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**HAZARDS ASSOCIATED WITH THE OPERATION OF
MICROWAVE OVENS**

James D. Wallace

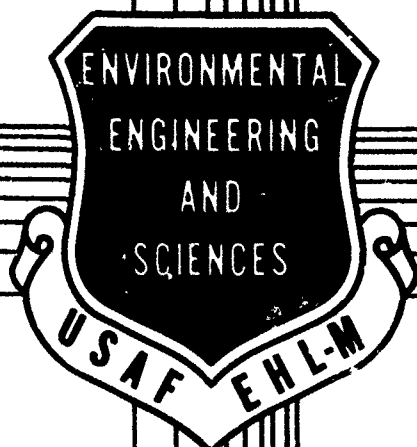
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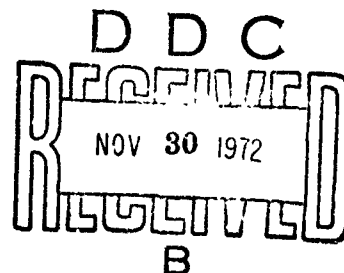
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James D. Wallace, Captain, USAF, BSC

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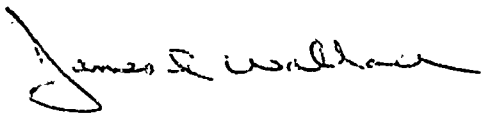
USAF ENVIRONMENTAL HEALTH LABORATORY
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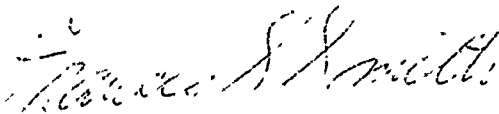
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It was concluded that there is very little hazard associated with the normal operation of these ovens, even though some leakage may occur. Periodic surveys of these ovens are necessary to determine if interlocks have failed or have been "jumped" (overridden), and if significant leakage is occurring. Recommendations are made for survey procedures and equipment to be used. Levels of microwave radiation leakage which require corrective action are presented.

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APPENDIX

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II	Ltr, Hq AFLC (MCDPE) to All AFLC Bases, 16 July 68, Subject: Microwave Ovens
III	Survey Equipment and Description Empire Power Density Meter, Model NF-157 Probes, Model NF-157, Power Density Meter Ramcor Power Density Meter Microlite (Probe) 287 Fluorescent Bulb
IV	Survey Procedures

SECTION I

INTRODUCTION AND PURPOSE

In letter from Hq USAF (AFMSPAP) to all commands, dated 11 July 1968, subject: "Microwave Ovens" (See Appendix I), it was pointed out that certain reports have indicated that excessive amounts of microwave radiation may be emitted from microwave ovens. These reports indicate that this situation is brought about by malfunctioning interlock switches, poorly installed seals, or misaligned doors.

Commands were requested to forward consolidated listings of bases not having the capability to survey these ovens to Hq AFLC (MCDPE). AFLC then was to arrange for the survey of these ovens (See Appendix II).

Field guidance is needed as to appropriate survey equipment, procedures, and periodicity of surveys. The magnitude of the hazard associated with the operation of microwave ovens at USAF bases needs to be defined so the above guidance could be given. It is the purpose of this study to fulfill these requirements.

SECTION II

REVIEW OF LITERATURE AND DISCUSSION

A. Near and far-field Regions: Microwave radiations fall within the spectrum of electromagnetic radiation. Generally they encompass the range of frequencies of from 300 to 3×10^5 megahertz (MHz), wavelengths of 1.0 meter and 0.1 cm respectively. The UHF, SHF, and EHF bands of the Hertzian or radio frequencies are contained in this range. These frequencies include radio, television, and commercial and military radar bands. Also, frequencies designated for medical diathermy treatment and those used in microwave ovens are in this range.

1. Near-field: In close proximity to the radiator or source of radiation such as an area of leakage from a microwave oven, a near field region exists which is similar to fresnel region (See T.O. 31Z-10-4 for description, Ref 1). In a paper entitled "Near Field Radiated Emission Characteristics" the following observation was made:

"The near-field and far-field regions for an antenna or radiating element are difficult to define because there are no discrete dividing lines between the regions. The definition is further complicated by the fact that different criteria are used to define the dividing line between the regions. In one case, the dividing line is based on the ratio between

"induction" or "reactive" energy and propagated energy, in another case the dividing line is based on the degree of phase shift in the wave front, and in still another case, the dividing line is based on the degree of amplitude variation in the wave front. While each of these criteria has some significance in terms of measurement accuracy, the criteria do not, in the general case, establish a unique dividing line between the near-field and the far-field regions of an electromagnetic radiator" (Ref 20).

An example of this is the difference between the guidelines for defining these regions as presented in the above paper and in T.O. 31Z-10-4, "Electromagnetic Radiation Hazards", dated 1 August 1966, and are respectively:

Near-field	Fresnel Region	Far-field
(1) $0 \leq D \leq \frac{\lambda}{2\pi}$	$0 \leq D \leq 2 \frac{L_b^2}{\lambda}$	$D \geq 2 \frac{L_b^2}{\lambda}$
(2) $0 \leq D \leq \frac{L_a^2}{\lambda 4}$	$0 \leq D \leq \frac{L_a^2}{\lambda 4}$	$D \geq \frac{L_a^2}{\lambda 4}$

Where: D= the distance from the antenna in feet.

L_a = the antenna aperture, in feet.

L_b = the largest linear dimension of the source or test antenna aperture, whichever is larger.

λ = wavelength in feet.

In the near-field region description (1) above or in the very near field description (2) also above, a substantial part of the energy is in the form of "inductive" or "reactive" energy (Ref 20). These electrostatic and magnetic energies oscillate back and forth between the radiator and the surrounding space (Ref 20). The intensity of the electrostatic field varies as the inverse of D^3 where the magnetic field varies as the inverse of D^2 . For a short dipole source the field strength changes at a rate of 18dB per octave of distance. For this source, for distances greater than $\lambda/2\pi$ the field changes at a rate of 6dB per octave of distance (Ref 20). Therefore at distances less than $\lambda/2\pi$ the fields are predominately reactive or inductive, and at distances greater than $\lambda/2\pi$, the fields will be predominately propagated (Ref 20). When some element such as a horn or a human appendage is placed in these regions any one of a number of situations may arise, some of which have been described by Crapuchehas (Ref 21):

1. The element may act as a tuning element causing the slot or leakage area to transmit in ways it does not transmit in the absence of the element.

