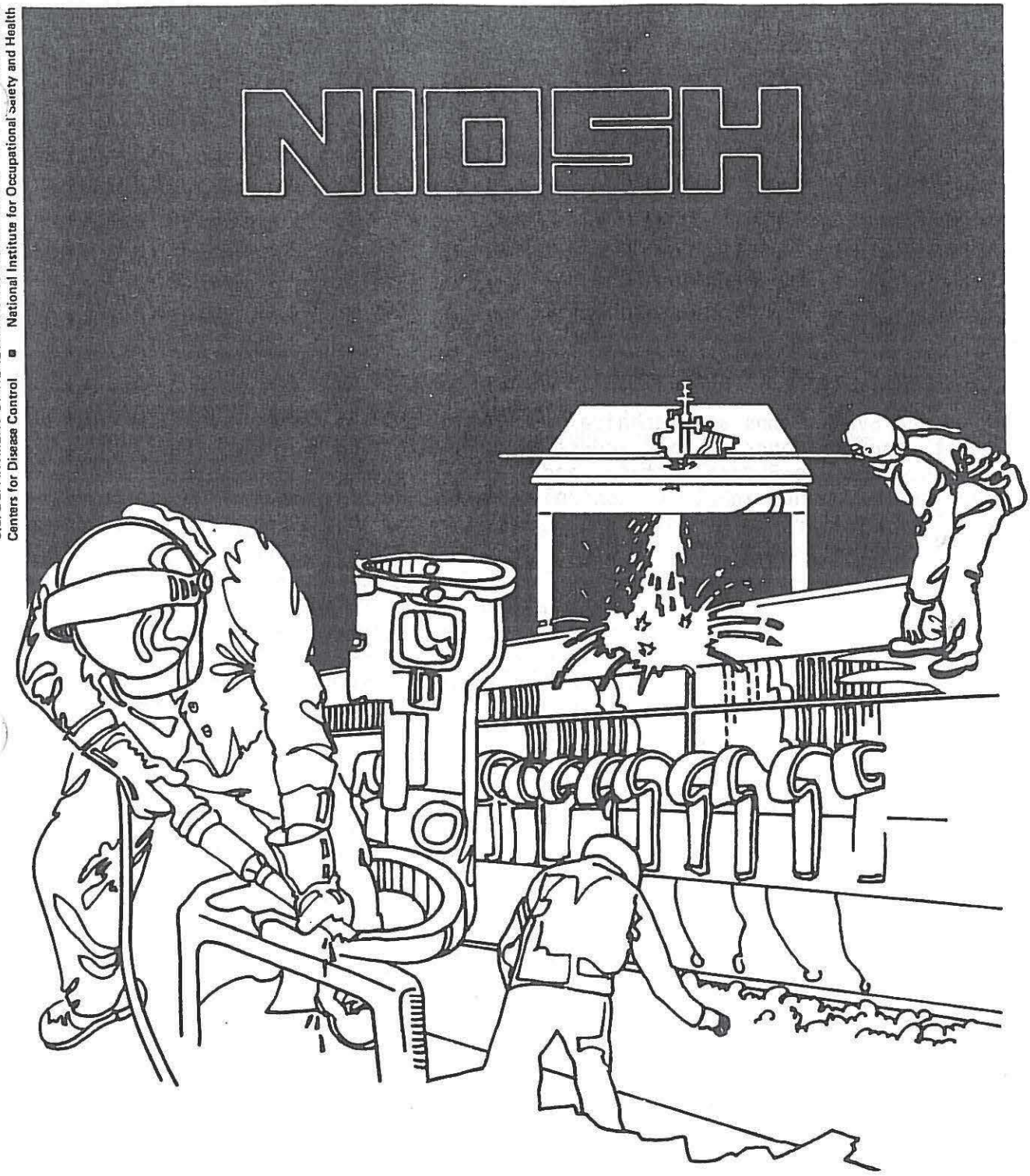
U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES ■ ...alth Service
Centers for Disease Control ■ National Institute for Occupational Safety and Health

NIOSH



Health Hazard Evaluation Report

HETA 81-435-1142
NCR MICROELECTRONICS-MIAMISBURG
MIAMISBURG, OHIO

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 81-435-1142
July 1982
NCR Microelectronics-Miamisburg
Miamisburg, Ohio

NIOSH INVESTIGATORS:
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I. Summary

On August 17, 1981, the National Institute for Occupational Safety and Health (NIOSH) received a health hazard evaluation request from the NCR Microelectronics-Miamisburg, Miamisburg, Ohio. The request concerned radiofrequency (RF) radiation from barrel plasma etchers and parallel plasma etchers. On September 2, 1981, NIOSH measured the radiation from nine etchers in use by the company. On June 17, 1982, a follow-up survey was made after installation of controls.

The radiation was recorded in volts squared per meter squared (V^2/m^2) for electric fields and amperes squared per meter squared (A^2/m^2) for magnetic fields.

Although the plasma systems were enclosed, some radiation leakage was detected around the door seals and through glass windows. No magnetic field was found to be in excess of the permissible exposure standard, but excessive electric field measurements ranged from $5x10^4$ V^2/m^2 to $5x10^5$ V^2/m^2 compared with an OSHA electric field standard of $4x10^4$ V^2/m^2. However, in all cases the field strengths were nondetectable at 6 to 12 inches from the glass window. After the recommended controls were installed, no detectable radiation was found.

On the basis of the initial measurements, NIOSH concluded that operators of the systems surveyed would not be exposed to radiofrequency radiation at their normal working distances. However, under some conditions that require a close observence of the etching process, the eyes and hand could possibly be exposed to excessive levels of electric-field radiation. Because of this potential exposure, protective measures for reducing radiation levels were recommended, instituted and their effectiveness demonstrated.

KEYWORDS: SIC 3611 (Radiofrequency measuring equipment) Plasma systems, etchers, nonionizing radiation, radiofrequency, microwave

II. Introduction

On August 17, 1981, the National Institute for Occupational Safety and Health (NIOSH) received a request from NCR Microelectronics-Miamisburg, Miamisburg, Ohio, to evaluate the potential health hazards from working with or near barrel plasma etchers and parallel plate plasma etchers. NCR had a report[1] on a previous survey at another manufacturing location that had measured radiation emitted by plasma etchers in excess of current OSHA standards. Their primary concern was worker exposure to potentially hazardous radiofrequency (RF) radiation. The NIOSH survey was conducted September 2, 1981, and a follow-up survey was made on June 17, 1982.

