U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES ■ Public Health Service
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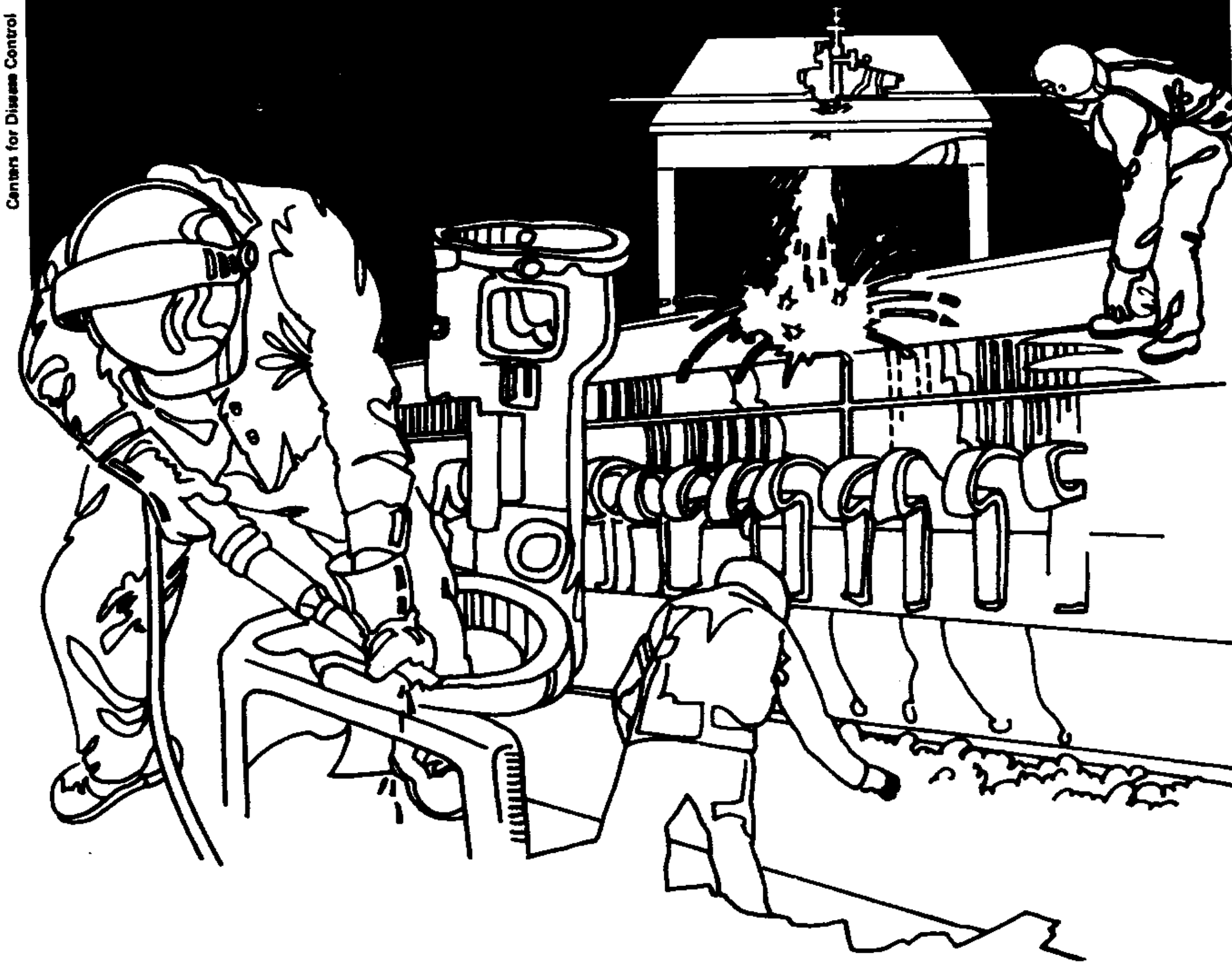
NIOSH



Health Hazard Evaluation Report

HETA 87-405-1858
SEARS, ROEBUCK AND COMPANY
CHICAGO, ILLINOIS

PREFACE

The Hazard Evaluations and Technical Assistance Branch of NIOSH conducts field investigations of possible health hazards in the workplace. These investigations are conducted under the authority of Section 20(a)(6) of the Occupational Safety and Health Act of 1970, 29 U.S.C. 669(a)(6) which authorizes the Secretary of Health and Human Services, following a written request from any employer or authorized representative of employees, to determine whether any substance normally found in the place of employment has potentially toxic effects in such concentrations as used or found.

The Hazard Evaluations and Technical Assistance Branch also provides, upon request, medical, nursing, and industrial hygiene technical and consultative assistance (TA) to Federal, state, and local agencies; labor; industry and other groups or individuals to control occupational health hazards and to prevent related trauma and disease.

HETA 87-405-1858
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I. SUMMARY

On September 8, 1987 the National Institute for Occupational Safety and Health (NIOSH) received a request from the Sears, Roebuck and Company for assistance in evaluating potential occupational exposure of optical radiation emitted from a new type of counter cook top that will be sold in the very near future. Since these counter cook tops will be serviced by Sears service technicians concern was expressed about possible health effects from exposure to any ultraviolet, visible, or infrared radiation levels emitted by the cook top.

The cook top was evaluated for optical radiation levels on October 6-7, 1987 at the Sears testing laboratory in Chicago under various use conditions. The measured infrared radiation irradiance levels under certain test conditions were in excess of 10 milliwatt per square centimeter (mW/cm^2), which is the proposed American Conference of Governmental Industrial Hygienists (ACGIH) guideline value for exposure to infrared radiation. The luminance, or brightness, of the source was found to be in excess of 1 candela per square centimeter (cd/cm^2), also a ACGIH guideline value, under certain use conditions.

These results suggest that under certain test conditions workers may need to wear appropriate protective eyewear in order to minimize burns and infrared radiation exposure. Recommendations are made for additional control measures and training to protect the worker.