2. The element may act as a reactance in space and the field is "coupled" to the element.

3. The element and the horn being reflectors may become boundaries for a resonator system or resonant cavity.

It has been postulated that the effects of these errors to measurement may be a factor of ± 10 in the power density measured (Ref 21).

Horns for use in far-field are characteristically tightly coupled to the field, i. e., they intercept the greater percentage of the energy of the field in which they are inserted. This is necessary to give high sensitivity for in the far field the energy is low. The opposite is true in the near field. The horn or device used to intercept these fields would have to be a "point" probe that would not perturb the field devices but some of the mathematics for such a device have been developed (Ref 21).

In the Fresnel region, description # (1), or the latter portions of the near or fresnel region, description # (?) the criterion is based on the phase characteristics of the incident wave front. In this region the wave front will be a portion of a spherical surface having some finite curvature. As the wave front is received at the center of the antenna, the outermost portions are still some distance from the aperture, i. e., the signal received at the end of the antenna will have a phase lag relative to the signal received at the center of the antenna. For most applications the magnitude of this error is considered to be acceptable if this phase variation is 22.5 degrees or less across the aperture of an antenna. This results in a gain error of approximately less than 0.1dB and a negligible change in pattern shape. This occurs when D is $\geq 2 L^2 / \lambda$, description # (1). Therefore, in this region the gain, effective aperture, and pattern of an antenna are functions of the distance from the source. All antenna parameters are specified in terms of a uniform plane wave, one having exactly the same phase and exactly the same magnitude (Ref 21). The energy from complex waves cannot be specified in any simple way.

2. Far-field: In the far-field regions there are no contributions from the "reactive" fields surrounding the source and no significant phase variation in the wave front. Therefore, in this region the gain, effective aperture, and pattern of the test antenna are independent of the

distance from the source. It is within this region, at distances greater than $2 L^2 / \lambda$ from the source, that the inverse square law implies in free space. In areas where the propagated wave may be reflected off surfaces, not in free space, the field intensity may be enhanced or diminished. This reflection is associated with dimensional resonance phenomena where the field amplitude build up because the dimensions are such that successive reflections from walls or boundaries just overlay one another properly in space and time. This may occur in the near or Fresnel region or in the far-field. For the Ramcor 1200 with S band horn the far field would begin at approximately 6" from the oven surface. Because the dimensions of the areas of leakage are small, the greatest dimension of the effective horn aperture were used to determine where the far-field region begins.

B. Criteria: The criteria for evaluation of exposures to far-field microwave radiation is set forth in AFM 161-7, "Control of Hazards to Health from Microwave Radiation", dated December 1965. According to field strength (power density, mw/cm²), three conditions may exist:

<u>Condition</u>	<u>Field Strength (mw/cm²)</u>	<u>Area Designation</u>
safe	≤ 10.0	continuous occupancy
potentially hazardous	$> 10 \leq 100$	limited occupancy
hazardous	> 100	denied occupancy

The "Maximum Permissible Power Density" for continuous exposure is then defined as 10 mw/cm². For "limited occupancy areas", accessible areas in which the incident power density is in excess of 10 mw/cm² but less than or equal to 100 mw/cm² (Ref. 7), the following equation may be used to determine the permissible exposure time T_p (units are minutes/hour in any one-hour period) irrespective of the frequency involved:

$$T_p = \frac{6000}{W^2}$$

Where: W = power density in exposure area expressed in mw/cm². This equation is applicable when power density is $> 10 \text{ mw/cm}^2 \leq 100$. Therefore, any realistic evaluation of hazards associated with operation of microwave ovens must include the incident power and the exposure period.

C. Test Equipment: Several basic types of test equipment are being used to detect and quantitate microwave radiations in the far-field. A few of these are calibrated wave meters (frequency meters), power meters,

field strength meters, test antennas, and test lights. For a basic discussion of these instruments, see Appendix III.

D. Biological Effects: Biological effects of exposure to microwave radiation in the far-field have been described elsewhere (Ref. 3, 4, 5, 6, 7, and 23). The primary response is an overall rise in temperature of the exposed tissue or organ. Microwave ovens utilize this biological response of energy absorption and conversion to thermal energy in the preparation of foodstuffs. Microwave ovens for cooking foodstuffs operate at 2450 MHz; for thawing food, they operate at 915 MHz. The eyes are most susceptible to the 3000 MHz frequency (Ref. 8). Between 1000 and 3000 MHz, absorption in the deeper body tissues tend to diminish, depending on skin thickness, the total mass of body, thickness of fatty layer, and the frequency of the energy (Ref. 9). Little information is available as to the biological effect of exposure to the near-field radiations.

E. Results of Other Surveys:

1. Results: Results of surveys of leakage radiation from microwave ovens are shown in the following, Tables I-VI, to show the leakages that have been found by others (Ref. 8, 9, 14, 15, 16 & 17). The extent of these leakages should indicate the magnitude of the hazard involved in operating these ovens.

TABLE Ia

SUMMARY OF RELEASED MICROWAVE INTENSITIES

	Hinged Door	Vertical Sliding Door
Number of ovens monitored	58	18
Number leaking	48	6
Percent emitting $< 1 \text{ mw/cm}^2$	17%	67%
Percent emitting $1-10 \text{ mw/cm}^2$	40%	33%
Percent emitting $> 10 \text{ mw/cm}^2$	43%	0%

Rentos, P. G., "Microwave Oven Survey - A Composite Report,"
Public Health Service Occupational Health Program, Occupational
Health Field Station, Salt Lake City, Utah, 1968.