III. Background

At the facility, the NCR Company produces microelectronic devices. Each of these devices is produced by etching selected films by using a photoresist mask. Two types of RF plasma systems are used. One system is used to etch the film and the other system completely removes the photoresist film after the etch is complete.

Basically, the RF plasma system operates at a frequency of 27.12 MHz and acts as a large vacuum tube. The system consists of an RF generator with controls, a vacuum pump with controls, and a vacuum chamber. The parts to be stripped or etched are placed inside the vacuum chamber. The chamber is then evacuated and refilled (but not to atmospheric pressure) with an inert gas such as nitrogen. Once the chamber is filled with gas, but still under negative pressure, the RF generator is activated. The inert gas is ionized by the RF electromagnetic fields. These ions then strike the wafers causing a release of etched ions (plasma).

IV. Methods

On September 2, 1981 an opening conference was held with company representat ves to discuss measuring procedures and the release of reports that would follow, and a closing conference was held to give an oral report on the measurements and to recommend protective procedures. A follow-up survey after new radiation controls were installed was conducted on June 17, 1982.

RF measurements were made by slowly scanning all accessible surfaces of each system as closely as possible. When RF radiation was detected, the level and location were recorded. The probe was slowly removed from the surface until the radiation was no longer detected and the distance recorded.

Measurements were made with Holaday Instruments, the Model HI-3002 meter, (S/N 26092) and two probes, the electric field probe (S/N 186GR) and the magnetic field probe (S/N 017). The probes were calibrated on August 13, 1981, and were used to measure the electric field

strength in volts squared/meter squared (V^2/m^2) and the magnetic field strength in amperes squared/meter squared (A^2/m^2). The minimum detectable limit for the electric probe was 500 V^2/m^2 and for the magnetic probe it was 0 .005 A^2/m^2. The overall accurracy of both probes was $\pm$ 2.5 dB, corresponding to +78 and -44 percent. For the electric field probe, the operational frequency range was 0.5 MHz to 6 GHZ and for the magnetic field it was 5 MHz to 300 MHZ.

V. Evaluation Criteria

For nonionizing radiation in the radiofrequency and microwave range of 10 MHz to 100 GHz, OSHA specifies in 29 CFR 1910.97, a power density limit of 10 milliwatts/centimeter squared (mW/cm^2) averaged over any possible 6-minute period. In the far field, this power density corresponds to $4x10^4$ V^2/m^2 for the electric field and 0.25 A^2/m^2 for the magnetic field.

VI. Results

Both electric field and magnetic field measurements are shown in figures 1 through 9. All magnetic field measurements were considerably below the permissible exposure level of 0.25 A^2/m^2 except for the machine depicted in Figure 9. In this case the measured level was the equivalent of the standard when the door was opened. However, the permissible electric field radiation, 40,000 V^2/m^2, was exceeded in the plasma systems with plexiglass glass windows in doors (Figures 3, 6, 8 and 9). The electric field measurements in contact with these window surfaces ranged from $5x10^4$ to $5x10^5$ V^2/m^2, with no measureable radiation at distances from 6 inches to 12 inches.

Following the initial survey, NCR was advised to replace the plexiglass windows in the doors with RF shielded windows. The Branson/IPC corporation was also informed of the findings and immediately sent replacement windows to NCR for installation. Follow-up measurements made in June, 1982, showed that the radiation levels were nondetectable through the replacement windows, that were installed in response to our recommendation.

VII. Discussion

Although at the time of the initial survey, RF radiation was being emitted at levels that could result in exposure above c··rrent standards at some of the locations, because of normal operating distances and operating times, the operators are not likely to have received personal exposures in excess of the OSHA standard.

The hi~h reading (figure 9) of $5x10^5$ V^2/m^2 is more than 10 times that of the standard, but the close distance from the machine at which the measurements were made must be taken into consideration. Normally, only the operator's hands and eyes would have had the potential to be exposed, and this for only a short time period. This exposure becomes possible when the operator places his hands on the surface of the glass window when attempting to view the etching process in the chamber, a viewing time of about 30 seconds would exceed the permissible exposure level. For the lower measured radiation levels the permissible exposure time would be longer.

VIII. Conclusion

Each figure (1 through 9) shows the initial measured radiation levels for that particular plasma system as compared with the current occupational standard. As shown, all magnetic field measurements are within the permissible exposure range and do not pose as a radiation hazard. The electric field measurements, however, under certain working conditions could have exceeded permissible exposure levels when working near the Branson/IPC units with plexiglass windows in the door. Installation of replacement windows with RF shields eliminated this source of radiation.

The replacement windows with RF shields eliminated all potential exposure except where leakage may occ''r around improperly d''r seals.

IX. Recommendations

Although the operators were not likely to have been exposed to excessive radiation because of the work procedures involving sh rt potential exposure times and long distances, the following recommendations are made for preventive measures.

1. Management should post warning signs as indicated in 29 CFR 1910.97.

2. Operators should be made aware of the health hazards associated with radiofrequency radiation and the means of reducing exposure to potentially high radiation through increasing distance from source, keeping potential exposure times to a minimum, and by shielding the source.

3. For the plasma systems where leakage was found around the edges of the door (figure 8), inspect the door seals and remove excessive paint and other obstacles that would prevent a tight seal and thus allow radiation to leak from a closed door. A program for inspecting and maintaining seals should be instituted.

4. In the future, any plasma etchers systems should be equipped with windows that includes an RF shield.

X. REFERENCES

1. Cox, C., J. Flesch, B. Gunter.: Hewlett-Packard Company, Loveland, Colorado, NIOSH Technical Assistance Report No. 80-97-713. Cincinnati, National Institute for Occupational Safety and Health, 1980, 10pp

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XII. DISTRIBUTION AND AVAILABILITY

Copies of this report are currently available upon request from NIOSH, Division of Standards Development and Technology Transfer, Technical Information Branch, 4676 Columbia Parkway, Cincinnati, Ohio 45226.

After ninety (90) days the report will be available through the National Technical Information Service (NTIS), Springfield, Virginia 22161. Information regarding its availability through NTIS can be obtained from the NIOSH Pulbications Office at the Cincinnati, Ohio address.