KEYWORDS: SIC 5311 (Department Stores); infrared radiation, counter cook tops

II. INTRODUCTION

The counter cook top is designed to operate with four cooking areas but on the day of measurement the cook top only produced energy in three of these areas. All of the cooking areas were located in a rectangular frame having dimensions of 48 by 76 centimeters (cm) as shown in Figure 1. Four infrared radiation (IR) lamps are located within each of the 19 cm diameter cooking areas. The 450 watts lamps are manufactured by Philips and have a the typical spectral output as shown in Figure 2. The lamps have a peak IR wavelength around 1200 nanometers (nm) and are capable of producing both visible and IR radiation of biological concerns. The tubular quartz IR lamps, that are used in the cook top, are small high-powered heat sources that incorporate a long Tungsten coil filament (operating at 2400 K) within a quartz envelope. Figures 3a-e show the increasing level of optical radiation produced by one burner as a function of increasing wattage. All of the pictures in Figure 3 were taken at the same distance. The lamp used in the cook top is of the halogen type which minimizes blackening thereby extending its lifetime to 3000 hours. Each lamp is designed to reach full power within a second as well as take the same length of time to emit no power after being turned off.

The lamps, as well as the entire cook top surface, are covered by a special glass ceramic material, called CERAN, manufactured by Schott Glaswerkes in West Germany. The relative spectral output of a typical lamp and the spectral transmittance of the CERAN material are plotted as a function of wavelength in Figure 4. The shaded area represents that lamp radiation which can pass through the CERAN cover and expose the worker. The data to produce this figure was taken from manufacturer published results, however spectral measurements by NIOSH did confirm these results.

III. EVALUATION CRITERIA

As a guide to the evaluation of the hazards posed by workplace exposures, NIOSH field staff employ environmental evaluation criteria for assessment of a number of chemical and physical agents. These criteria are intended to suggest levels of exposure to which most workers may be exposed without experiencing adverse health effects. It is, however, important to note that not all exposures are maintained below these levels. A small percentage may experience adverse health effects because of individual susceptibility, a pre-existing medical condition, and/or a hypersensitivity situation.

In addition, some hazardous substances may act in combination with other workplace exposures, the general environment, or with medications or personal habits of the worker to produce health effects, even if the occupational exposures are controlled at the level set by the evaluation criteria. Also, some substances are absorbed by direct contact with the skin and mucous membranes, and thus, potentially increase the overall exposure. Finally, evaluation criteria may change over the years as new information about chemical and physical agents become available.

The primary sources of environmental evaluation criteria for the workplace are: (1) NIOSH criteria documents and recommendations, (2) the ACGIH's Threshold Limit Values (TLV), and (3) the U.S. Department of Labor (OSHA) occupational health standards. Often, the NIOSH recommendations and ACGIH TLV's are lower than the corresponding OSHA standards. Both NIOSH recommendations and ACGIH TLV's usually are based on more recent information than are the OSHA standards. The OSHA standards also may be required to take into account the feasibility of controlling exposures in various industries where the agents are used; the NIOSH-recommended standards, by contrast, are based primarily on concerns relating to the prevention of occupational diseases. In evaluating the exposure levels and the recommendations for reducing these levels found in the report, it should be noted that industry is legally required to meet those levels specified by an OSHA standard.

At present there is limited information from OSHA on exposure criteria for workers exposed to physical agents. Criteria for physical agents come exclusively from either ACGIH, NIOSH, or in some cases from consensus standards promulgated by the American National Standards Institute.

A. Infrared Radiation

All objects having temperatures above absolute zero emit infrared radiation(IR) as a function of temperature. In biological systems the major insult of IR appears to occur as a result of a rise in temperature of the absorbing tissue.

The physical factors associated with temperature rise are the wavelength, heat conduction parameters, exposure time, and total amount of energy delivered to the exposed tissue. Since IR photons are low in energy, they would not be expected to enter into photochemical reactions with biological systems. Molecular interactions with radiation in the IR regions are characterized by various vibrational-rotational transitions resulting in an increase in thermal energy of the molecule.

Since the primary effect of IR on biological tissues is thermal, the skin provides its own warning mechanism by having a pain threshold below that of the burn threshold. However,there is no such adequate warning mechanism in the eye and hence additional protective equipment is often necessary. Traditionally, safety personnel consider IR to be a cataractogenic agent but recent literature (see References) has cast serious questions about the etiology of IR cataracts that could occur in the workplace from non-coherent optical sources.

Wavelengths of IR beyond 1400 nm can produce corneal and eyelid burns leading to the conditions of dry eye and skin. Figures 5 and 6 give a conceptual explanation of how near IR can produce such effects. The primary biological effect of IR on the retina and choroid is thermal in nature, with the amount of damage being proportional to the length of exposure. If the radiation intensity is low enough, however, the normal retina blood may be sufficient to dissipate any heat generated. Nevertheless, due to the focusing effect of the anterior ocular components, small amounts of IR can produce a relatively intense point energy distribution on the retina resulting in a lesion.

B. Visible Radiation

Visible radiation from either the sun or artificial sources is probably one of the more important occupational health considerations because of its major role in our daily life. When light levels are high at certain wavelength regions obvious retinal issues arise that require protective eyewear devices. These types of direct effect have been well known for many years and documentation exists within the scientific literature, i.e. staring at welding arcs or the sun.

Indirect effects of light, however, can occur-not from absorption of light energy in tissues-but from the action of chemical signals liberated by cells in the body. In many cases such indirect effects occur at much lower intensities than the direct effect. As a result such effects often are not considered a major occupational health hazard. Examples of this relationship of light to biological rhythms, include physical activity, sleep, food consumption, etc. Another well-known indirect effect is the inhibition of melatonin synthesis by the pineal gland which in turn affects maturation and activity of the sex gland. Only within the last few years have investigators begun to discover the various subtle physiological and biochemical responses to light.

Another issue which often arises is that associated with poor room or task lighting conditions. Such conditions lead or cause aesthenopia (eye strain). Although the etiology of eye strain is debatable, it appears that repeated occurrences probably do not lead to any permanent eye damage. Workers over 40 years of age will probably encounter more symptoms of eye strain (headache, tired eyes, irriation) since they require more light to perform a similar job than younger workers.

The ACGIH TLV's for visible radiation exist to offer protection from retinal thermal injury and for photochemical injury that can occur from exposure to wavelengths in the region from 400-500 nanometers.

C. Ultraviolet Radiation

Ultraviolet (UV) Radiation is an invisible radiant energy produced naturally by the sun and artifically by arcs operating at high temperatures. Some of these soureces are germicidal and blacklight lamps, carbon arcs, welding and cutting torches, electric arc furnaces, and various laboratory equipment.

Since the eyes and skin readily absorb UV radiation, they are particularly vulnerable to injury. The severity of radiation injury depends on factors which include exposure time, intensity of the radiation source, distance from the source, wavelength, sensitivity of the individual, and presence of sensitizing agents.

