DTIC FILE COPY

(2)

AD-A197 115

Front Cover

FUNDING NO. DAMD17-85-C-5083

TITLE: Operations and Management of Government Owned - Contractor Operated Microwave Exposure Facility

SUBTITLE: Pulsed Microwave Effects on Rat Blood Pressure and Heart Rate

PRINCIPAL INVESTIGATOR

Clarion E. Johnson, M.D.

PI ADDRESS

ERCT Facilities Service Corporation
3211 Jermantown Rd.
P.O. Box 10107
Fairfax, VA 22030

REPORT DATE

February 28, 1988

TYPE OF REPORT

Final - Volume 2

PREPARED FOR: US ARMY MEDICAL R & D COMMAND
FT. DETRICK
FREDERICK, MD 21701-5012

DISTRIBUTION STATEMENT:

approved for public release; distribution unlimited

SECURITY CLASSIFICATION OF THIS PAGE

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1a. REPORT SECURITY CLASSIFICATION Unclassified	1b. RESTRICTIVE MARKINGS NONE
2a. SECURITY CLASSIFICATION AUTHORITY	3. DISTRIBUTION/AVAILABILITY OF REPORT Approved for public release; distribution unlimited
2b. DECLASSIFICATION/DOWNGRADING SCHEDULE	
4. PERFORMING ORGANIZATION REPORT NUMBER(S)	5. MONITORING ORGANIZATION REPORT NUMBER(S)
6a. NAME OF PERFORMING ORGANIZATION ERCI Facilities Service Corp. 6b. OFFICE SYMBOL (If applicable)	7a. NAME OF MONITORING ORGANIZATION
6c. ADDRESS (City, State, and ZIP Code) 3211 Jermantown Rd. P.O. Box 10107 Fairfax, VA 22030	7b. ADDRESS (City, State, and ZIP Code)
8a. NAME OF FUNDING/SPONSORING ORGANIZATION 8b. OFFICE SYMBOL (If applicable)	9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER DAMD17-85-C-5083
8c. ADDRESS (City, State, and ZIP Code) Fort Detrick Frederick, MD 21701-5012	10. SOURCE OF FUNDING NUMBERS

PROGRAM ELEMENT NO.	PROJECT NO.	TASK NO.	WORK UNIT ACCESSION NO.
62777A	3M1-622 777A878	BB	006

11. TITLE (Include Security Classification)
Operations and Management of Government Owned - Contractor Operated Microwave Exposure Facility

12. PERSONAL AUTHOR(S)
Johnson, Clarion E., Dennis Brown, Howard Bassen, Frank Bates

13a. TYPE OF REPORT	13b. TIME COVERED	14. DATE OF REPORT (Year, Month, Day)	15. PAGE COUNT
Final-Volume 2	FROM 3/1/88 TO 2/1/88	1988 February 28	17

16. SUPPLEMENTARY NOTATION
Subtitle- Pulsed Microwave Effects on Rat Blood Pressure and Heart Rate

17. COSATI CODES

FIELD	GROUP	SUB-GROUP
06	18	
06	02	

18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)

19. ABSTRACT (Continue on reverse if necessary and identify by block number)
Using a specialized waveguide exposure system, the head and neck of 15 Sprague Dawley rats weighing 300-350 grams, were selectively exposed to 1250 MHz pulsed microwaves (400 Kw peak power, 10 microsecond pulse width, 2 watts average power). Blood pressure, heart rate, and temperature were continually recorded. Blood pressure was measured via the rat tail artery. Each animal's baroreceptor reflex (which controls heart rate and blood pressure) was prechallenged with a standardized dose of phenylephrine before and after microwave exposure. Fiber optic temperature probes were placed subcutaneously in the head and into the colon. Spatial-peak SARs were determined in a cadaver. Temporal peak values of 4 Megawatts/kg and 8 MW/kg were measured in the center of the brain and neck, respectively. All animals with one exception, responded to the baroreceptor challenge. One non-responsive animal showed no effect when exposed to microwaves. Statistical analysis of the physiological parameters that were recorded continuously revealed that during the exposure the animals exhibited no statistically significant change in core or head temperature, while

20. DISTRIBUTION/AVAILABILITY OF ABSTRACT ☐ UNCLASSIFIED/UNLIMITED ☒ SAME AS RPT. ☐ DTIC USERS	21. ABSTRACT SECURITY CLASSIFICATION Unclassified
22a. NAME OF RESPONSIBLE INDIVIDUAL Mary Frances Bostian	22b. TELEPHONE (Include Area Code) 301-663-7325 22c. OFFICE SYMBOL SGRD-RMI-S

DD Form 1473, JUN 86 — Previous editions are obsolete. — SECURITY CLASSIFICATION OF THIS PAGE

19. heart rate decreased over 20% ($p=0.0022$). The mean blood pressure remained constant but exhibited a sinusoidal undulation during exposure that was disassociated from heart rate. Cardiovascular parameters returned to normal soon after cessation of exposure. In summary, statistically significant changes were recorded concomitant with microwave exposure. Blood pressure exhibited a heretofore unreported oscillation, disassociated from heart rate. It is possible that this microwave reaction is mediated via baroreceptor cardiodepressor mechanisms.