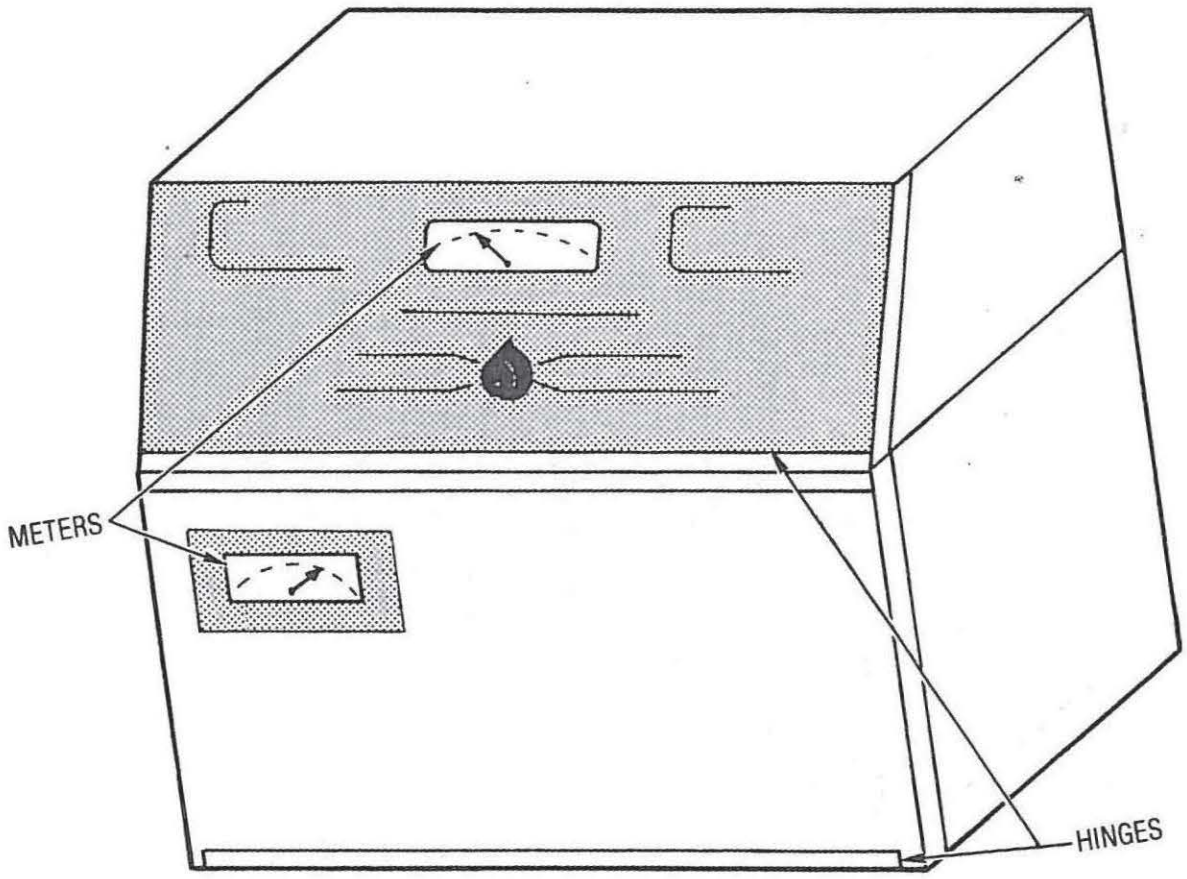
Copies of this report have been sent to:

1. Ohio Department of Health
2. NCR Microelectronics - Miamisburg, Ohio
3. OSHA Region V
4. NIOSH Region V

FIGURE 1
NCR MICROELECTRONICS — MIAMISBURG
MIAMISBURG, OHIO
HETA 81-435

*E — Field (V^2/M^2)
Standard = 4.0×10^4

**H — Field (A^2/M^2)
Standard = 25.0×10^{-2}



*Reading Door Open = 0
*Reading Door Closed = 0

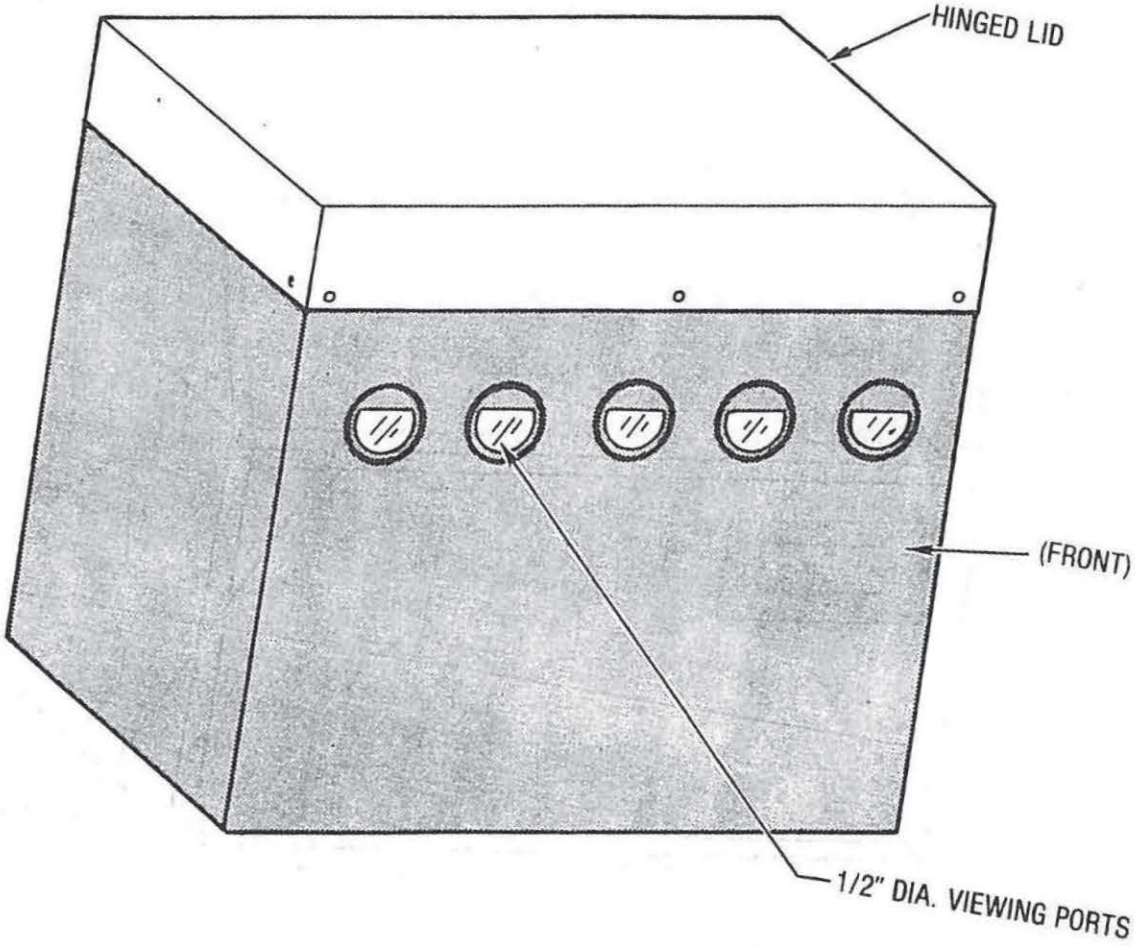
**Reading Door Closed. = 1×10^{-2}
**Reading Door Open = 5×10^{-2}
**Reading at 2" Away = 0

