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Agency

Pesticides and
Toxic Substances
Enforcement Division
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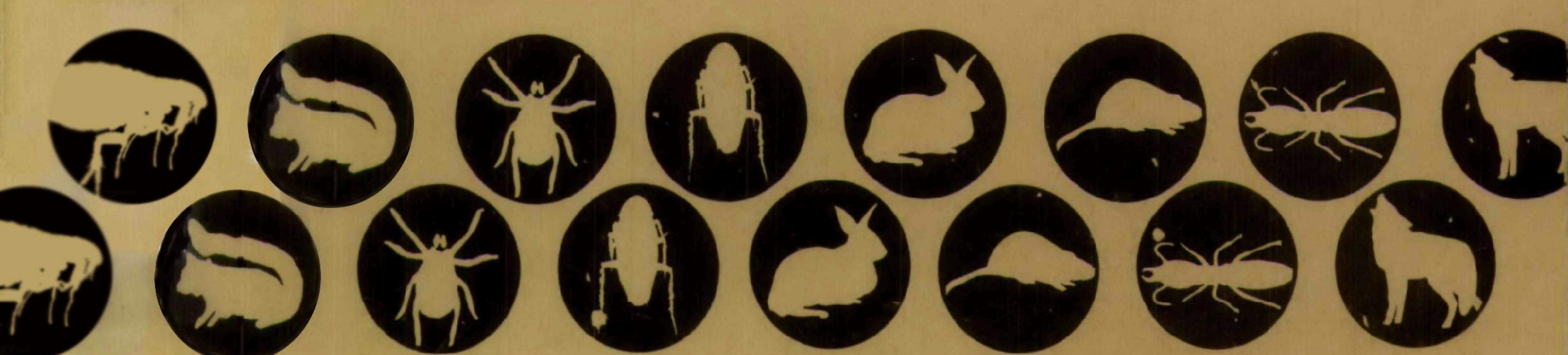
Investigation of Efficacy and Enforcement Activities Relating to Electromagnetic Pest Control Devices



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FOREWORD

In an era of increasing environmental concern, humans sometimes seek a panacea to solve various problems. In the area of pest control, one such proposed alternative to the use of chemicals for rodent and insect control is a group of instruments known as Electromagnetic (EM) Pest Control Devices. The manufacturers of these devices claim that the units are effective against many common rodent and insect pest species, yet they claim that beneficial animals are not harmed. The means by which these devices supposedly attain this control is through a magnetic field emitted by the device which acts as a shield and causes pests within its zone of influence to stop eating, drinking, and mating. Because no pre-market testing is required for pesticide devices, there was no background data to decide whether these EM devices were actually effective.

In 1977, the Pesticides and Toxic Substances Enforcement Division (PTSED) undertook a cooperative testing program with three other government agencies and two universities which was designed to determine if the theory of low-level EM emission could be utilized in pest control.

Results of these studies indicated clearly that there were no biological effects on the pest species tested. It was also found that in many cases little or no electromagnetic radiation was actually emitted from the devices.

At the outset of the investigation, the Environmental Protection Agency was aware of only a few major manufacturers of EM devices. As the program progressed, however, PTSED uncovered an industry constituting some thirty manufacturers/distributors, with an annual sales volume of several million dollars. Since receiving the results of electronic and biological testing, a total of thirty-six enforcement actions have been taken against manufacturers or distributors. These actions were taken on the basis that the devices were ineffective and therefore misbranded according to the provisions of the Federal Insecticide, Fungicide, and Rodenticide Act, as amended.

In addition, a court challenge of a Stop Sale, Use or Removal Order (SSURO) by one manufacturer led to the initial decision of Administrative Law Judge Marvin E. Jones that the device was indeed misbranded, that the SSURO was valid and that a civil penalty should be assessed against the manufacturer.

The following report outlines PTSED's approach to the problem, the results of studies completed for the program, and the ensuing enforcement actions. I wish to thank the participants in the program for their research efforts and for their willingness and skill in presenting their findings in the legal arena.