FOREWORD

Opinions, interpretations, conclusions and recommendations are those of the author and are not necessarily endorsed by the U.S. Army.

___ Where copyrighted material is quoted, permission has been obtained to use such material.

___ Where material from documents designated for limited distribution is quoted, permission has been obtained to use the material.

___ Citations of commercial organizations and trade names in this report do not constitute an official Department of the Army endorsement or approval of the products or services of these organizations.

___ In conducting research using animals, the investigator(s) adhered to the "Guide for the Care and Use of Laboratory Animals," prepared by the Committee on Care and Use of Laboratory Animals of the Institute of Laboratory Animal Resources, National Research Council (NIH Publication No. 86-23, Revised 1985).

___ For the protection of human subjects, the investigator(s) have adhered to policies of applicable Federal Law 45CFR46.

PI Signature Date

TABLE OF CONTENTS

For those exposed inadvertently to microwaves, as well as operators of microwave devices questions frequently arise as to safety. The role of non-heating effects of microwaves to health pose another area of interest. Specifically, the role of low level non-heating effects of pulsed microwaves on heart rate and blood pressure is examined in this report.

1. Statement of the Problem and Rationale

The clinical effects of microwaves are considered under the heading of heating and non-heating. Interpretation of reported findings of non-heating, clinical effects must be viewed with beforehand knowledge that reported entities such as cataracts and sterility (1) are viewed with extreme skepticism by many western scientists (2,3,4). The list of symptoms complained of during low level non-heating microwave exposure (specific absorption rate;SAR) less than 4 watts/kg are grouped under the term, microwave sickness. Headache, fatigue, weakness, irritability and auditory clicking (microwave hearing) (8,9) are described by those exposed to microwave fields. The proposed mechanism of the non-heating effects of microwaves are changes in membrane structure, macromolecule denaturation, and low level thermal effects.

The effects of microwaves on the central nervous system include the already described symptoms, i.e., headache, irritability, etc. The mechanisms ascribed to these symptoms are believed to be caused by hysteria, hyperresponsiveness and cutaneous perception (hyperesthesia). An alternate theory proposed here for central nervous system effects is a subtle resetting of the body's intrinsic pressure monitoring center, the baroreceptors (15). The role of baroreceptor-microwave interaction has not been examined.

The baroreceptors comprise several centers throughout the body. These pressure sensitive sites form the afferent limb of the neurocirculatory center. Baroreceptors are located in the heart, both atria, left ventricle, lung, carotid sinus, aortic arch, and the brain. The latter, termed the neurocirculatory center, is located in the medulla. In a typical example of this neurocirculatory reflex arc at work, a pressure evoked impulse originating in any of these pressure sensors will proceed centrally via the glossopharyngeal and vagus nerves to the medullary vasomotor center. After reaching the vasomotor center, the medulla will send out either sympathetic or parasympathetic discharges in order to adjust the blood pressure either up or down. For instance, low blood pressure elicited sympathetic discharges cause prominent effects on both the arterial and venous systems with decreased venous distension and arterial constriction, and an increase in heart rate combining to elevate blood pressure. The parasympathetic response predominates when an increase in blood pressure occurs, decreasing heart rate, increasing venous distension, and arterial relaxation. This study attempts to selectively look at the role of baroreceptors when exposed to a microwave source.

2. Background

The literature, especially in the field of hypertension, has extensively examined baroreceptor mechanisms. These pressure sensitive receptors are well documented to be abnormal in hypertensives. Exogenous normal baroreceptor function is altered by ethanol, digoxin, water loading, anti-hypertensive medications, certain physiologic maneuvers, and surgical denervation. The integrity of the baroreceptor reflex arc can be tested with the drug phenylephrine. At present, there are no studies on the selective effect of microwave effects on baroreceptor function. Hypothetically, minor alterations in baroreceptor function might explain many of the alleged adverse effects humans complain of when exposed to microwaves (i.e., headache, dizziness). Important in any experiment to test the microwave baroreceptor hypothesis, is separating out the effect of heating. Therefore, this study used low average power pulsed microwaves, with careful monitoring of temperature to limit heating effects and aid the selection of the specific microwave effect (5, 12, 13).

The rodent (rat) provided an excellent baroreceptor reflex model, the integrity of which was easily tested. The literature sites numerous studies with rodents in continuous microwave fields looking at heart rate and blood pressure. However, the hypothesis of this work, that non-heating microwave exposure effects blood pressure, had no precedent in the literature. This experiment was designed to show that baroreceptors undergo non-thermal alteration in a microwave field.