TEGAL MODEL 700 (PLASMA IN LINE) CHART RECORDER FA 1415
ACC #FA 1413 Service #7234
R & D

FIGURE 2
NCR MICROELECTRONICS — MIAMISBURG
MIAMISBURG, OHIO
HETA 81-435

*E — Field (V^2/M^2)
Standard = 4.0×10^4

**H — Field (A^2/M^2)
Standard = 25.0×10^{-2}



*Contact Measurements = 0 (All Surfaces)
*Generator = 0 (Front and Back)

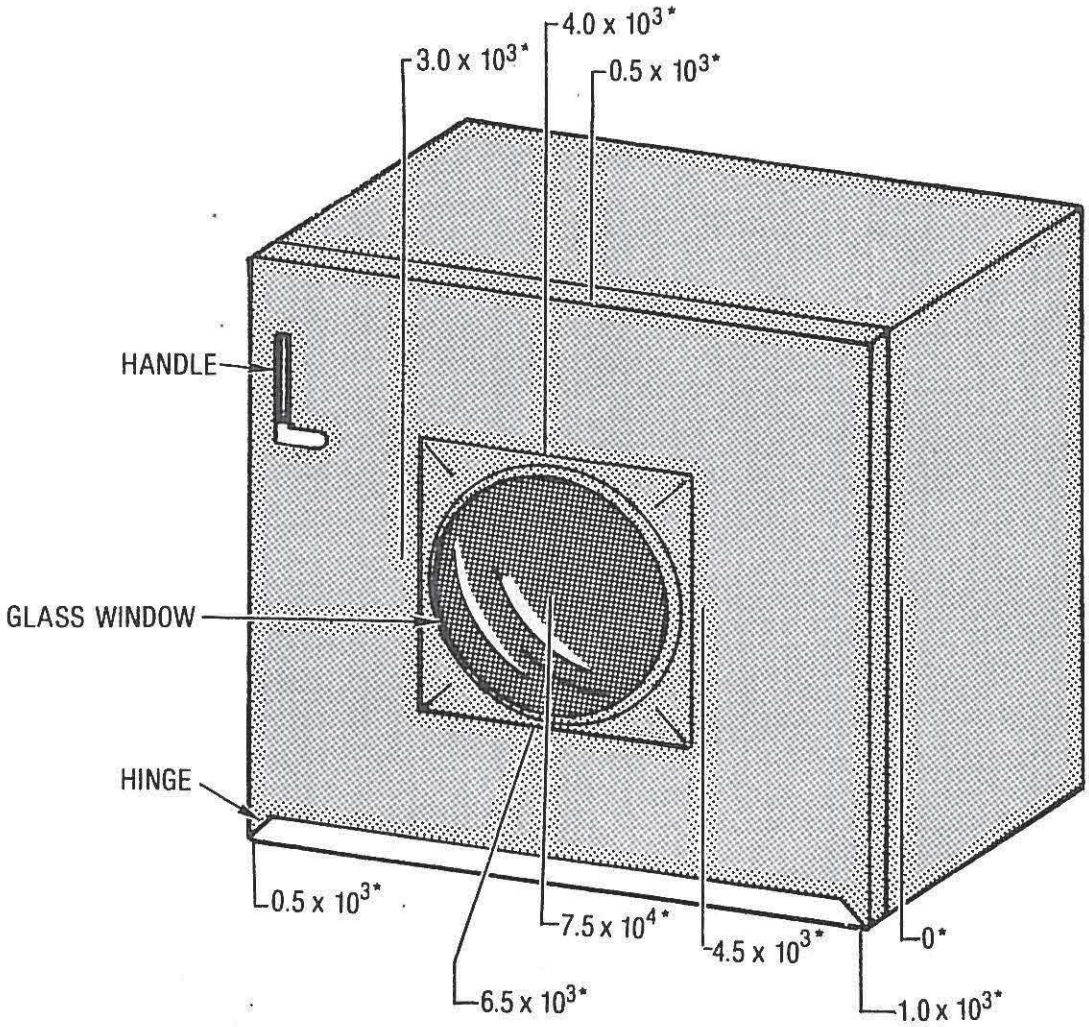
**Generator = 0 (Front and Back)
**Underneath Planer-Etcher at Rear of Cabinet = 0

BRANSON/IPC MODEL 2000 800 WATT (PLANER — ETCHER)
ACC #FA 1412 Model #PM 1421 Reactor
Model 1500 R. F. Generator (Serial #5335-4)
R & D