TABLE Ib

SUMMARY OF RELEASED INTENSITIES - ALL UNITS MONITORED

	Hinged Door	Vertical Sliding Door
Number of ovens monitored	93	25
Number emitting $> 10 \text{ mw/cm}^2$	27	1
Percent emitting $> 10 \text{ mw/cm}^2$	29%	4%

(Amendment to Report by Rentos, 1968)

TABLE II

SUMMARY OF RELEASED MICROWAVE INTENSITIES
DENVER AREA

	Hinged Door	Vertical Sliding Door
Number of ovens monitored	17	2
Number leaking	12	1
Percent emitting < 1 mw/cm ²	29%	50%
Percent emitting 1-10 mw/cm ²	29%	50%
Percent emitting > 10 mw/cm ²	41%	0

Personal correspondence, Lt McElwey, Lowry AFB, Colorado

TABLE III

SUMMARY OF RELEASED MICROWAVE INTENSITIES

	Number Units
Number monitored	42
Number leaking > 10 mw/cm ² (maximum distance 12")	15

Personal correspondence, Captain Conrad, Patrick AFB.

TABLE IVa
MICROWAVE INTENSITIES EMITTED FROM CLOSED OVENS
(Milliwatts/sq. cm)

Oven Description	Location of Measurements			
	Face of Door	Periphery of Door		
		Left Side	Top	Right Side
Bottom-hinged door	2	2	0	2
open grill front	8	4	0	4
mechanical lock	2	12	0	4
1 generating tube	3	9	0	0
	0	2	0	2
	0	2	0	2
	1	0	0	1
Bottom-hinged door	0	10	0	0
open grill, mechanical	0	6	10	5
lock, 2 generating	3	0	0	0
tubes	2	4	0	2
	3	10	2	0
	1	0	0	3
Vertical sliding	0	0	0	0
door, open grill	0	0	0	0
1 generating tube	0	0	0	0
	2	0	0	0
	0	6	0	4
	1	0	0	0
Vertical sliding				
door, open grill	0	0	0	0
2 generating tubes				
Side-hinged solid	0	2	0	1
panel door, mechanical	6	0	6	2
lock, 1 generating	1	2	4	4
tube				
Bottom-hinged door	0	0	0	0
open grill, magnetic				
lock				

Surovec, H. J., "Microwave Oven Radiation Hazards in Food-Vending Establishments," Archives Environmental Health (March 1967), Vol. 14

TABLE IVb

SUMMARY OF RELEASED RADIATION INTENSITIES OF
MONITORED OVENS

	Bottom-Hinged Door	Vertical Sliding Door	Side-Hinged Door
Maximum level detected (milliwatts/sq cm)	12	6	6
Average levels detected (milliwatts/sq cm)	2.4	0.5	2.3
% emitting 10 or more milliwatts/sq cm	28	0	0
% emitting 1 or more milliwatts/sq cm	93	43	100

Suroviec, H. J., "Microwave Oven Radiation Hazards in Food-Vending Establishments, Archives Environmental Health, Vol. 14, March 1967.

TABLE V

MICROWAVE LEAKAGES ASSOCIATED WITH THE OPERATION
OF VARIOUS MICROWAVE OVENS

Oven Number	Location of Leakages	Load	Power Density* Milliwatts Per Square Centimeter (mw/cm ²)	Remarks
1	Front	Dummy	5.0	Only one magnetron functioning. Door shims worn. Can crack door open without unit shutting off. With power switch on, warning light on at all times. Light becomes brighter when cooking commences.
	Side	Dummy	5.0	
2	Right Front	Dummy	10.0	
3	None	Dummy	0.0	
4	Front	Dummy	0.5	
5	Front	Dummy	5.0 20.0	
6	Front	Dummy	5.0	
	Side	Dummy	7.0	
7	None	Dummy	0.0	
8	Front	Roast	1.0	Worn door shims prevented immediate activation of safety shut off.
	Side	Roast	0.25	
9	Front Side/Door Ajar	Sandwich	5.0	

Breyse, P. A. "Microwave Cookers", Occupational Health Bulletin, Vol. 21, No. 10, 1966.

TABLE VI
SUMMARY OF SURVEYS BY US ARMY

Survey Number	Number Ovens Surveyed	Number Leaking	Number Leaking	
			≥ 10	≥ 20
1	28	22	6	2
2	32	25	6	4

Survey No. 1 Taylor, 68.

Survey No. 2 Taylor, 67.

2. Critique of Results: The percentage of ovens with leakage (Tables Ia and b, II and IV) was: vertical sliding about 12 percent; hinged door, 29.6 percent. The majority of ovens shown in Tables I-V were not new and were located in public facilities receiving high usage. Therefore, oven construction is a critical factor as to leakage; and for ovens with higher usage, a greater probability exists that leakages would occur. The age of these ovens and their high usage tends to explain the high percentage of ovens that had leakages. Maintenance of these ovens was on contract basis. Rose, et al, (Ref 13) measured energy levels at a distance of 18 inches from the magnetron (high power tube) of a microwave oven, averaging 22 mw/cm² at his abdomen. They concluded that "Data available do not confirm the probability but do prove that adequate protection can be afforded the worker by use of a simple, inexpensive device to intercept and absorb the microwave energy. The device is a wooden frame covered with copper mesh screening which is placed on the oven to shield the worker from the microwave energy to levels less than 5 mw/cm²."

For surveys, Tables II, III, and V, the oven to survey instrument distance was not shown. This distance was from 2-3 inches for survey, Table IVa and b, and at the surface of the oven for Tables Ia, Ib, and VI. In surveys, Tables II, IV, V, and VI, dummy loads were used simulating operating conditions. This was not established for surveys, Tables Ia and b, and II. Survey instrument used in Tables Ia and b, and Table VI was the Ramcor 1200, and in Table V the Empire NF 157. Instrument used was not established for Tables II and III. As previously discussed, the distance from the oven at which leakage (power densities) are measured affects the reliability of the measurements; this distance should be at least 6 inches if the measurements are to be reliable.

It can be concluded from the preceding tables that leakages from microwave ovens do occur. As previously presented (See Section I, this report), the causes for these leakages are varied. In general, the authors (Ref. 8, 9, 14, 16-18) did conclude that these ovens represent a potential hazard.