3. Materials and Methods

Wistar rats of weight 300-350 grams were anesthetized with ketamine 35 mg/kg 1M in combination with acepromazine 5 mg/kg 1M intravenously for initial instrumentation. Subsequent to general anesthesia, the rat tail artery was injected with 1% xylocaine. a longitudinal incision of approximately 2.5 cm was made at the base with a scapel. Next, via blunt dissection, both the tail artery and vein were exposed. Following exposure of the vessels, a punctate incision was made to allow for catheter (polyurethane P50 filled with heparin) insertion. The catheter tips were then manipulated to approximately mid-abdominal level, after which both the tail fascia and overlying skin was carefully sutured and bandaged. Awake, the animals were placed in the waveguide system (Diagrams 1, 2) for exposure. The artery was used for blood pressure measurements while the vein was used for phenylephrine infusion. Prior to waveguide exposure, all the animals studied were given 2-4 micrograms of phenylephrine/kg to test baroreceptor integrity measuring heart rate and blood pressure response (11). Specifically before and after microwave exposure, via slow intravenous infusion, we raised the mean arterial pressure 30 mm Hg within 5 minutes. Prior to phenylephrine challenge, while still under anesthesia, for initial instrumentation, RF transparent probes were placed subcutaneously in the head and colon (14). Electrocardiogram (EKGs) recorded arterial pulse from the limbs.

Fifteen animals were exposed to the microwave fields while two functioned as controls. All animals were placed in a custom 1.25 GHz waveguide (WR650) fixture (Diagram 2). The animals were placed in an animal restrainer affixed to the waveguide exposure apparatus. An adjustable RF transparent mount was used to maintain the position of the animal's head and limit movement (Diagram 2). Exposure parameters were 1250 MHz pulsed microwaves, 400 KW peak power, 10 microsecond pulse width, 2 watts average power. No exposure occurred sooner than 30 minutes post phenylephrine baroreceptor challenge. Dosimetry was performed using fiber optic temperature probes. Spatial-peak SARs were determined in a cadaver. Temporal peak values of 4 Megawatts/kg and 8 MW/kg were measured in the center of the brain and neck, respectively.

4. Results

The results of the effects of pulsed microwaves on baroreceptor function are recorded using three parameters. Figures 1 and 2 denote the effect of pulsed microwaves on animal temperature change. Analysis of the animals' baseline and exposure temperature indicate no overall statistically significant change. These temperatures were recorded from probes placed in the head subcutaneously, and in the rectum. Lack of heating was corroborated by statistical significance where $p=2.6$ (Figures 1, 2). Heart rate (Figure 4) shows a statistical decrease due to microwave exposure. Blood pressure (Figure 3) showed no major change. However, during exposure the appearance of sinusoidal blood pressure fluctuation (Figure 5), with heart rate remaining fixed, represented frank blood pressure-heart rate disassociation. Heart rate (Figure 4) showed a significant drop with a p value of 0.0022 noted.

5. Discussion and Conclusion

In summary, using a specialized waveguide exposure system, the head and neck of 15 Sprague Dawley rats weighing 300-350 grams, were selectively exposed to 1250 MHz pulsed microwaves (400 KW peak power, 10 microsecond pulse width, 2 watts average power). Blood pressure, heart rate, and temperature were continually recorded. Blood pressure was measured via the rat tail artery. Each animal's baroreceptor reflex (which controls heart rate and blood pressure) was pre-challenged with a standardized dose of phenylephrine before and after microwave exposure. Fiberoptic temperature probes were placed subcutaneously in the head and colon. All animals with one exception, responded to the baroreceptor challenge. One non-responsive animal showed no effect when exposed to microwaves. Statistical analysis of the physiological parameters that were continuously recorded, revealed that during the exposure, the animals exhibited no statistically significant change in core or head temperature, while heart rate decreased 20% ($p=0.0022$). The mean blood pressure remained constant but exhibited sinusoidal undulation during exposure that was disassociated from heart rate. Cardiovascular parameters returned to normal soon after cessation of exposure. In summary, statistically significant changes were recorded concommitant with microwave exposure. Blood pressure exhibited a heretofore unreported oscillation, disassociated from heart rate. It is possible that this microwave reaction is mediated via baroreceptor mechanisms as a specific cardio-depressor effect.

The relevance of the above findings in rodents when extrapolated to humans, while speculative, is intriguing. The heart rate and blood pressure changes could easily explain the clinical symptomology of light headedness, fatigabiltiy, dizziness and hyperesthesia. However, more study is required. Emphasis on comparisons of pulsed versus continuous microwave sources will have to be performed at the same SAR. Also, the average dose rate and temporal peak SAR should be varied to find the threshold for our findings.