FIGURE 3
NCR MICROELECTRONICS — MIAMISBURG
MIAMISBURG, OHIO
HETA 81-435

*E — Field (V^2/M^2)
Standard = 4.0×10^4

**H — Field (A^2/M^2)
Standard = 25.0×10^{-2}



*Reading at 6" From Glass = 3.0×10^3
*Reading at 9" From Glass = 0

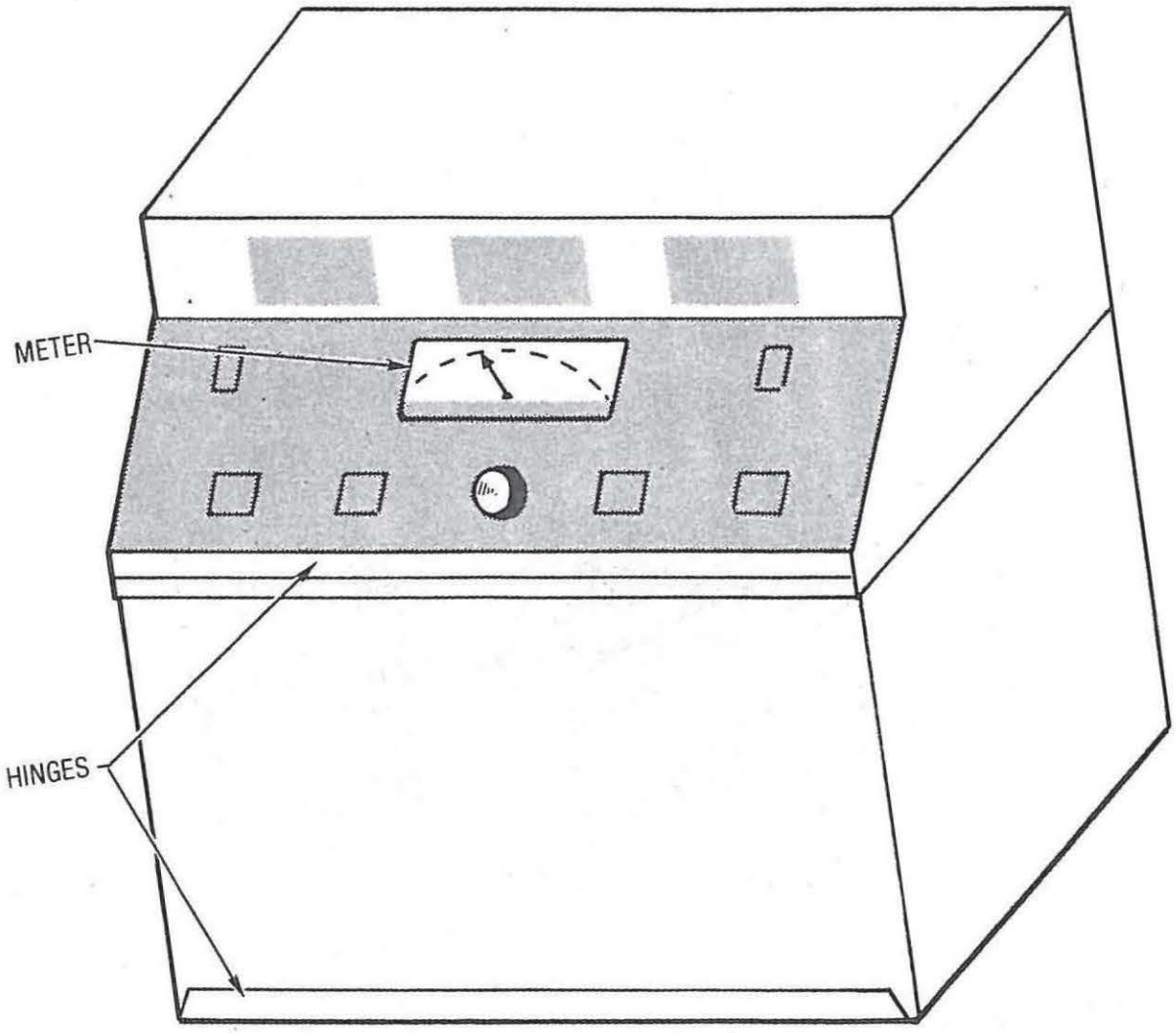
**Door (Front Edge) = 1.25×10^{-2}
**Door at 6" = 0

BRANSON/IPC PLASMA BARREL ETCHER 400 WATT
NCR #627069 ACC #FA 1417
R. F. Generator FA #1419 (Used 3 Hr/Day)
R & D

FIGURE 4
NCR MICROELECTRONICS — MIAMISBURG
MIAMISBURG, OHIO
HETA 81-435

*E — Field (V^2/M^2)
Standard = 4.0×10^4

**H — Field (A^2/M^2)
Standard = 25.0×10^{-2}



**All measurements = 0

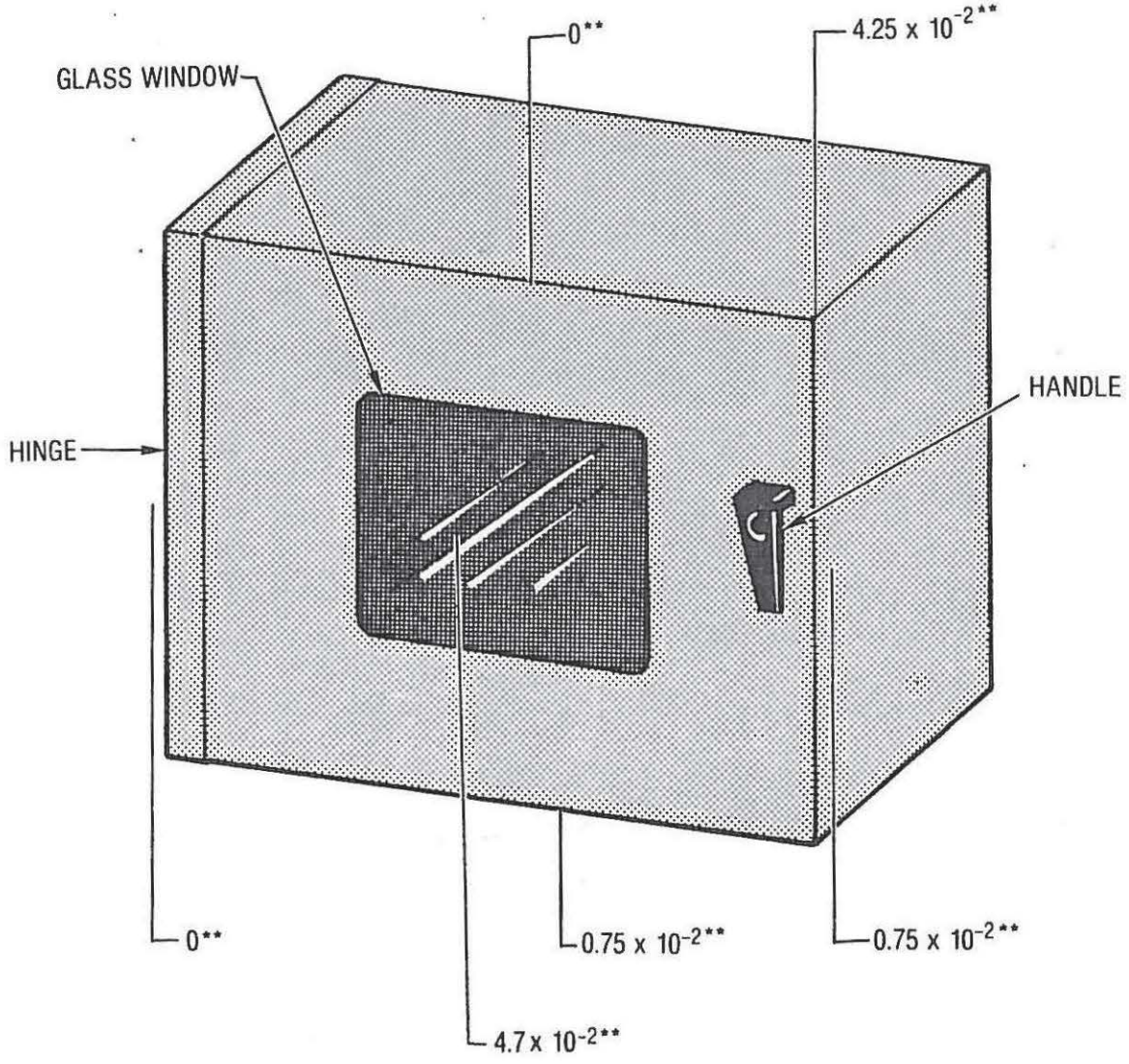
*Reading Door Open = 0
*Reading Door Closed = 0