Sunburn is a common example of the effect of UV radiation on the skin. Repeated UV exposure of lightly pigmented individuals may result in actinic skin-a dry, brown, inelastic, wrinkled skin. Actinic skin is not harmful in itself, but is a warning that conditions such as senile keratosis, squamous cell epithelioma, and basal cell epithelioma may develop.

Since UV is not visible, the worker may not be aware of the danger at the time of exposure. Absorption of the radiation by the mucous membranes of the eye and eyelids can cause conjunctivitis (commonly known as "welder's flash"). Lesions may also be formed on the cornea at high exposure levels (photokeratitis). Such injuries usually manifest themselves 6 to 12 hours after exposure. The injuries may be very painful and incapacitating, but impairment is usually temporary. Workers also need to be aware of the presence of certain photosensitizing agents that, upon contact with the skin, produce exaggerated sunburn when exposed to UV at wavelengths.

IV. METHODS

All measurements taken on the cook top were designed to measure the optimum optical irradiance levels that a worker would receive during a typical servicing activity. Measurements were made at an eye to cook top distance of 70 cm. Maximum levels were obtained since no cooking pans or utensils were placed over the cooking areas. During the measurements the CERAN material was removed in order to simulate a broken lid cover situation, however, except for this simulation, the cooking lid was down during all the other measurements.(see Figures 7 and 8). The following equipment was used to document levels of radiant energy produced by the counter cook top:

A. An EG&G model 555 spectroradiometer was used to measure the spectral irradiance in the wavelength from 200 to 800 nm. The unit of measurement is the watt per square centimeter per nanometer. The values obtained are summed to give the total irradiance in a particular optical region in units of watts per square centimeters. The spectroradiometer operated at a 10 nm bandpass with a ten degree field of view.

B. Luminance or brightness levels were measured with a Spectra Mini-Spot photometer having a one degree field of view. The values were obtained in terms of footlamberts (fL) which are converted to candela per square centimeter (cd/cm^2). The luminance of a source is a measure of its brightness when observed by an individual without eye protection, regardless of the distance from source.

C. An International Light model 730A radiometer with specially calibrated detectors was used to evaluate the ultraviolet radiation levels. One detector was designed to read the actinic UV radiation (200 to 315 nm) in biologically effective units of microwatt per square centimeter (uW/cm^2), while the other detector measured near UV (320-400 nm) in units of milliwatt per square centimeter (mW/cm^2) with no biologic weighting factor.

D. A Solar Light Sunburn meter was also used to document the presence of any erythermal producing radiation in the 290 to 320 nm wavelength region. This meter reads in sunburn units per hour.

E. An Eppley model 901 calibrated thermopile with a quartz window was used to measure irradiance in units of milliwatts per square centimeters over the wavelength range from 200 to 4500 nm.

All optical radiation instruments used in this evaluation had been calibrated by their respective manufacturer within 12 months and were checked by NIOSH before and after field measurements for compliance with calibrations. In addition, photographs of the cook top and various measurement processes were taken with a 35 mm single lens reflex camera.

V. RESULTS AND DISCUSSION

Ultraviolet Radiation:

The spectral output of the cook top, as measured by the spectroradiometer, did not demonstrate the presence of significant levels of ultraviolet radiation (Figure 9). This fact was confirmed by the spectral transmittance plot of CERAN, the results from the International Light meter and the recorded level from the sunburn meter. Therefore the lamps used in the cook top under normal operating conditions do not present a ultraviolet radiation hazard.

Visible Radiation:

The maximum luminance value recorded with the cook top lid in place was 1000 fL (@ 0.3 cd/cm^2) when the lamps in the cooking area were turned to the highest setting. When the lid was removed luminance values were greatly in excess of 1 cd/cm^2 and would clearly represent an optical hazard unless protective eyewear or barriers were used.

Infrared Radiation:

The highest IR level recorded was 128 mW/cm^2 and was obtained with three areas of the cook top operating at their highest setting and no cooking pans placed on the heating areas. The highest IR level recorded for one burner was 94 mW/cm^2. The presence of cooking pans would help reduce this value. A plot of the data showing the correlation between one and two heating areas is shown in Figure 10. Table 1 shows the maximum recorded optical radiation levels emitted by the cook top on the day of measurement as compared to the ACGIH recommended TLVs.

VI. CONCLUSIONS

Figure 9 shows a plot of spectral irradiance values versus wavelength for the cook top taken at a distance of 0.7 meters. The spectral irradiance values cover only the wavelength range from 200 to 800 nm and the graph of these values generally support the manufacturer's result over the same wavelength region. The summed spectral irradiance value from 200 to 800 nm is 0.11 mW/cm^2. The Eppley meter recorded a maximum value of 94 mW/cm^2 from one burner over the region from 200 to 4500 nm. This value of approximately 94 mW/cm^2 for the IR region is in excess of the proposed ACGIH threshold value by a factor of 9. However, it must be realized that the cook top was being tested in a manner different from normal use, i.e. no cooking pans or pots were used. It is suggested that servicemen do not perform maintenance tests on the cook tops at maximum outputs without appropriate eye and skin protection. In addition perhaps testing should be performed by Sears to insure adequate consumer protection for maximum cook top output levels.

VII. RECOMMENDATIONS

The following recommendations are offered as a means to reduce occupational exposure:

1. All maintenance work on these units performed by the servicemen should be done at operating levels less than maximum output. If it is necessary to operate a unit at maximum output consideration should be given to wearing protective eyewear and/or gloves. In addition, it is recommended that standard operating procedures be developed that address cooking implements being used while servicing is performed in order to further minimize occupational exposure.

2. Under no conditions should the protective lid be lifted when the lamps are activated. If an interlock is not already on the lid, it is suggested that one be developed that would prevent an accidental exposure.

3. The special protective lid is quite good for protecting from portions of the optical spectrum, however, this protection would be altered if the lid was broken or became broken as a result of cooking implements coming into hard contact with the lid. Servicemen should be cautioned about the need to observe for broken glass.

4. In the event that it becomes necessary to stare at the cook top surface, we would suggest a pair of impact goggles with an optical density value of 2-4 be worn. The actual density value would depend on the level of optical radiation being produced.

5. It is suggested that training be provided to servicemen who will work on ther counter cook top concerning optical hazards. This training should cover the basic physics of infrared radiation, nature of the source, types of biological effects that can result from over exposure, need for eye and skin protection, other control measures and standards.

6. One must keep in mind concern about burn hazards as well as eye and skin problems. Touching the surface of the counter cook top when activated can burn the unprotected skin.