REFERENCES

1. Minecki, L. (1964): "Critical Evaluation of Maximum Permissible Levels of Microwave Radiations", Archiv. za Higijenu Rado. 1 Toksikologiju (Zagreb), 15, 47-55.

2. McRee, D. (1972): "Environmental Aspects of Microwave Radiation", Environ, Health Perspective, 2, 41-53.

3. Letavet, A. A. and Gordon, Z. V. (1960): The Biological Action of Ultrahigh Frequencies, Acad. Med. Sci. U.S.S.R., transl by U.S. Joint Pub. Res. Serv., 12471, 1962.

4. Michaelson, Sol. M. (1980): "Microwave Biological Effects: An Overview", Proceedings of the IEEE, Vol. 68, No. 1, 40-49.

5. Longheust, J.C. (1984): "Cardiac Receptors, Their Function in Health and Disease", Pioneering in Cardiovascular Disease, 279, (3), P201-222.

6. Lin, J.C., (1978): "Microwave Auditory Effects and Applications", Springfield, IL: Charles C. Thomas.

7. Frey, A. H. and Messenger, Jr., R., (1973): "Human Perception of Illumination with Pulsed Ultra-High Frequency Electromagnetic Energy", Science, Vol. 181, 356-358.

8. Guy, A. W., Chou, C. K., Lin, J. C., and Christensen, D., (1975): "Microwave-Induced Acoustic Effects in Mammalian Auditory Systems and Physcial Materials", Ann. N.Y. Acad. Sci., Vol 247, 194-218.

9. Lin, J. C., (1981): "The Microwave Hearing Effect" Biological Effects of Nonionizing Radiation, K. H. Illinger, Ed., Amer Chem. Soc., 317-330.

10. Chou, C. K., Guy, A. W., and Glambos, R. (1977): "Characteristics of Microwave Induced Cochlear Microphonics" Radio Sci., Vol. 12, 221s-228s.

11. Lydin, A. Y., Ricksten, S., and Thoren, P., (1984): "Interaction Between 'Mental Stress' and Baroreceptor Reflex Concerining Effects on Heart Rate, Mean Arterial Pressure and Renal Sympathetic Activity in Conscious Spontaneously Hypertensive Rats", Acta-Physiol-Second, Feb 120 (2), 273-281.

12. Hamick, P. E., and McRee, D., (1980): "The Effect of 2450 MHz Microwave Irradiation on the Heart Rate of Embryonic Quail", Health Physics, Vol. 38, 261-268.

13. Kaplan, I. T., et al. (1971): "Absence of Heart Rate Effect in Rabbits During Low Level Microwave Irradiation" IEEE Trans. Microwave Theory Tech., Vol. 19, 168-173.

14. Bassen, H. I., and Smith, G. S., (1983): "Electric Field Probes-A Review", IEEE Transaction on Antenna and Propagation, Vol. AR31, No. 5, September.

15. Morphology of Rat Carotid Sinus Nerve 1, Course Connections Dimension and Ultra Structure, McDonald, DM Necrocytology 12 (3).