TEGAL MODEL 701 PLANER PLASMA ETCHING
PRODUCTION

FIGURE 5
NCR MICROELECTRONICS — MIAMISBURG
MIAMISBURG, OHIO
HETA 81-435

*E — Field (V^2/M^2)
Standard = 4.0×10^4

**H — Field (A^2/M^2)
Standard = 25.0×10^{-2}



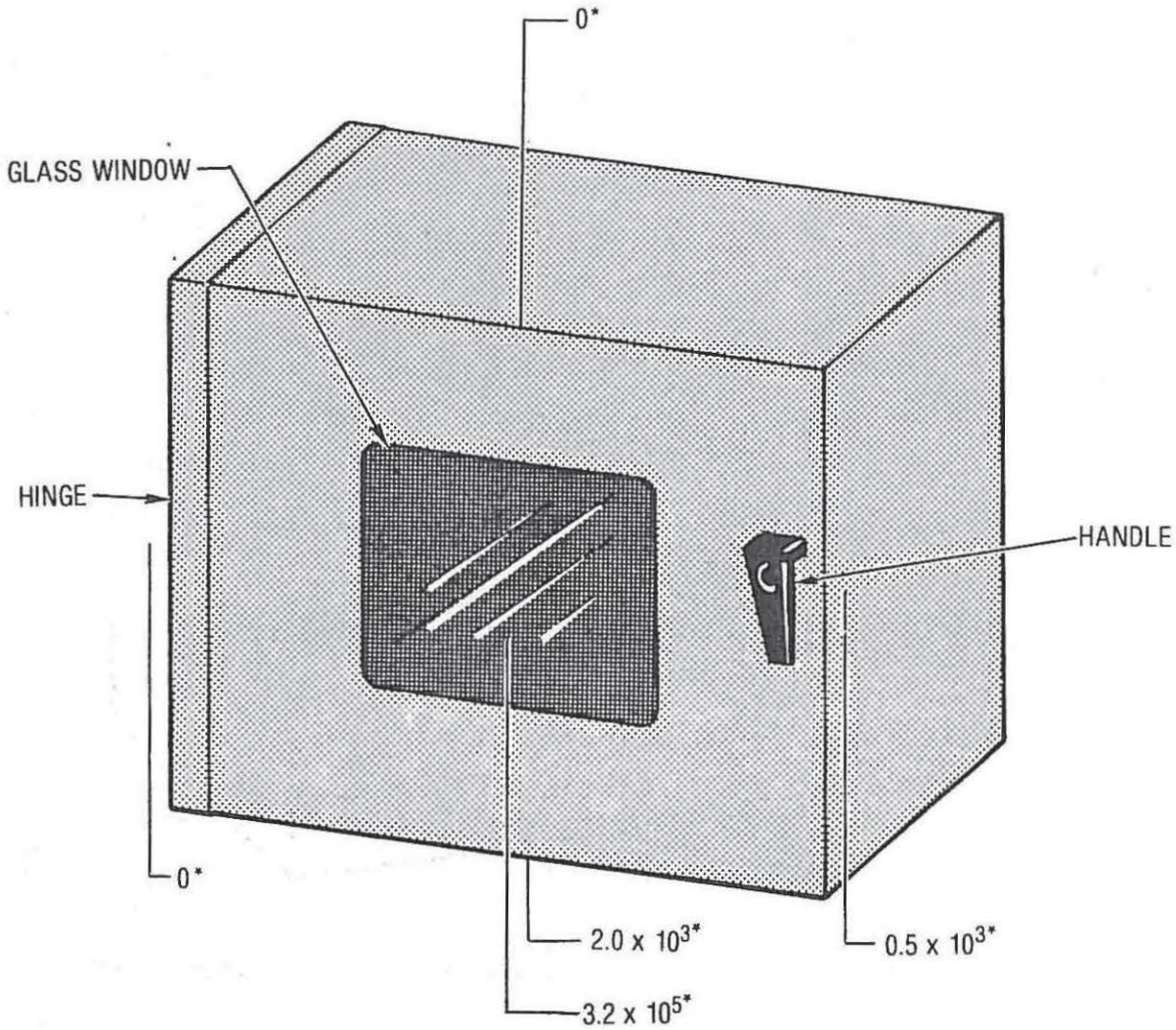
**6" Away All Readings = 0

BRANSON/IPC 4000 SERIES FA 972 LINE 4 ASHER
PRODUCTION

FIGURE 6
NCR MICROELECTRONICS — MIAMISBURG
MIAMISBURG, OHIO
HETA 81-435

*E — Field (V^2/M^2)
Standard = 4.0×10^4

**H — Field (A^2/M^2)
Standard = 25.0×10^{-2}



