadchikova, and Snegova and experimental investigations such as those reported by Presman and Levitina; Levitina; Jaff, Deichmann, and Boucek; and Yakovleva. Although, individually, each of the reports can be criticised and in some cases dismissed, the pattern of reports suggest that an effect did occur. They also suggest that the mechanism of the effect is rather complex.

Within the context of our thinking and experience, it seemed likely that by using UHF energy as a stimulus, a band of frequencies that we have found to be a useful stimulus since it penetrates tissue, that we could help clarify the situation. Further, it seemed that if this energy affected the heart directly, then it seemed likely that the effect would appear most clearly when the isolated frog heart was illuminated with low intensity pulsed modulated energy. On a logical basis, the most useful procedure appeared to be synchronization of the UHF energy pulses with certain critical points in the ECG in an attempt to induce a positive feedback condition. In this way, we felt that it might be possible to drive the heart.

The first experiment was designed to yield information on the effect of illuminating the heart at the P wave, at the QRS complex, and at a point between these events.

Twenty-two isolated frog hearts were illuminated with UHF energy pulses that were synchronized with those points in the ECG. The UHF source was set to emit pulses 10 µsec in duration at a carrier frequency of 1.425 GHz (20cm.). Due to the narrow pulse width, the energy was actually contained within a spectrum centered about the cited frequency. Each ECG P wave triggered, sometimes after a set delay, a pulse of UHF energy. Hearts were illuminated at the peak of the P wave, 100 msec after the P wave peak, and at the QRS complex.

Since the isolated heart beats at a slowly decreasing rate of approximately 1 beat/sec and the rate is stable for at least 20 minutes, each heart was used for one session of three periods (250 beats/period). During a session, periods of illumination with UHF energy alternated with periods of no illumination. The experiment was counterbalanced by assigning half of the hearts to the reverse sequence. The moment to moment change [illegible] was [illegible] displayed in histogram form with a Techni[illegible] Corp Computer of A[illegible] Transients, model [illegible]

Two control [illegible] were also included in the experiment. One was intended to answer the [illegible] of whether exposure of the preparation to UHF energy was necessary to obtain the effect. Th[illegible] hearts were used, as in a regular session, but with two layers of Echosorb AN77 (a UHF energy abs[illegible]r) interposed between the antenna and preparation. The other group was intended to answer the ques[illegible] whether the UHF energy could induce currents on the recording electrodes to a degree that would [illegible] the hearts' rate of beating. Though preliminary studies with dead hearts showed that the curr[illegible] induced on the electrodes was negligible, this control was included. Hearts were used as in a regu[illegible] session, but with the UHF energy replaced with electrical pulses placed across the electrodes

A lucite mount, a material which causes minimal distortion of a UHF energy field, was constru[illegible] to hold platinum electrodes. These electrodes were used to support and record from the heart. The electrodes terminated in a teflon insulated subminiature coaxial cable. This cable minimized [illegible] electrical pickup which might have interfered with data processing or possibly influenced the heart The mount was located within a test enclosure constructed of Echosorb AN77. Echosorb is a UHF ener[illegible] absorber which allows simulation of a free field by minimizing UHF energy reflection and field [illegible] To further minimize distortion of the UHF field in the enclosure and the possibility of UHF energy pickup, the portion of the coaxial cable within the enclosure was carefully positioned perpendic[illegible]ar to the direction of the E vector (electrical field strength).

The coaxial cable terminated in a Tektronix model 2A61 low level preamplifier used in con[illegible]ti with a Tektronix model 565 oscilloscope. The entire data processing system and the UHF illum[illegible] system are shown in Fig. 1.

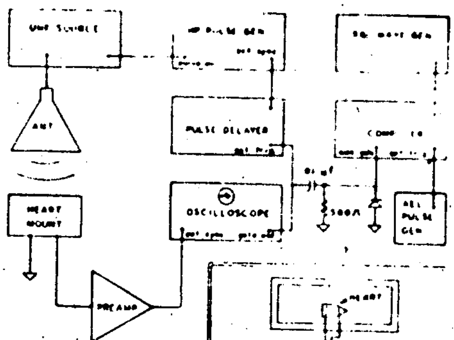

Fig 1. a) Heart mount, b) schematic diagram of data recording and processing system and the UHF illuminating system.