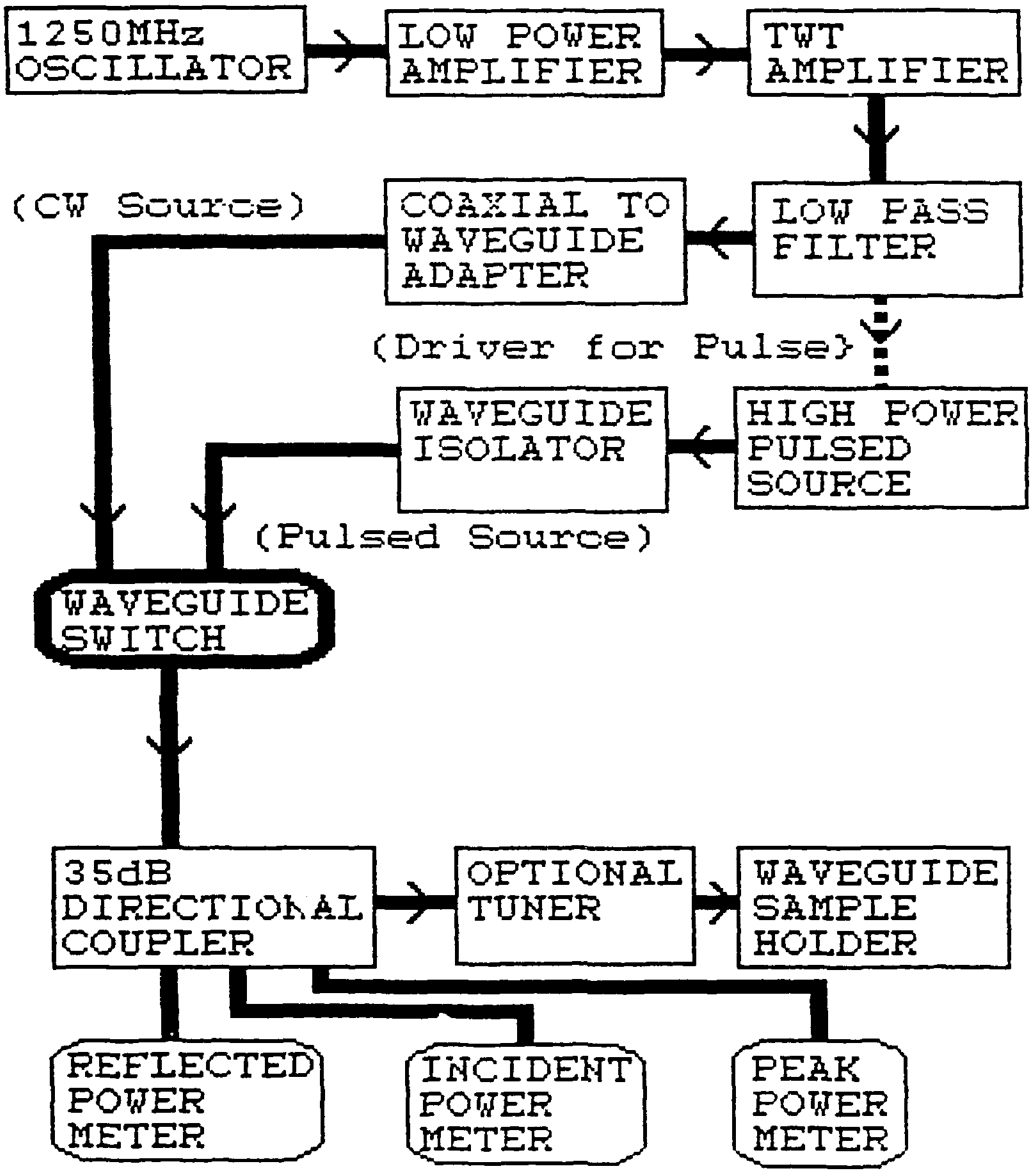

Diagram 1:Exposure system in block form.