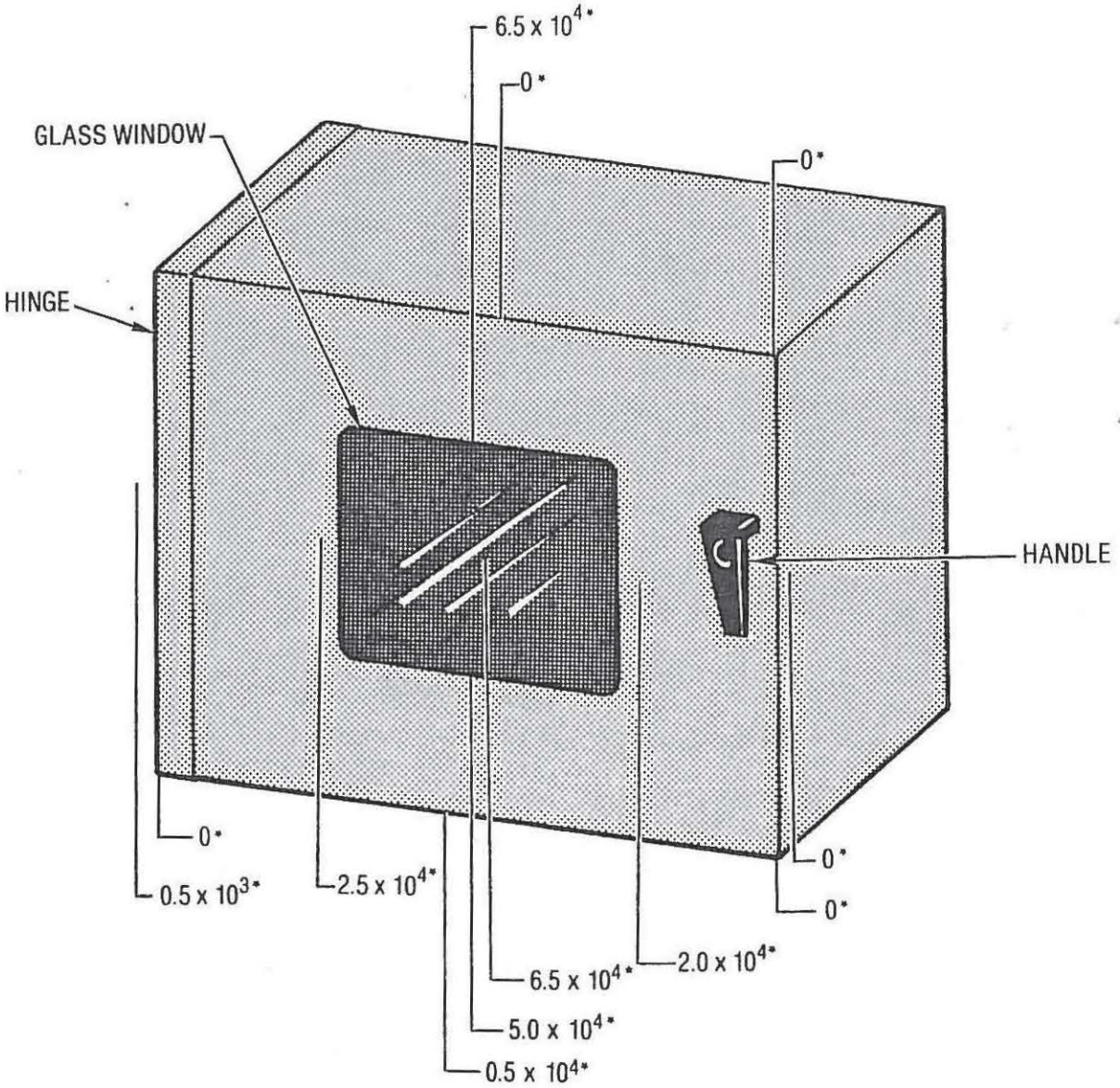
*Reading at 3" From Glass = 4.0×10^4
*Reading at 10" From Glass = 0

BRANSON/IPC 4000 SERIES FA972 LINE 4 ASHER
PRODUCTION

FIGURE 7
NCR MICROELECTRONICS — MIAMISBURG
MIAMISBURG, OHIO
HETA 81-435

*E — Field (V^2/M^2)
Standard = 4.0×10^4

**H — Field (A^2/M^2)
Standard = 25.0×10^{-2}



*Reading at 8" From Glass = 0

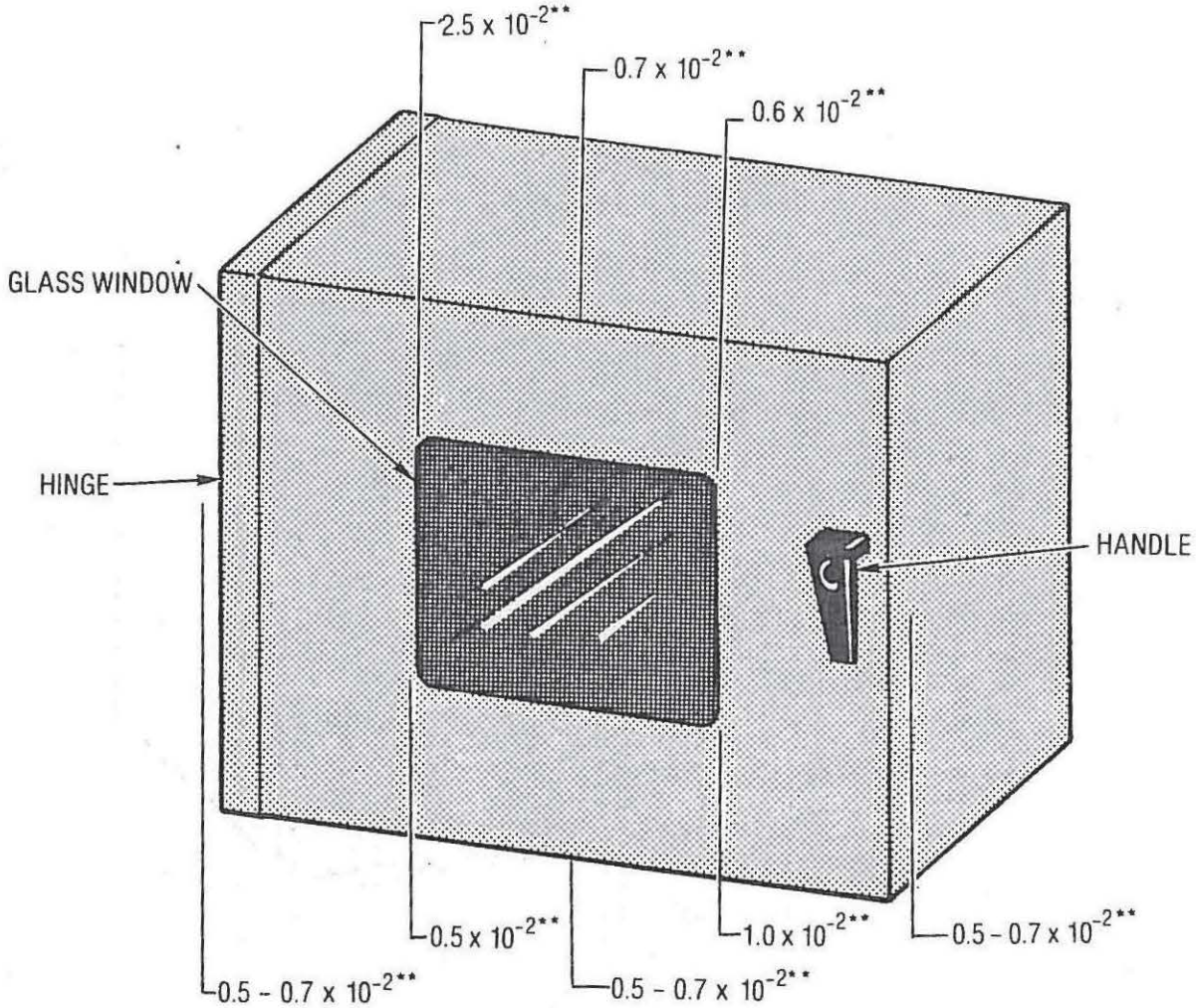
**Lower Right Corner = 0.5×10^{-2}
**All Other Readings = 0