SECTION III

SCOPE OF SURVEY

Surveys of 19 microwave ovens being operated at 12 Air Force installations were accomplished. The amount of microwave radiation leakage from these ovens and physical cause of leakage, when possible, along with the condition of the interlocks was determined. Survey procedures for these determinations were those shown in Appendix IV. Survey instruments were the Empire instruments, Models 157, Serial Nos. 181 and 195, calibrated 12 July 1968 and microlite (Probe) 287.

Determinations of the magnitude of hazard of operating these ovens when interlocks malfunction were also made. For these determinations, an oven of the sliding door type was brought into the laboratory and operated with interlocks "jumped", door opened, and dummy load inside the oven. The size of the beam and the power densities of the microwave field at various positions around the oven were determined. Ionization radiation was measured with a RF shielded Victoreen 440, survey instrument, Serial No. 306, calibrated 26 September 1968.

SECTION IV

SURVEY RESULTS

The results of field surveys of microwave ovens are shown in Table VII. Results of investigations in laboratory are shown in Table VIII. The locations of measurement are seen in Figure 1.

In the field surveys, Table VII, the energy escaping was found to be directional giving a narrow beam, usually parallel to the plane of the door for ovens with hinged doors.

In the laboratory investigation with the oven door open, the energy escaping is directional, but the beam is extensive, extending to all sides of the oven, 180° from center front of oven. With the oven door closed and no dummy load in the oven, only one area of leakage was detected; 1/4 inch length of tube glow with the microlite, and 0.2 mw/cm^2 with the Empire 157. With dummy load, glass half full of water only a needle deflection was seen, using the Empire 157 survey instrument. No response was registered by the microlite 287. The operating procedure for these ovens is to place food inside the oven which is normally located on counters. The oven is activated for a pre-set period of time, and during this operation the operator can be in another area. The

TABLE VII

SUMMARY OF RESULTS OF SURVEYS
AT AIR FORCE INSTALLATIONS

	Side Hinged Door	Vertical Sliding Door
Number of ovens monitored	9	10
Number leaking	6	3
Percent emitting $> 1 \text{ mw/cm}^2$	0%	0%
Percent with malfunctioning interlocks	0%	0%

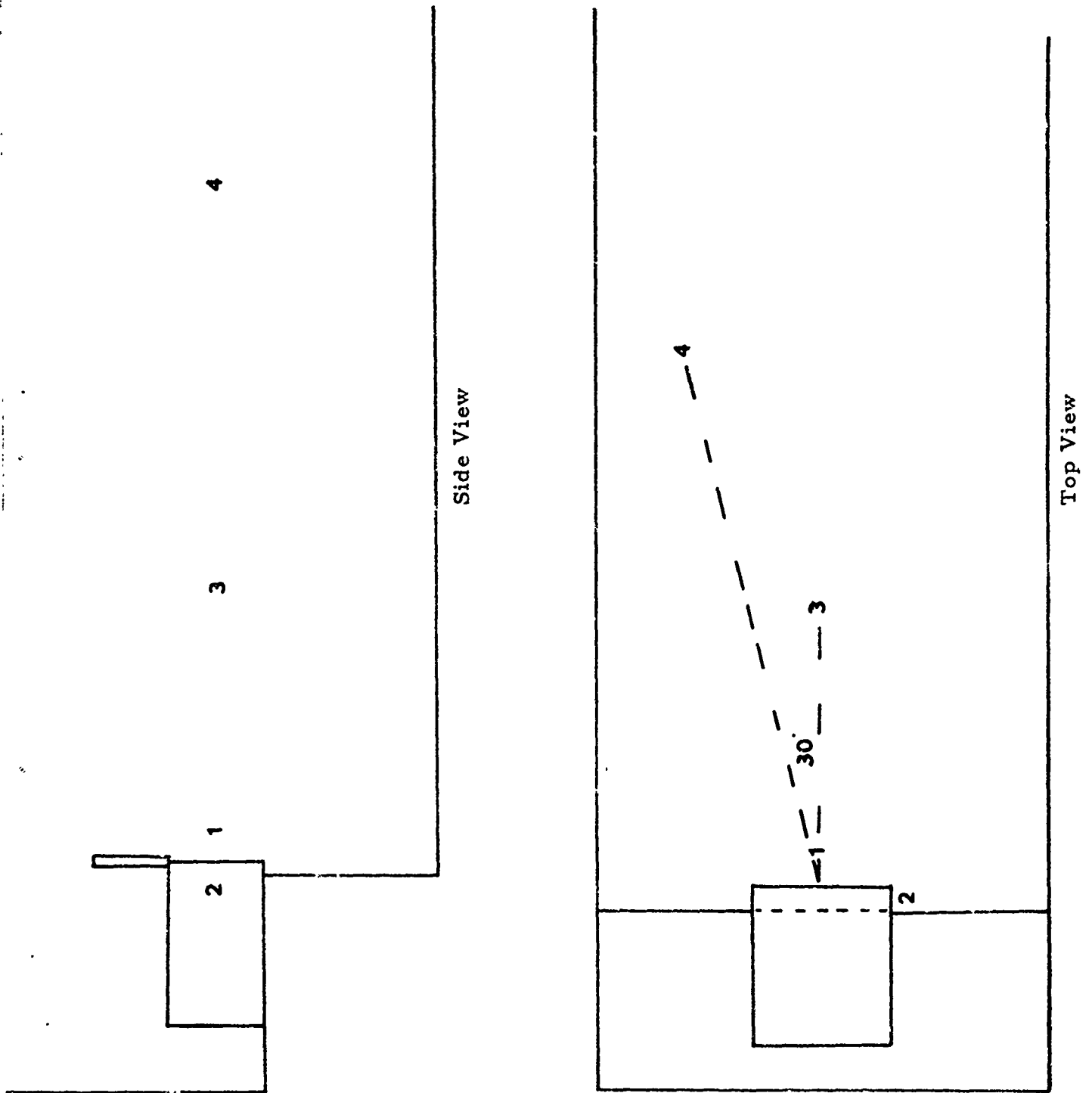
TABLE VIII

MICROWAVE FIELD FROM AN OVEN, DOOR OPEN

Location	Microlite	Empire 157	Ramcor 1200	Distance
1	full glow	150 mw/cm^2	* --	0'-8"
2	full glow	50 mw/cm^2	* --	0'-2"
3	full glow	10 mw/cm^2	2 mw/cm^2	5'-1"
4	flashing glow	2 mw/cm^2	* --	14'-0"

* Limit of instrument, 20.0 mw/cm^2

Figure 1
Location of Survey Points



operation time period is for several seconds to a few minutes and operation is by more than one person or on self-service basis. These short operating periods and intermittent operation by any one operator result in short individual exposure. It is possible for the operator to place his face or other parts of his body in close proximity of the oven. Probes have not been developed to measure the radiation within these near or Fresnel regions. Neither are there any guidance or criteria with which to evaluate this potential hazard and until such guidance is available and instruments are developed to measure these radiations, these exposures should be minimized (Ref 22). To the most probably susceptible organs, the eyes and gonads, these exposures should be prohibited.