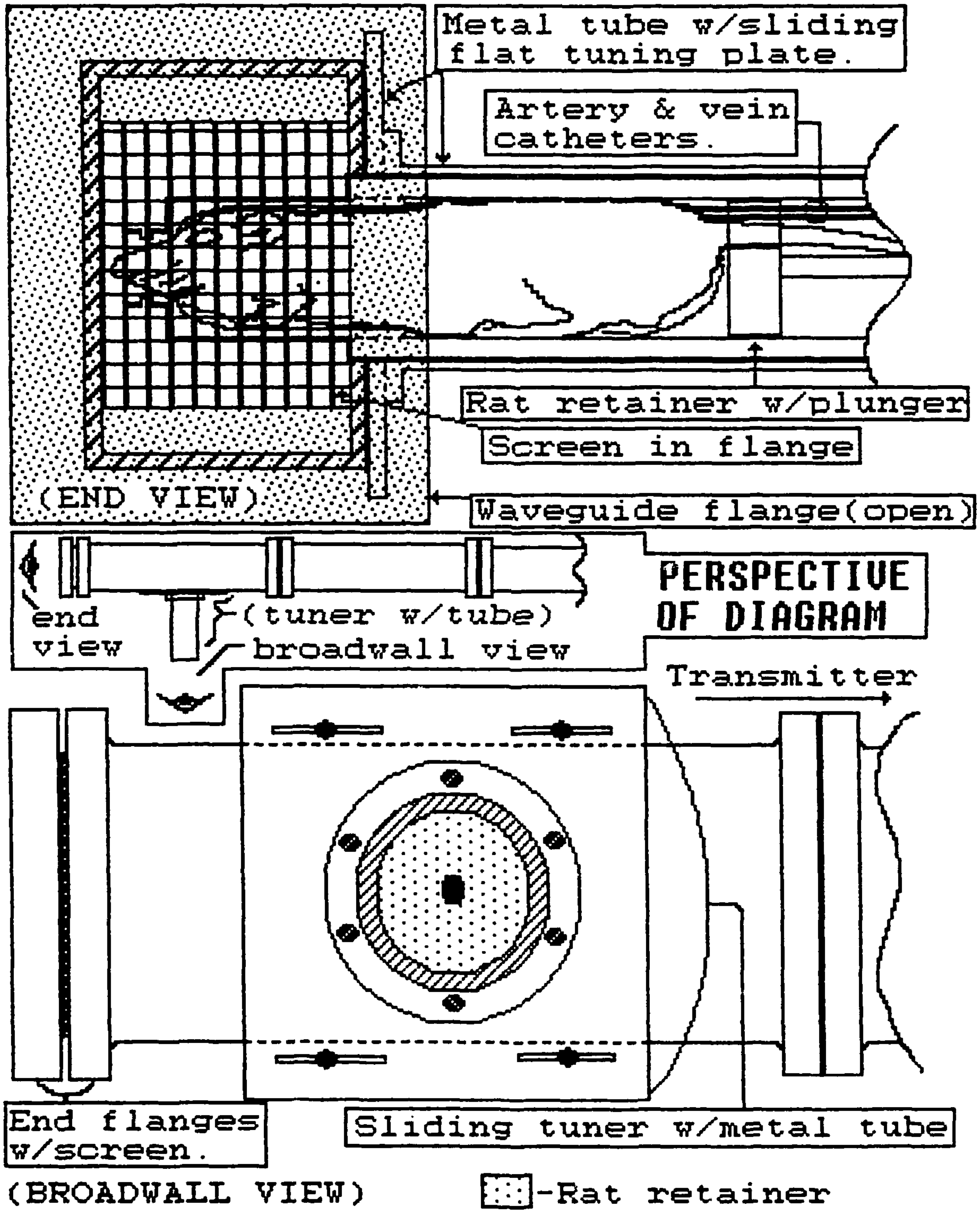

Diagram 2 -modified WR650 waveguide.

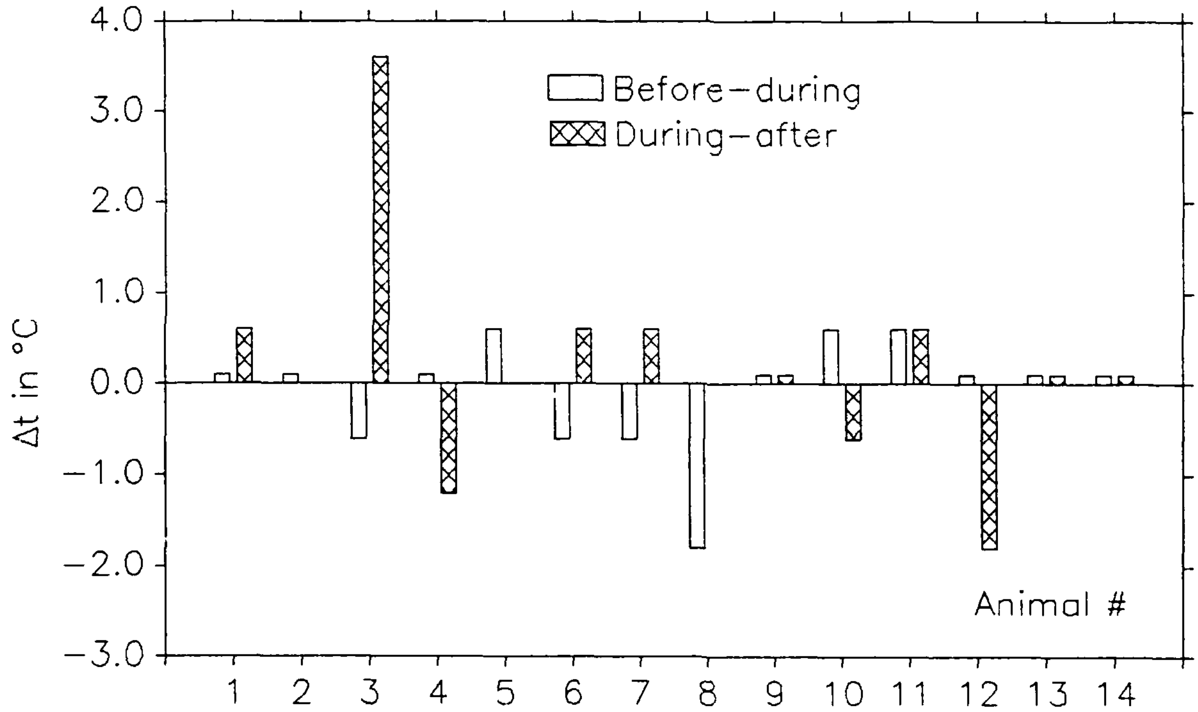

Fig.1, Subcutaneous head temperature difference before, during & after microwave exposure.

N	MEAN	MEDIAN	TRMEAN	STDEV	SEMEAN
39	31.855	31.750	31.931	2.789	0.447
	MIN	MAX	Q1	Q3	
	26.100	36.400	29.900	33.900	

STATISTICAL EVALUATION OF SUBCUTANEOUS HEAD TEMPERATURE DIFFERENCE DURING MICROWAVE EXPOSURE.