7. The scientific literature on IR biological effects often cites concerns about upper respiratory problems reported by workers. Under some repair conditions where servicemen may be closer than normal to the cook top this issue could arise and needs to be recognized.

8. Medical consideration should be given towards implementing vision examination programs for the servicemen handling such sources. The issue of how to handle broken bulbs should also be addressed.

9. Appropriate consumer and occupational labels should be placed on the counter cook tops according to the various requirements of Food and Drug Administration and/or Consumer Product Safety Commission.

VIII. REFERENCES

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IX. AUTHORSHIP AND ACKNOWLEDGEMENTS

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X. DISTRIBUTION AND AVAILABILITY OF REPORT

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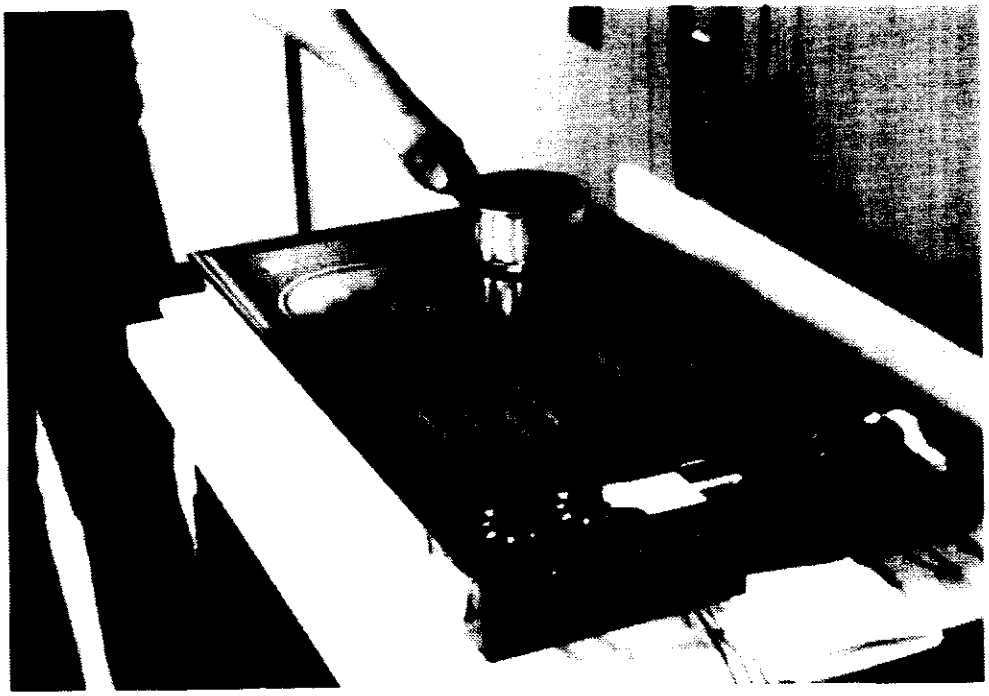
1. Sears, Roebuck and Company
2. NIOSH, Cincinnati Office.
3. OSHA, Region V

For the purpose of informing affected employees, copies of this report shall be posted by the employer in a prominent place accessible to the employees for a period of 30 calendar days.

TABLE 1. MAXIMUM OPTICAL RADIATION LEVELS RECORDED ON THE OVEN WITH NO.3 BURNER SET AT HIGHEST LEVEL AND NO PANS PLACED ON THE PROTECTIVE COVER.

Radiation Type and Wavelength (nm)	Location and Distance of Source	Level Measured	Optical Radiation Guideline Value (4)
Actinic UV (200-315)	70 cm	Not Detectable	0.1×10^{-6} W/cm^2
Near UV (320-400)	30 cm	6×10^{-6} W/cm^2	1.0×10^{-3} W/cm^2
Luminance (400-760)	70 cm	0.33 cd/cm^2	1.0 cd/cm^2
Infrared (760-4500)	70 cm	94×10^{-3} W/cm^2	10×10^{-3} W/cm^2