Surface readings of ionizing radiation at the air intake and outlet of oven, front and back respectively, showed 0.1 mr/hr.

SECTION V

DISCUSSIONS OF RESULTS & CONCLUSIONS

Two types of ovens are being operated on USAF installations. These are the hinged or the vertical sliding door, both operating at 2450 MHz. All models were relatively new. Measured leakage, consisted of narrow directional beams, always less than 1.0 mw/cm^2 at the surface of the ovens, using the NF 157 survey meter. Leakage was not detected six inches from the surface of the ovens. Note, that in using the NF 157 or Ramcor power density meters to measure leakage from slots or small areas the intensity of beam has been integrated, averaged, over the effective aperture of the antenna. Therefore, these instruments are not ideally suited for measuring the power density of beams of smaller cross sectional area than the effective aperture of their horn. But a conservative estimate of the actual power density within these small areas would be the measured power density times the ratio of the effective aperture of the horn to the cross sectional area of the leakage. Since no measurement was recorded at more than six inches from the oven surface this would not effect the results of our measurements. Therefore, the probability of a hazardous exposure to microwave radiation occurring during the normal operation (operation of ovens with interlocks not "jumped" and not damaged) of microwave ovens is remote. Likewise, there is no hazard from ionizing radiation.

The microlite-287 has proven adequate as a survey instrument for microwave ovens. Microwave energy can be detected and field pattern can be explored, using this probe. The response of this probe at other frequencies is being investigated and will be reported later, but the probe does seem to have application for detecting microwave energies

from other sources. It is inexpensive, quick, and responsive. Length of glow of microlite tube is proportional to field density.

Whether an oven leaks or the amount it leaks, in the absence of some element to perturb the radiation fields, is a function of such items as oven construction, age of oven, or usage oven has received, type or manufacturer of oven, etc. Therefore, the periodicity of survey for leakage will have to be determined locally for each set of circumstances. None of the ovens checked (See Table VII, this report) had malfunctioning interlocks, but they still require checking due to the magnitude of hazard their malfunction presents.

Equipment for measuring and criteria for evaluating the radiations within the near-field of leakage from microwave ovens are not available, but the energy levels within these regions may be significant (Ref 22). Until such time that the tools to evaluate this situation are available, these exposures should be precluded. The most common exposure to near-field radiations occurs when the cooking operation is viewed through the perforated panel, door screen.

In the laboratory investigation, Table VIII, the maximum credible accident that could occur was shown in measurement location No. 1. This measurement and measurement, location No. 2, were probably within the near-field and therefore must be considered ambiguous. Solem, et al (Ref 19) made similar evaluations of various ovens operated in an anechoic chamber, a chamber designed to approximate freespace incorporating suitable attenuation of reflected waves. At 12 inches from the center of the face of the oven, they measured power densities ranging from approximately 160 to 700 mw/cm². They used a Ramcor 1200 B with S Band Horn and appropriate attenuators. They concluded that "Although far field conditions are expected at distances beyond 30 cm from the open oven doors, the observed radiation power density decreases less rapidly than would be predicted from inverse square law determinations. Part of this effect may be caused by reflections from the floor" (Ref 19). We conclude a most serious condition would occur if an oven were operated with interlocks defeated and the area in which the hazard would exist would be normally occupied.

SECTION VI

RECOMMENDATIONS

1. All ovens should be surveyed by Base Bio-Environmental Engineer

or Preventive Medicine Technician initially and periodically with microlite-287 test lite.* This survey should include both a physical inspection of the integrity of the oven, test to determine whether interlocks are functioning and measurement of leakage radiation. Survey procedures for these tests are shown in Appendix IV.

2. If leakage at 6 inches away from the face of the oven causes microlite to glow full length of tube, the oven should be taken out of service for repair, which will usually be done on contract basis. After repair and before oven is put back into service, it should be resurveyed.

3. If interlocks are not working, the oven should be taken out of service for repair. Before it is again placed in service, the interlocks should be rechecked.

4. To minimize the potential hazard from exposures to near and far-field radiations of leakages from these ovens, viewing of these operations or other actions which would result in the possible exposure to the near-field radiations should not be condoned.

*Six of these lights are available from each of the USAF Environmental Health Laboratories.

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Model NF 157, dated 15 August 1962**

APPENDIX 1
DEPARTMENT OF THE AIR FORCE
HEADQUARTERS UNITED STATES AIR FORCE
WASHINGTON D.C. 20333



REPLY TO
ATTN OF AFMSPAP

SUBJECT Microwave Ovens

11 July 1968

TO	AAC	ATC	MAC	CINCUSAFE	AFMFO
	ADC	AU	CINCPACAF	USAFSS	Phoenixville PA
	AFCS	USAFSO	SAC		
	AFLC	HQ COMD USAF	TAC	1002 IG GP	
	AFSC	CAC	USFA	Norton AFB CA	

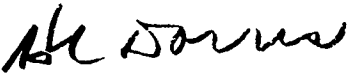
(Surgeon)

1. Microwave ovens are being used with increasing frequency in the USAF. Food service facilities using these devices include hospitals, BX concessions, dining halls, officer, NCO, and service clubs. It has been reported that these ovens can emit excessive amounts of microwave radiation because of malfunctioning interlock switches, poorly installed seals, or misaligned doors.