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INTRODUCTION

Description of the Program

The Environmental Protection Agency (EPA) has responsibility for the regulation of pesticides and pest control devices subject to the provisions of the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) as amended. Section 3 of FIFRA requires that pesticides be registered and that data be submitted to the Agency in support of registration. FIFRA does not give EPA the authority to require the same pre-market submission of data for pest control devices. Whether a pest control agent is considered a pesticide or a device is resolved in Sections 2(h) and 2(u) under FIFRA. Briefly, if an agent uses physical or mechanical means to trap, destroy, repel, or mitigate a pest, it is considered to be a device. If the agent incorporates a substance or mixture of substances intended to prevent, destroy, repel, or mitigate a pest, it is considered to be a (chemical) pesticide.

On July 3, 1975, the Administrator of EPA promulgated regulations which provide that all devices are subject to the requirements of FIFRA section 2(q)(1) (misbranding), section 7 (establishment registration) and section 12 (unlawful acts). FIFRA section 2(q)(1)(A) provides that a product is misbranded if "its labeling bears any statements, designs or graphic representation --- which are false or misleading...." Regulations at 40 CFR 162.10(a)(5) expand upon what EPA may consider false or misleading. These include statements which make false or misleading claims regarding composition, effectiveness, safety, or government endorsement of the product.

Electromagnetic devices initially came to the attention of the EPA in 1976, when the AMIGO was first marketed by Mira Manufacturing Company, Pine Valley, California. Market surveillance by Regional and Headquarters staff and consumer inquiries regarding effectiveness of electromagnetic devices led to scientific investigation of the claims that were being made.

Manufacturers of the devices claimed that rodent and insect pest species such as rats, mice, squirrels, moles, gophers, coyotes, roaches, termites, aphids, ants, and thrips were either killed or prevented from eating, drinking or mating by waves of electromagnetism or "contraclusive" magnetism produced by the device. However, they assert, harmless or domesticated animals such as dogs, cats, horses, earthworms, bees, fish and birds would not be affected by the magnetism because of differences in their physiology due to domestication. The manufacturers further claimed that laboratory animals or caged wild animals, because of their dependence on humans for survival, were not expected to be affected by output from the devices.

Agency and other scientists could find no information in the established scientific literature for any of these claims. The testing program described in this publication arose as a result of a desire on the part of EPA to determine whether electromagnetic pest control devices were effective against species of public health related pests and, if not, to take enforcement actions removing the devices from the market.

Since 1976 the number of manufacturers has increased from one to nearly thirty. Because of the proliferation of these devices and the cost of acquiring and testing each device model, the Electromagnetic Device Testing Program was established with the objectives of categorizing all available devices into two or three types and testing biologically only representatives of each type.

To this end, the National Bureau of Standards performed electronic analyses of fifteen devices in 1978 and 1979. Their paper, included in section B of this publication, grouped the devices into two major categories based on the characteristics of electronic output: (1) pulse output devices and (2) 60 Hertz alternating current output (60 Hz AC) devices.

Efficacy tests were performed by five organizations against the major pest species claimed to be controlled by the devices. The University of California, Davis, tested AMIGO (Phase 2), NATURE SHIELD, and MAGNA PULSE against the house mouse and the Norway rat in both laboratory and simulated field conditions. Field tests were employed by the Nevada State Department of Agriculture to evaluate control of pocket gophers by the MAGNA PULSE, NATURE SHIELD, and SIGMA devices. The Chemical and Biological Investigations Branch, EPA, Beltsville, Maryland, performed efficacy tests on AMIGO ELECTRONIC REPELLER, AMIGO PHASE II ELECTROMAGNETIC REPELLER, and NATURE SHIELD against house mice and Norway rats.

The U.S. Forest Service, Southeastern Experiment Station at Gulfport, Mississippi, ran several field studies to test the efficacy of the NATURE SHIELD, MAGNA PULSE and SIGMA against subterranean termites and woodboring beetles. They also monitored nearby fire ant colonies. Scientists at the University of California, Riverside, studied the effects of the same three devices on the mortality, individual growth, and population sizes of German and American cockroaches, drywood termites, and confused flour beetles.