FIGURE 1



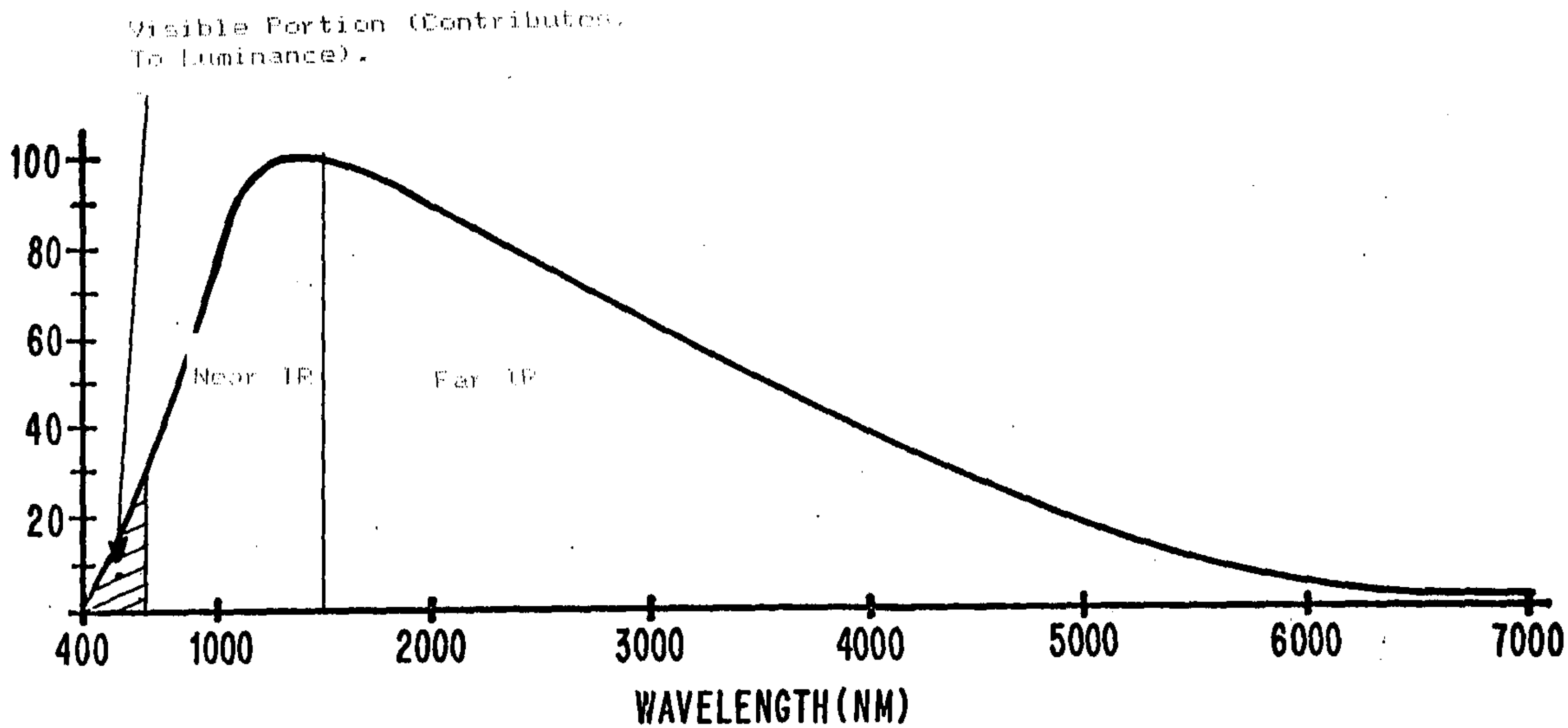


FIGURE 2 APPROXIMATE RELATIVE SPECTRAL DISTRIBUTION
(IN PERCENT) OF LAMP USED IN OVEN.