2. It is requested that you identify the bases within your command using microwave ovens and survey each oven to insure that individuals are not receiving excess exposure. If trained personnel and calibrated equipment are not available within your command, a consolidated list of those bases requiring microwave oven surveys should be forwarded to Headquarters, AFLC (MCDPE), with an information copy to this Headquarters (AFMSPAP).

3. The provisions of this letter will expire 1 July 1969.

FOR THE CHIEF OF STAFF


H. C. DORRIS, Brig General, USAF, MC
Director of Professional Services
Office of the Surgeon General



APPENDIX II

DEPARTMENT OF THE AIR FORCE
HEADQUARTERS AIR FORCE LOGIST & COMMAND
WRIGHT PATTERSON AIR FORCE BASE WMO 45433



MCDPE/76231

16 July 1968

Microwave Ovens

(Ltr, Hq USAF [AFMSPAP], 11 Jul 68)

2789 USAF Disp, Brookley AFB AL 36615

2845 USAF Hosp, Griffiss AFB NY 13440

2791 USAF Hosp, Hill AFB UT 84401

2794 USAF Disp, Kelly AFB TX 78241

2793 USAF Hosp, McClellan AFB CA 95652

2795 USAF Hosp, Robins AFB GA 31093

2792 USAF Hosp, Tinker AFB OK 73145

USAF Hosp, WPAFB OH 45433

8MAMA (LSGHM), McClellan AFB CA 95652

1. The attached letter from Hq USAF is forwarded for your information and action.
2. Request you provide the following information to this office not later than 26 July 1968.
 - a. Make, model and location of all microwave ovens at your base.
 - b. Date of last microwave survey for each oven.
 - c. Availability of trained personnel and calibrated microwave radiation measuring equipment at your base. If trained personnel and calibrated equipment are not available at your base, request you notify this Headquarters (MCDPE).

FOR THE COMMANDER

H. G. Wallace
H. G. WALLACE, Colonel, USAF, MC
Surgeon

1 Atch
Cy subj ltr

APPENDIX III

EQUIPMENT DESCRIPTION

Empire Broad Band Power Density Meter Model NF-157:

This instrument is designed to measure average power densities from 1.0 milliwatt per square centimeter (mw/cm^2) midscale to 2,000 mw/cm^2 . Frequency range is from 200 MHz to 10,000 MHz for either cw or pulse modulated signals. Components of unit are seen on pages 26 and 27 of this appendix.

The unit can be used for probing of high density RF fields and for detection of hot spots or leakage from antennas and other high power components. Probe selection is function of frequency of energy to be measured. Position of sensing element in the probe is commensurate with the specific energy to be measured. Read-out of power level being detected is directly in mw/cm^2 . Scale is divided into forty divisions, each division representing 0.5 mw/cm^2 . Step attenuator is provided which permits a choice from five coaxial sections ODB (XI) to 30 DB (X1000), 0-2000 mw/cm^2 .

NOTE: See T.O. 31Z-10-4 and 33A1-7-69-1 for more detailed description.

Ramcor Model 1200 (Ref 11):

This instrument is used for detecting and measuring VHF, UHF and microwave energy radiating from high power transmitters and related equipment. The scale is a direct reading decibel scale, mid-scale "0" db mark is 10 mw/cm^2 . Range is -10 db to +3 db scale readings or 1 to 20 mw/cm^2 . Conversion from db to mw/cm^2 is by chart. Five antennas are supplied with the instruments and cover the following bands:

VHF (200 - 225 MHz)

UHF (400 - 450 MHz)

L (1120 - 1700 MHz)

S (2600 - 3300 MHz)

C (5000 - 5900 MHz)

X (8500 - 10,000 MHz)

The response of each horn is not flat for range of frequencies it covers. Therefore, for a given horn and enclosed attenuator, a calibration curve must be provided.

Instrument calibration is with a signal generator and antenna capable of producing a field of 10 mw/cm^2 . Field density should be within $\pm 1 \text{ db}$.

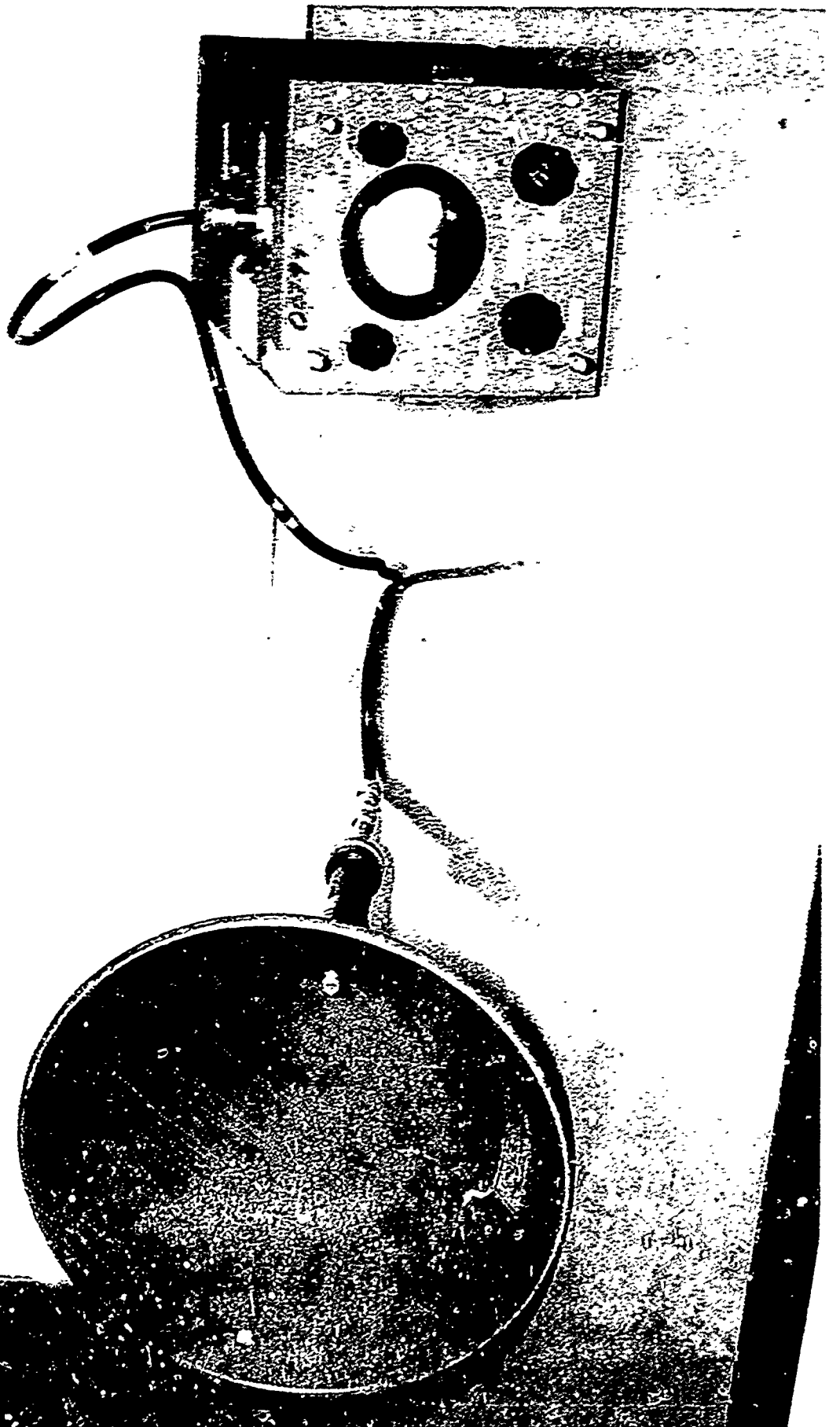
Microlite - 287:

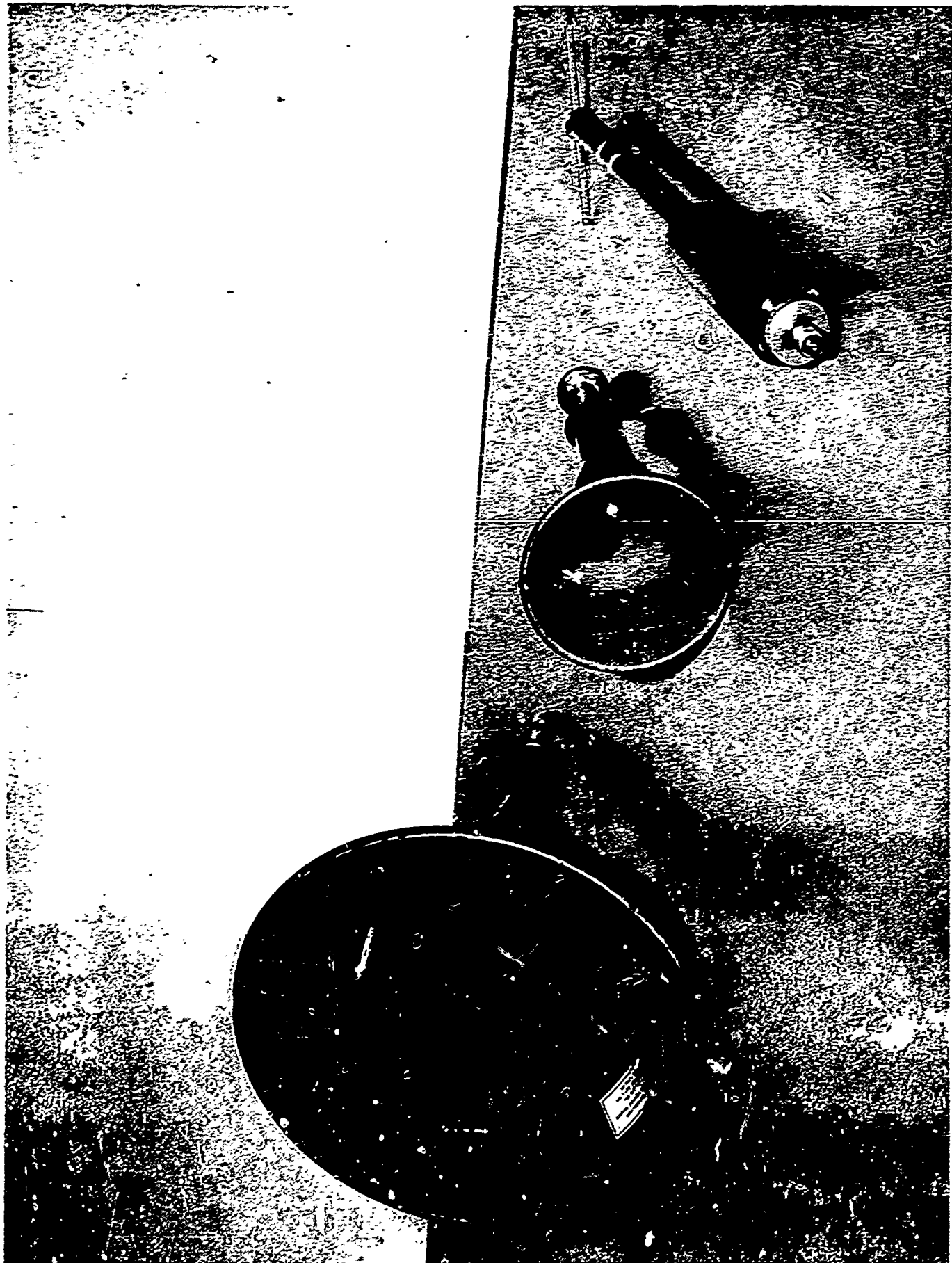
This survey instrument consists of a preignited neon lamp designed to indicate a field intensity of 10 mw/cm^2 at 2450 MHz . Length of glow along tube is a function of field strength, e. g., $1/4$ tube length indicates 2 mw/cm^2 , full length 10 mw/cm^2 or greater. For any other frequency the microlite probe can be expected to respond differently.