The ECG signal from the heart was amplified by the 2A61 preamplifier. The amplified signal was the inserted into the oscilloscope. The oscilloscope sweep triggering level was adjusted so that trigger[illegible] was synchronized with the peak of the ECG P wave and a sweep was completed just before the next P wav[illegible] occurred. In this way, the P wave was used as a control signal. When the P wave triggered the swee[illegible] a pulse appeared at the oscilloscope "gate out" jack. This was used, after being delayed with a [illegible] odel SD5 stimulator (pulse delayer) and shaping and amplifying with a Hewlett-Packard model 212 pulse enerator, as a control pulse to initiate the emission of a pulse of UHF energy from the UHF source. he UHF source was an Applied Microwave Lab., inc. model PGIK Signal Source with rf head model L2110C-1115. he UHF energy was conveyed via coaxial cable to a gain standard horn antenna. The "gate out" pulse was lso used, after shaping by a differentiator and diode clamp, to advance the computer to the next address.

When a shaped gate pulse arrived at the computer address advance jack, indicating the occurrence of P wave in the ECG, the computer advanced to the next address and began depositing counts there instead in the previous address. At the next P wave, the computer advanced to the next address, and so forth. e number of counts stored in a particular address was proportional to the time between the occurrence of e P wave which moved the memory to that address and the next P wave. Thus, a record of moment to moment ange in heart rate was obtained.

The UHF power density was measured between experimental runs with a quarter wave dipole connected in ries with a Hewlett-Packard model 477B thermister mount and a Hewlett-Packard model 430C power meter. is measuremtn assembly is one of the few that is not grossly inaccurate at UHF. The peak power density d was 60 mw/cm^2. At the rate of one 10 usec pulse/sec, the average power density was negligible, ., 0.6 micowatts/cm^2. Due to the fact that the preparation and even the dipole measuring instrument turb a UHF field, measurements of power density are considered to have order of magnitude accuracy.

When the heart was illuminated 200 msec after the P wave, at the time the QRS complex occurred in experimental situation, the beat rate increased. This increase, using the Wilcoxon test, was found to statistically significant at the .01 level. We also frequently saw skipped beats. In half the cases, hythmias occurred and they were associated with illumination. On occasion, the heart ceased after a iod of arrhythmia. There was no statistically significant effect of illuminating at the P wave or msec after the P wave.

The results of the control session in which the possibility was tested that induced currents on the ctrodes caused the effect, indicate that the effect can not be attributed to induced currents. This sibility was explored even to the point of using, at the same time, voltages 10^2 higher and 10^3 longer the maximum that the UHF energy induced on the electrodes.

The results of the control sessions for determining if illumination with UHF energy is necessary to ce the effect, indicate that illumination is necessary. When echosorb shielding was interposed een antenna and preparation, no effect appeared.

The results of this experiment generated a number of questions. One was what would be the effect of nergy if the heart were left in the animal, using pithing to restrain the frog? What would happen if frog were illuminated at other events in the ECG? For example, ordinary electrical shocks occurring he T wave are particularly effective in causing arrhythmia. What, also, would be the effect of a ge in carrier frequency?

These questions were addressed in the following two experiments in the series. Since, in large part, pparatus and procedures were similar to that used in the first experiment, I shall discuss only the changes in equipment and procedure and report the results.

The second experiment, an isolated heart experiment, was to a great extent a repetition of the first experiment. It differed in that a different carrier frequency, 1.25 GHz, was used. A different heart mount was also used. It consisted of differential recording electrodes projecting from a polystyrene tube which in turn was held by a micromanipulator which was located outside of the Echosorb inclosure. The synchronization apparatus was also slightly modified so that UHF illumination pulses would impinge on the heart at the rise of the R wave or at the rise of the T wave. The appropriate counterbalancing was used. This time there was no apparent effect on the heart when illuminated at the T wave, but there was one when illuminated at the rise of the R wave.

In the third experiment, intact frogs were used. The frogs were pithed and their chests opened. The electrodes at the end of the polystyrene tube were placed in contact with tissue near the heart, or in contact with the heart itself. Since this preparation stayed in good condition over a long period of time, the UHF on and off cycles were extended to 16 minutes. Observations on a heart were extended for more than two hours with additional information gathered such as ECGs.

Illumination was as used in experiment two. In this case, the heart was responsive at the R wave illumination, but the response was one of slowing. This is not surprising in as much as we went from an <u>in vitro</u> to an <u>in vivo</u> situation. Apparently there are complex interactions and the body's buffering systems do have an effect. There was also less heart instability in the R wave illumination condition.

This then is the general picture we have now. We have additional data undergoing analysis which will shed additional light on the mechanism. The only conclusion that can now be reached is that we can not generalize these results to the operational situation. The phenomenon is complex and we have relatively little information as yet.