BRANSON/IPC (2000 SERIES)
PRODUCTION

FIGURE 8
NCR MICROELECTRONICS — MIAMISBURG
MIAMISBURG, OHIO
HETA 81-435

*E — Field (V^2/M^2)
Standard = 4.0×10^4

**H — Field (A^2/M^2)
Standard = 25.0×10^{-2}



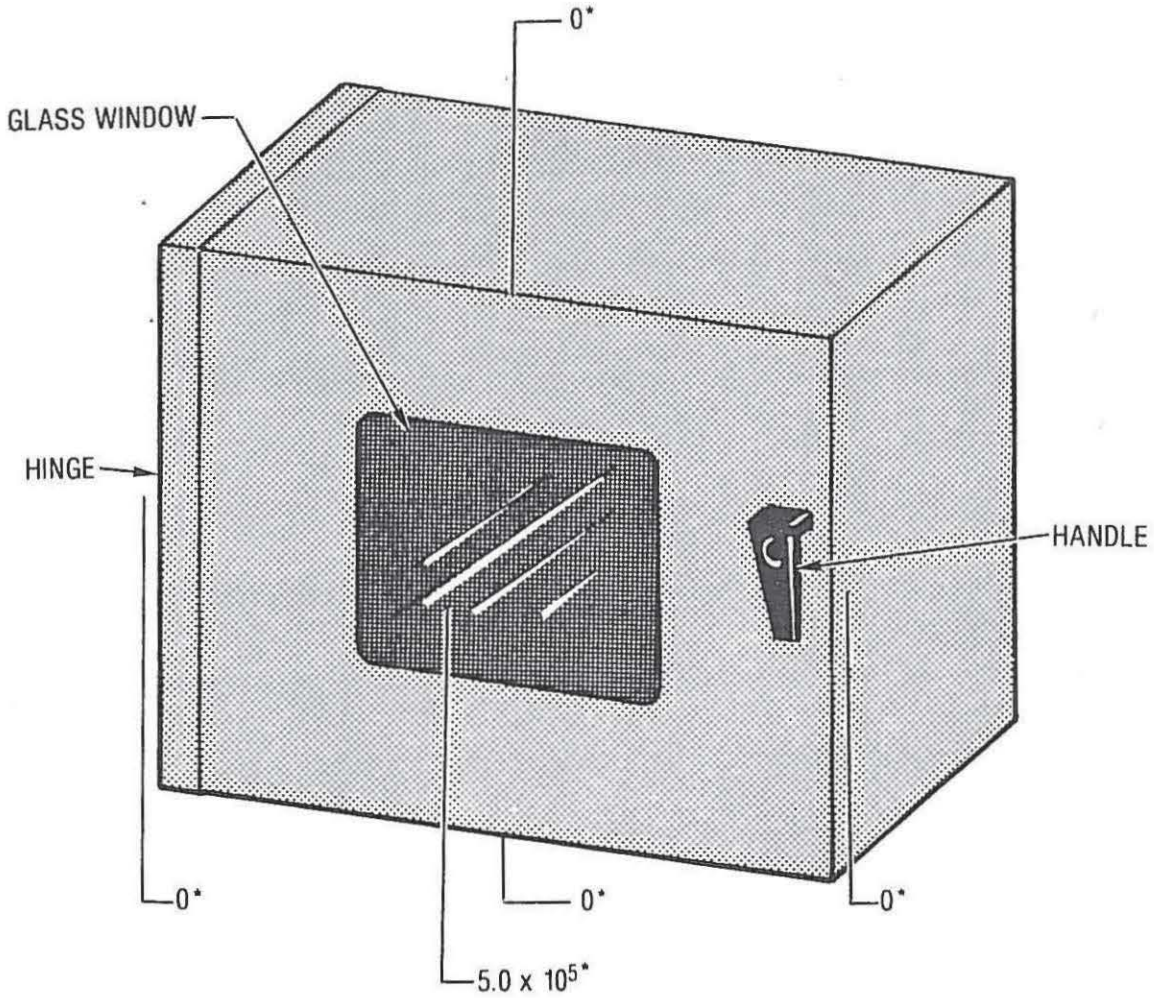
*All Readings Around External Cover = 0
*All Readings Around Door = 1.0 - 3.0 x 10^5
*Reading at Center of Glass in Door = 4.0 x 10^5
*Reading at 9" From Glass = 0
**All Readings at 4" = 0

DIONEX — 4000 SERIES ASHER 400 WATT
PRODUCTION

FIGURE 9
NCR MICROELECTRONICS — MIAMISBURG
MIAMISBURG, OHIO
HETA 81-435

*E — Field (V^2/M^2)
Standard = 4.0×10^4

**H — Field (A^2/M^2)
Standard = 25.0×10^{-2}



*Reading at 4" From Glass = 4.0×10^4 (V^2/M^2)
*Reading at 12" From Glass = 0

**Center of Window = 6.0×10^{-2}
**Top Open = 25.0×10^{-2}
**Door Open/Top = 25.0×10^{-2}

BRANSON/IPC (400W) SERIES 2000 #623644 Etcher Line #1
PRODUCTION