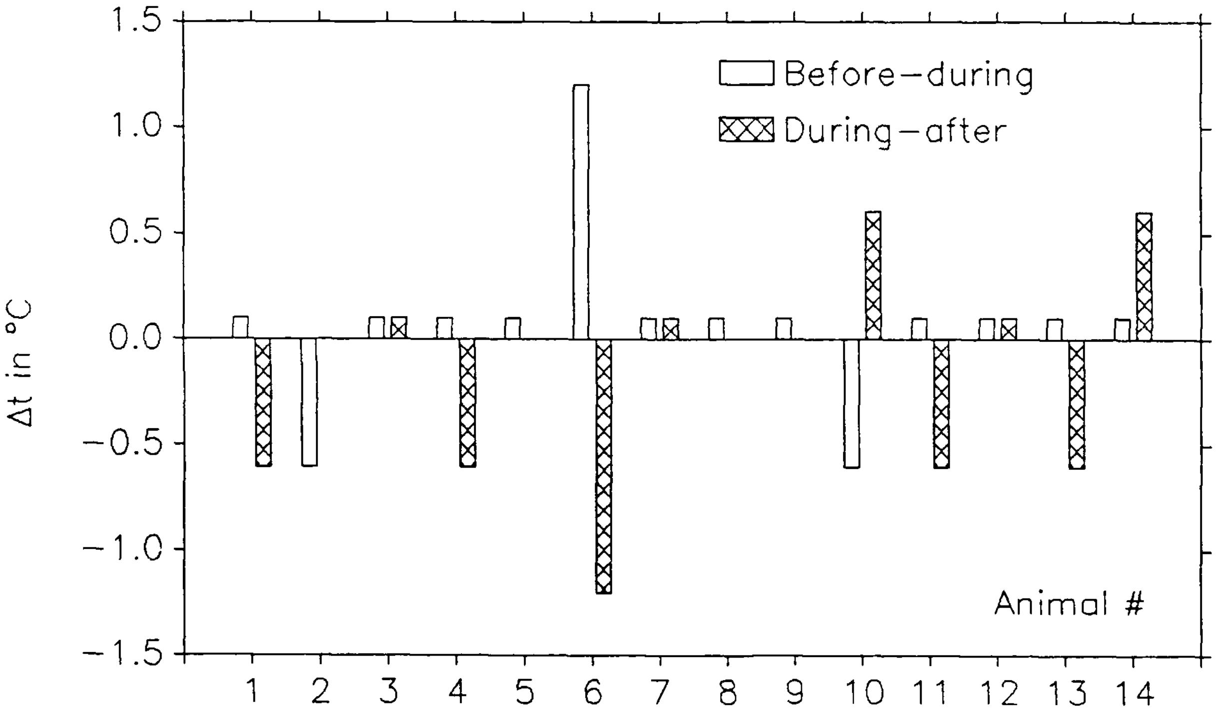

Fig.2, Colon temperature difference before, during & after microwave exposure.

N	MEAN	MEDIAN	TRMEAN	STDEV	SEMEAN
39	33.246	33.600	33.176	2.696	0.432

MIN	MAX	Q1	Q3
29.000	38.300	30.300	35.500

STATISTICAL EVALUATION OF COLON TEMPERATURE DURING MICROWAVE EXPOSURE.