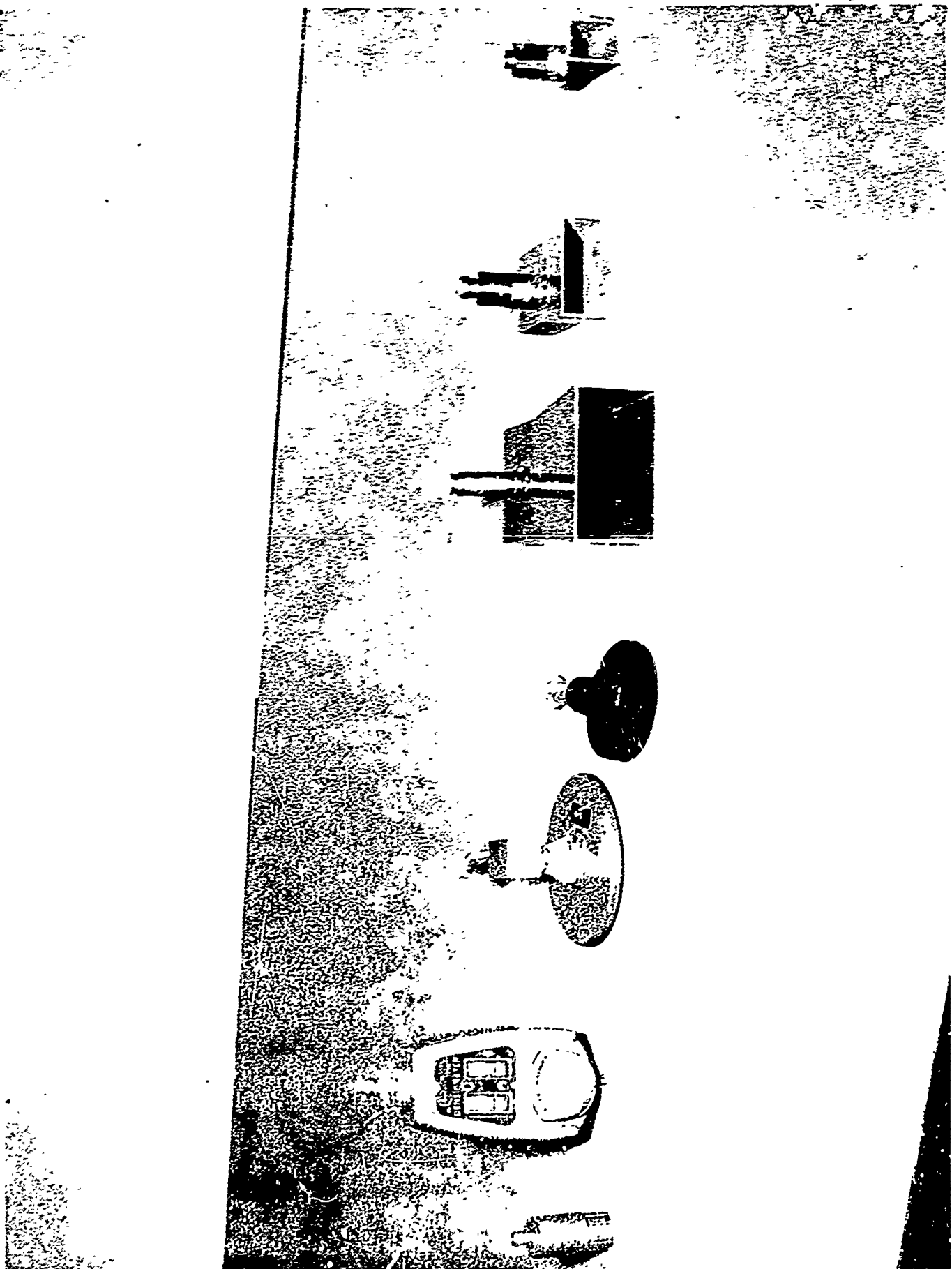
Fluorescent Bulb:

The bulb is used as an indicator of presence of microwaves. Energy required to fluoresce bulb being a function of frequency, geometry of bulb, and field strength. Example: 8 watt bulb, see page 30, this appendix, glows steadily if field strength is $18 - 20 \text{ mw/cm}^2$, and flickers in field of 6 to 8 mw/cm^2 (Ref. 13).

If fluorescent bulb is placed at surface of an oven, it may fluoresce when subsequent readings with power density meter show that power density at 6 inches is insignificant. The fluorescent bulb is not a good survey tool to quantitate leakages but does have its use when checking interlocks.









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APPENDIX IV

SURVEY PROCEDURES

Survey of microwave ovens is done in three parts: (1) physical inspection of oven, (2) survey for leakage radiation, and (3) check of interlocks.

In the physical inspection, the surveyor should check to see if: door shuts tight, all screws, doors screens, and other parts are in place, etc. For, areas where parts are missing can be sources of leakage. A strip of paper 1" wide and approximately 6" long can be used to check door seal. These are arbitrary dimensions. With the door open place the strip of paper at different positions along the periphery of the door. Each time, closing the door and removing the strip of paper. If there is considerable resistance to the removal of the paper the door seals can be considered tight. This is also a good check before placing an oven back into service that has been found to leak around the periphery of the door seals but should not take the place of the other procedures discussed in the following paragraphs:

Prior to making leakage measurements, determine from manufacturer's plaque, or by other means, the frequency at which the oven operates. If it operates at 2450, the microlite probe can be used to accomplish this part of the survey. If the oven operates at some other frequency, a broad band power density meter can be used for this part of the survey. These instruments can be borrowed from the USAF Environmental Health Laboratories. The ovens surveyed to date have operated at 2450 MHz. To locate the areas of leakage, operate the oven empty (without dummy load), so that the least energy will be absorbed; therefore, the leakage is maximized. These operating periods should be limited to prevent excessive energy absorption by magnetron tube and subsequent damage of the tube (Ref. 16, 17, and 18). Make surface measurements along the periphery of the door and screen (viewing window). Also, at any other site where an area of leakage may be suspected (see preceding paragraphs). Now place a standard 150 ml beaker containing 100 ml of water in the center of the oven cavity to simulate operating conditions, resurvey the previously identified areas of leakage. Survey distance should be 6 inches from surface of oven (outside the fresnel area, assuring good survey instrument response).

In checking the interlocks, place a fluorescent bulb (1-40 watts) in the oven cavity along with a dummy load. Operate oven and with varying amounts of pressure, open the door. If interlocks are functioning properly, the fluorescent bulb will discontinue fluorescing as the door opens. If bulb continues to fluoresce, the interlocks are either malfunctioning or have been jumped.