FIGURE 3a

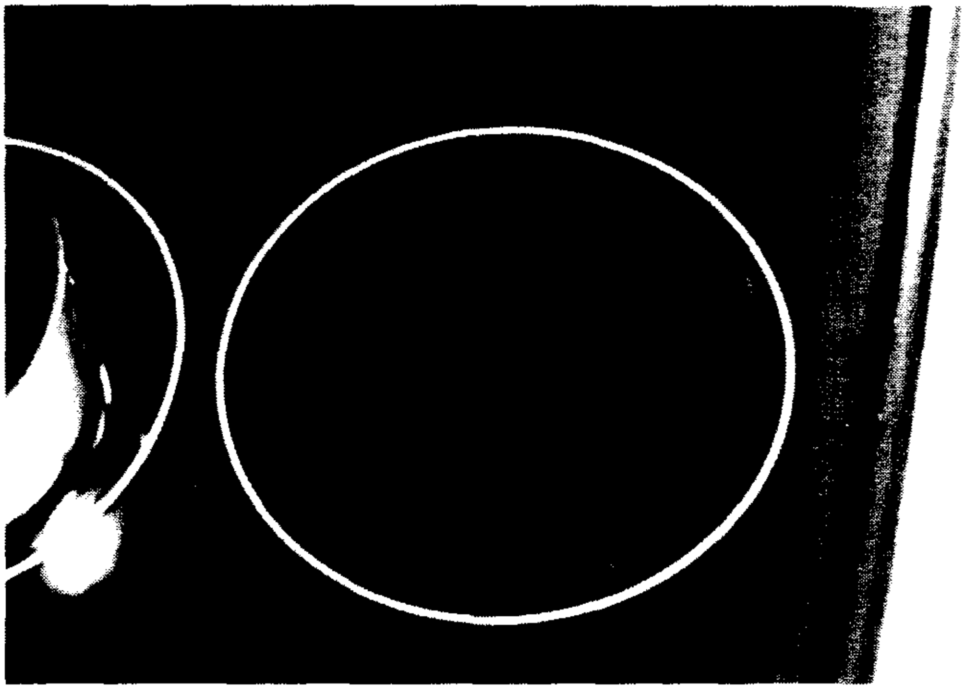


FIGURE 3b

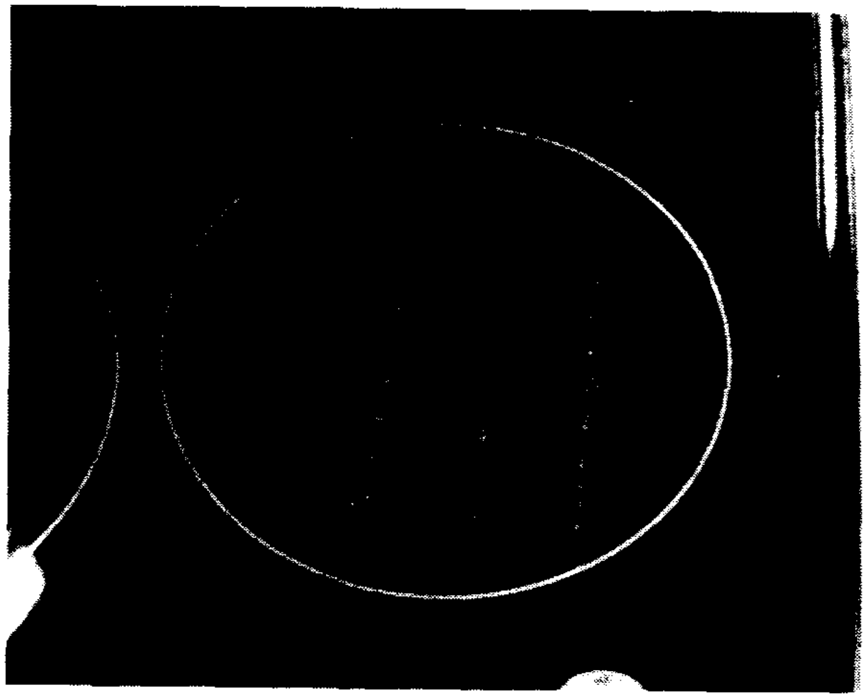


FIGURE 3c

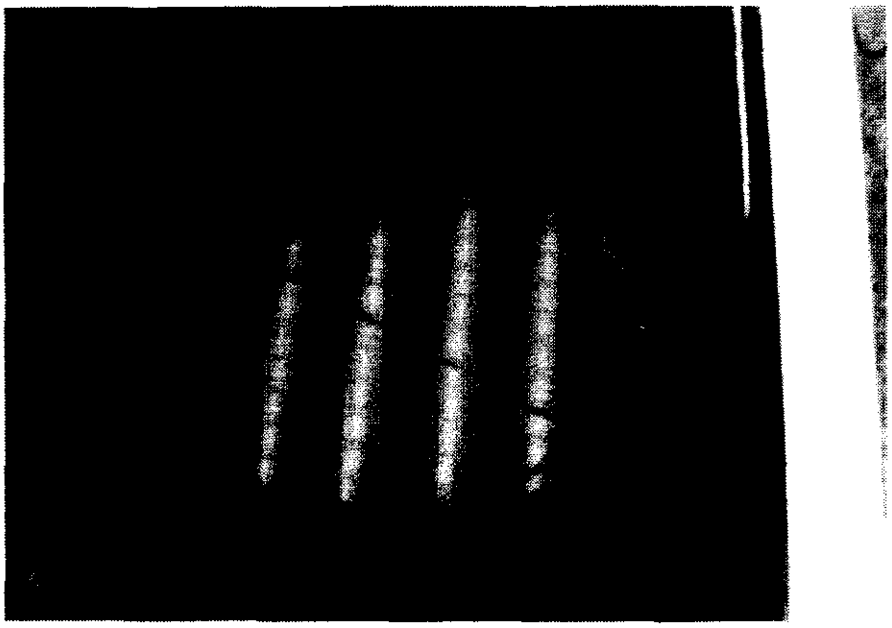


FIGURE 3d

FIGURE 3e

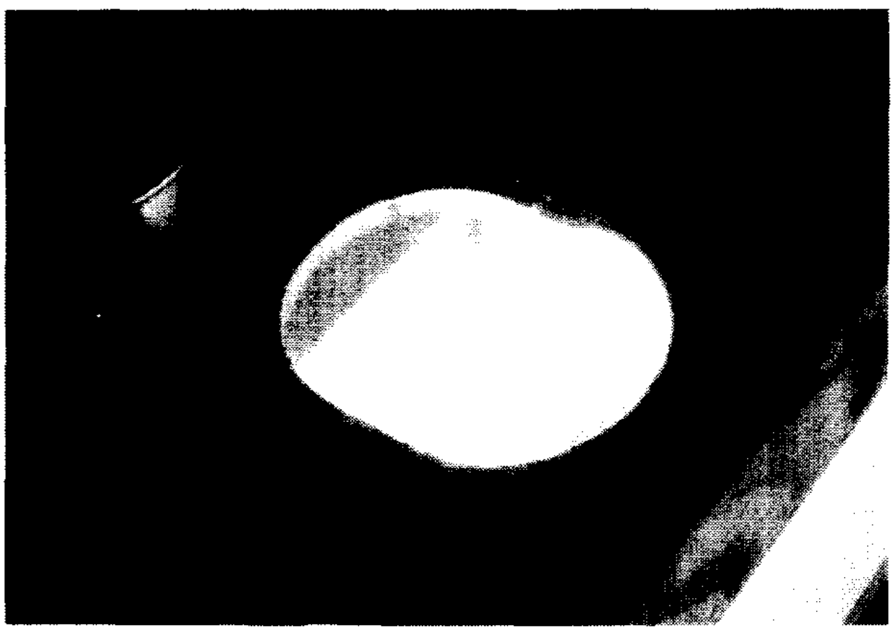
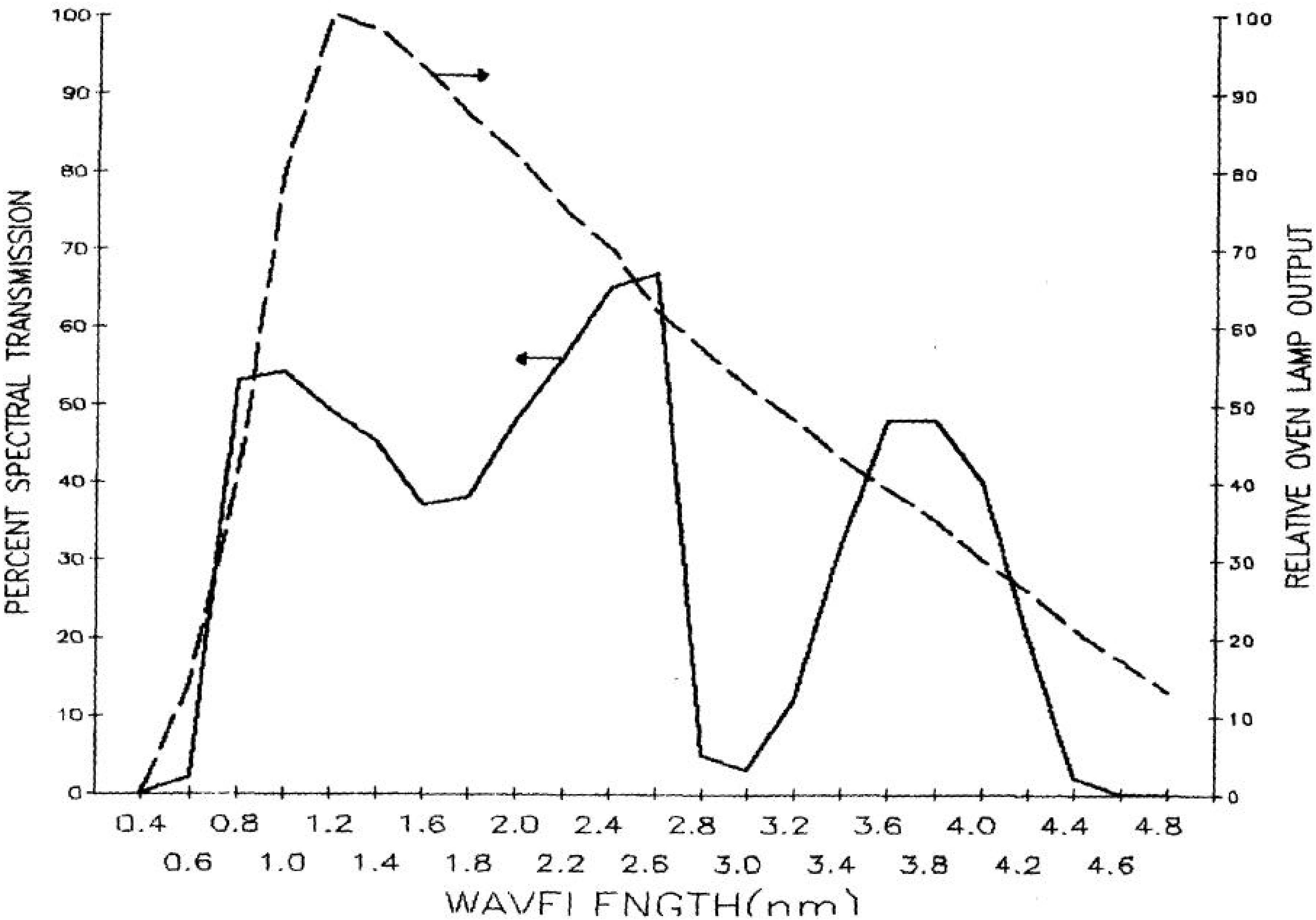


FIGURE 4. COMPARISON OF SPECTRAL TRANSMISSION OF OVEN LID WITH RELATIVE SPECTRAL LAMP EMISSION.