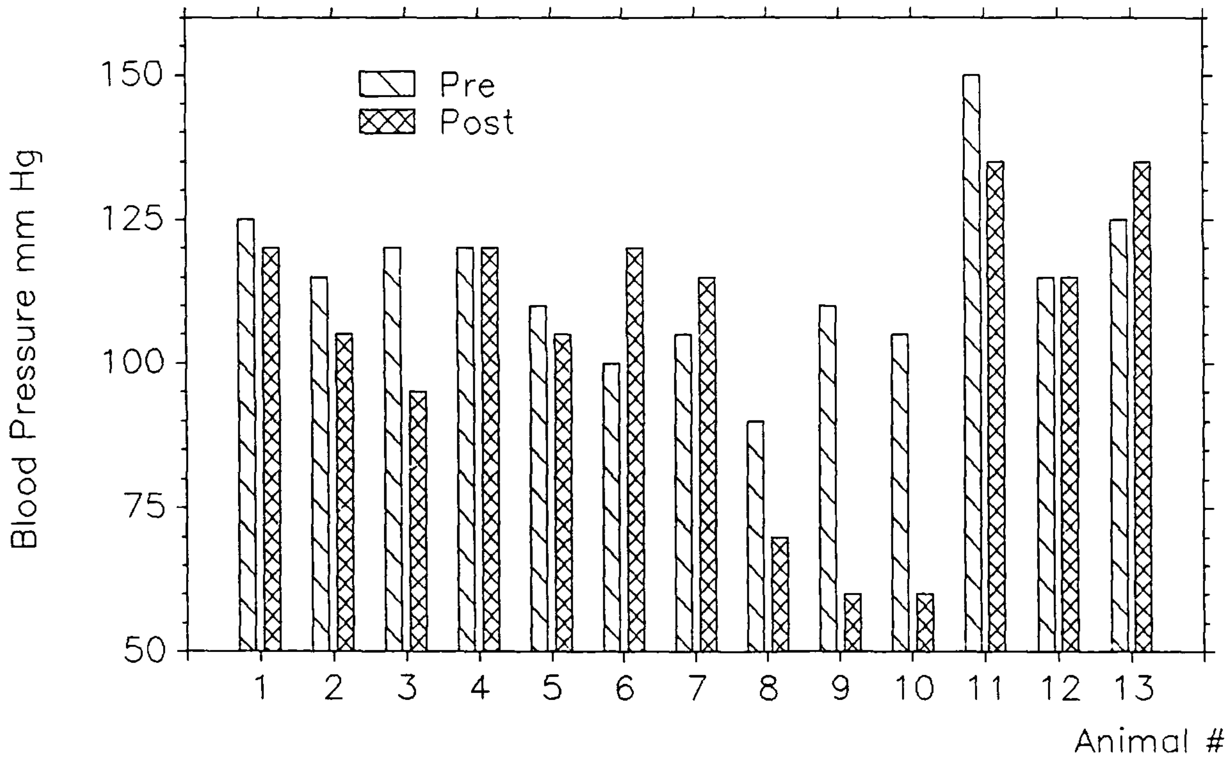

Fig.3, Blood Pressure, Pre & Post Microwave Exposure.

N	MEAN	STDEV	SEMEAN	T	PVALUE
13	-10.62	19.91	5.52	-1.92	0.079

STATISTICAL EVALUATION OF BLOOD PRESSURE DURING MICROWAVE EXPOSURE.

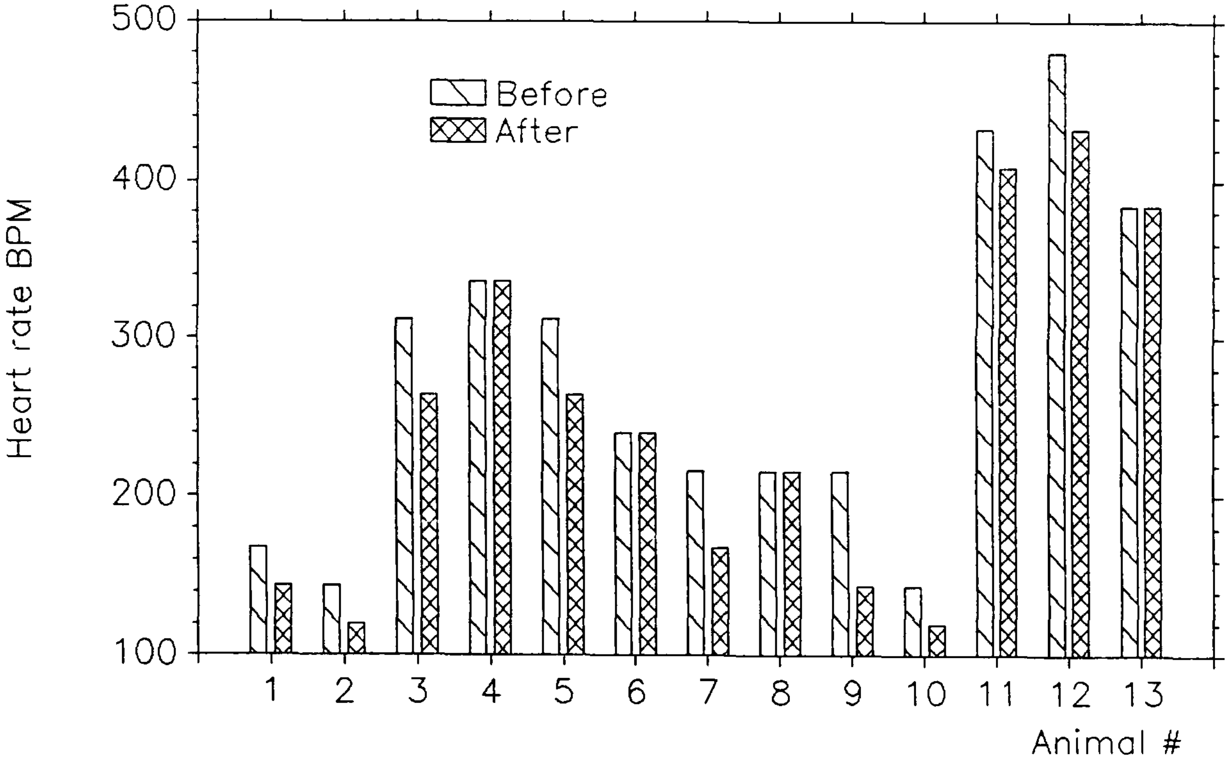

Fig.4, Heart rate before & after Microwave Exposure.

N	MEAN	STDEV	SEMEAN	T	PVALUE
13	-27.96	26.08	7.23	-3.87	0.0022

STATISTICAL EVALUATION OF HEART RATE
DURING MICROWAVE EXPOSURE.