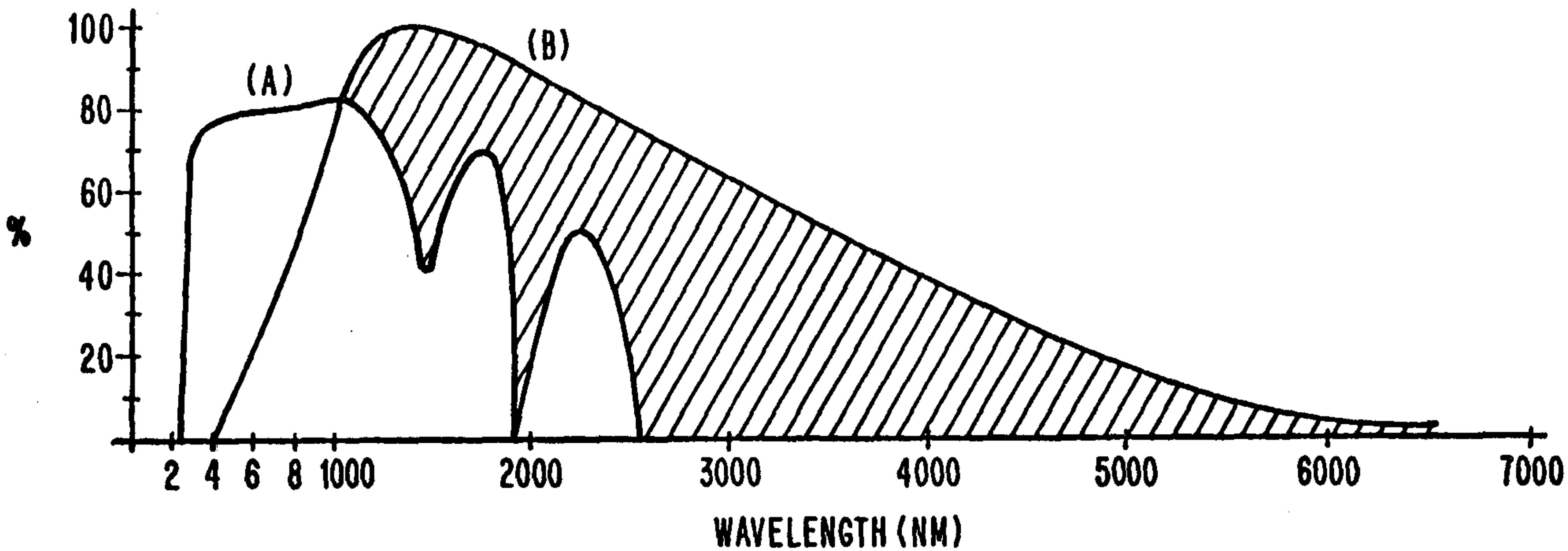


FIGURE 5. CONCEPTUAL EXPLANATION OF DRY EYE. CURVE (A) IS THE CORNEAL TRANSMISSION AND CURVE (B) THE LAMP SPECTRAL DISTRIBUTION. SHADED AREA REPRESENTS OPTICAL ENERGY THAT IS INCIDENT UPON CORNEA LEADING TO DRY EYE CONDITION.

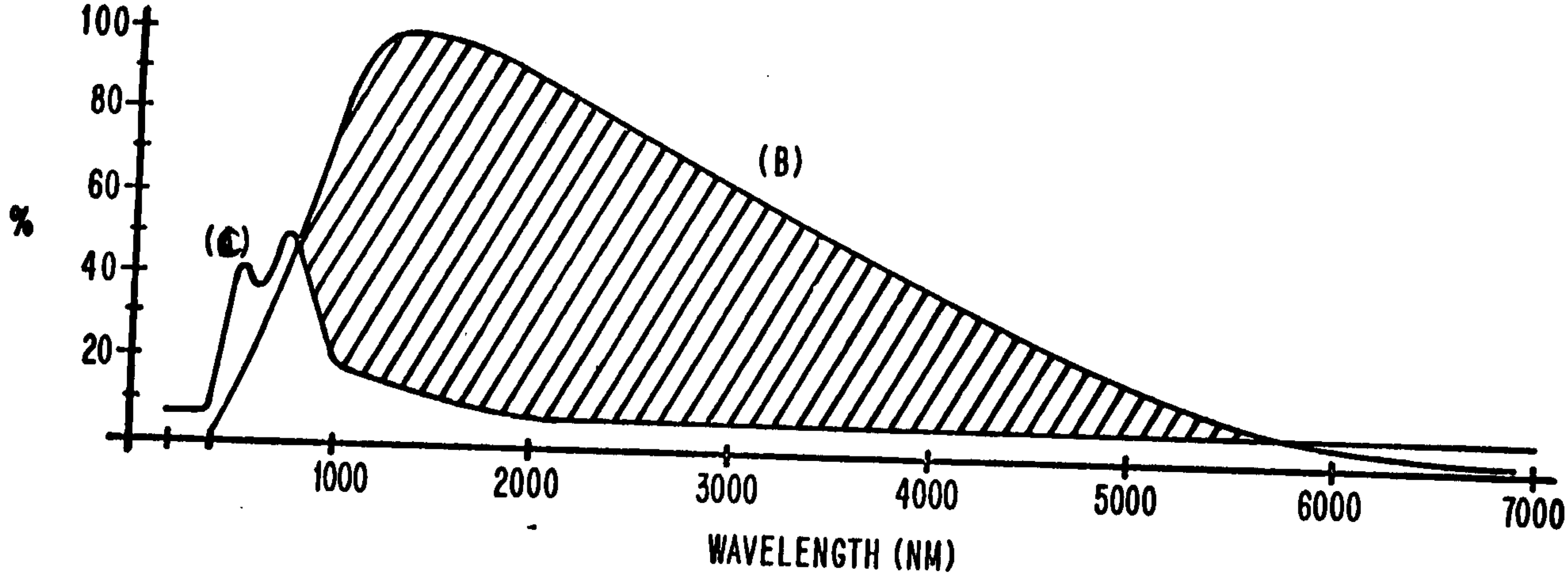


FIGURE 6. CONCEPTUAL EXPLANATION OF DRY SKIN. CURVE (C) IS THE REFLECTANCE OF WHITE HUMAN SKIN AND CURVE (B) THE LAMP SPECTRAL DISTRIBUTION. SHADED AREA REPRESENTS OPTICAL ENERGY THAT IS NOT REFLECTED BY SKIN AND HENCE CAN BE ABSORBED LEADING TO DRY SKIN.

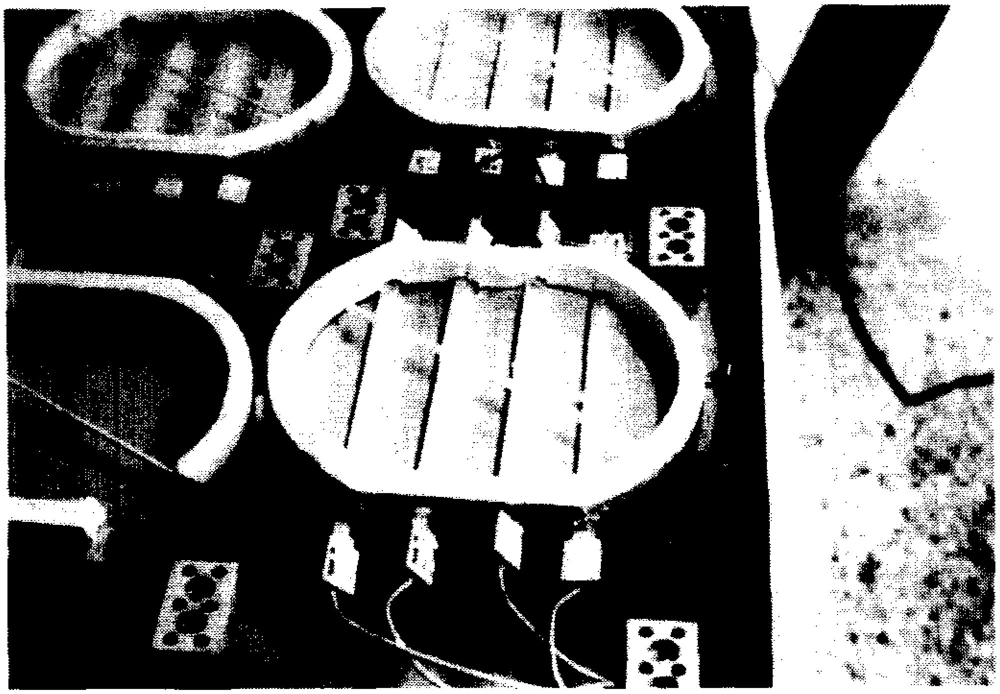


FIGURE 7

FIGURE 8

FIGURE 9. SPECTRAL IRRADIANCE OF OVEN.

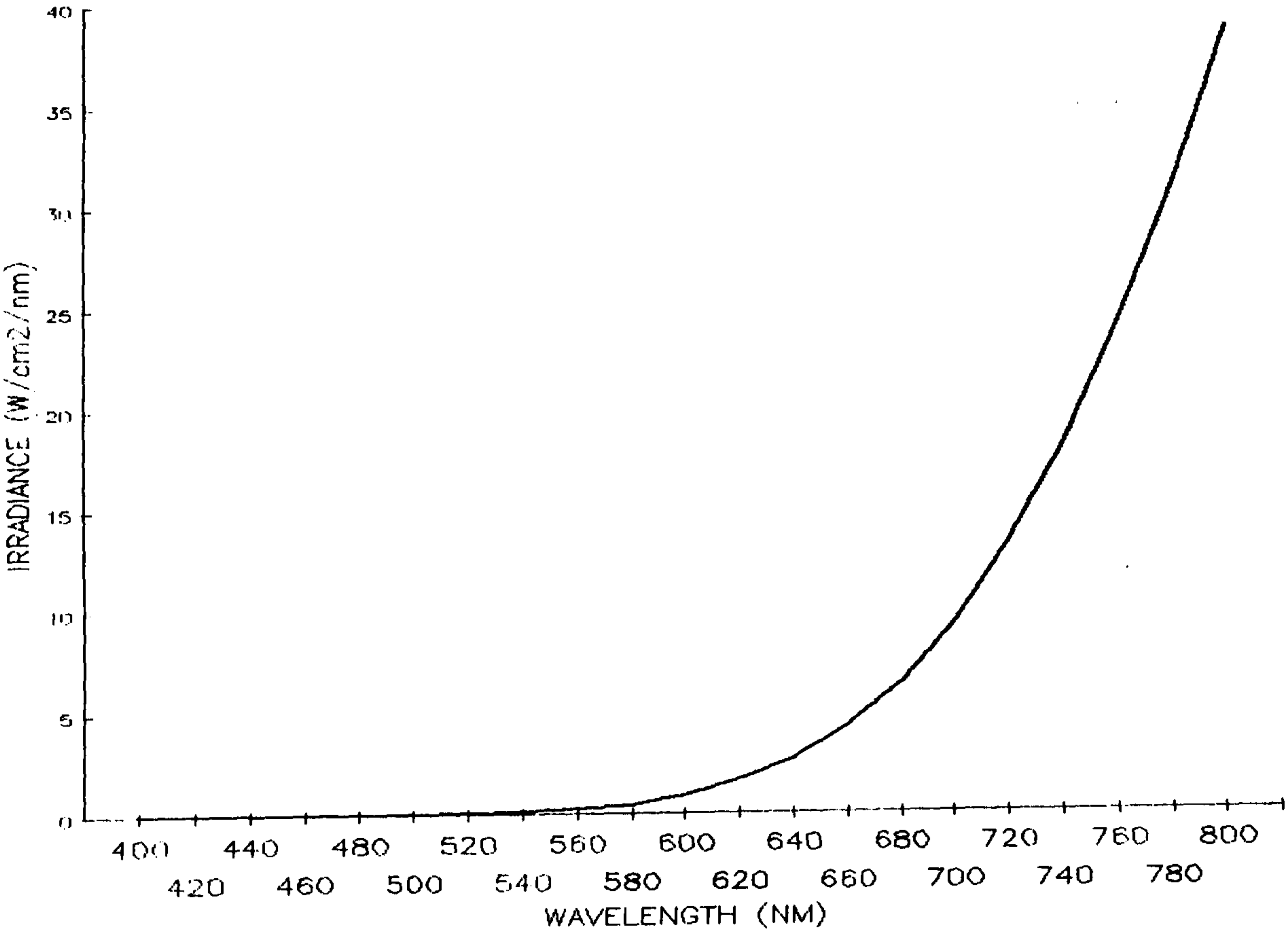


FIGURE 10. OVEN IRRADIANCE AS A FUNCTION OF SWITCH SETTING