Results of all of these studies were presented to the EPA on January 16, 1979. The National Bureau of Standards was unable to detect any electromagnetic fields surrounding the pulse output type devices. For the 60 Hz AC units their results showed that the field strength would be less than the earth's magnetic field at three meters. Several common household applicances were found to generate electromagnetic fields similar to the 60 Hz AC units.

In more than twenty tests against ten species of pest rodents and insects there was no demonstrated efficacy either in field, laboratory, or simulated field tests.

Accordingly, the Pesticides and Toxic Substances Enforcement Division directed the EPA Regional Offices to begin enforcement actions against both those devices which had been tested biologically and those which had been identified by the National Bureau of Standards as falling into one of the two categories of electromagnetic devices.

Enforcement Actions

Background

In conducting its market surveillance of pest control devices, EPA is empowered by FIFRA with several regulatory options for handling those units which are determined to be misbranded. These are: enforcement letters; civil warning letters; Stop Sale, Use or Removal Orders; seizures; voluntary recalls; civil complaints; criminal penalties; and injunctive relief.

An enforcement letter is an informal method utilized by EPA to inform persons or companies that they are in possible violation of EPA statutes or regulations. It contains suggested voluntary remedies to help solve the problem. A civil warning letter is an official warning of possible violations of EPA statutes or regulations.

A Stop Sale, Use, or Removal Order (SSURO) may be issued on a written list or printed form to any person who owns, controls, or has custody of a misbranded device. Upon issuance of the order, any movement of the specified device('s) in commerce is illegal. A court ordered seizure of misbranded devices is rarely invoked but is useful against products already distributed in commerce and as a back-up for SSURO's when the provisions of such orders are not being complied with. Although the Federal pesticide law contains no authority for a recall, the Agency may make a request to the distributor for a voluntary recall of violative pesticides or devices.

In concert with, or independent of any of the above actions, the Agency can also issue a civil complaint to any wholesaler, dealer, retailer or other distributor who violates any provision of the Act and may assess a civil penalty of up to $5,000 for each offense. For this same group, if it can be shown that they have knowingly violated any provision of the Act, they may be subjected to criminal penalties. Upon conviction, they can be fined up to $25,000 and/or imprisoned for up to one year.

Lastly, FIFRA section 16 vests the U.S. District Courts with the authority to specifically enforce, prevent, and restrain violations of the Act. The EPA can request injunctive relief within a U.S. District Court when all of the above administrative remedies has been diligently exercised, yet the violation has continued unabated.

Strategy

The results of the EPA sponsored tests proved to the Agency's satisfaction that the use of low-level electromagnetic emission for the control of pests was ineffective. It was felt that the situation warranted a swift, decisive, and well coordinated enforcement response.

For this reason, the EPA requested that inspectors from certain Regional Offices visit the designated device manufacturers for purposes of issuing a SSURO, requesting that they initiate a voluntary recall down to and including the retail level and conduct a books and records search for purposes of identifying distributors in the event that a manufacturer was uncooperative in following through on the recall. These initial enforcement actions were to be completed within a two-week period. These Regions were also asked to issue civil complaints within a reasonable time frame. For any other suspected EM device manufacturers found in the future, samples are to be collected and tested electronically at the National Bureau of Standards. If the Bureau's tests show that any of these devices are based on the electromagnetic principle, EPA headquarters will contact the appropriate Regional Office with instructions to proceed in a manner similar to that described in the above paragraph.

Results

Table 1 is a status report on each of the known manufacturers/distributors of EM devices and the actions that had been taken at the time of printing of this publication.

From January 1979 - October 1980, a total of thirty-six enforcement actions have been taken against manufacturers or distributors of electromagnetic devices. These include six civil complaints, twenty-one Stop Sale Use or Removal Orders, eight recalls, and one criminal referral.

On December 5, 1979, Administrative Law Judge Marvin E. Jones concluded that THE ELIMINATOR manufactured by Monty's Environmental Services, Inc. was ineffective and therefore misbranded. He ruled that the SSURO issued in March, 1979, was valid and should not be disturbed and that a civil penalty of $1,250 should be assessed against the manufacturer. Because THE ELIMINATOR had been tested electronically and assigned to the pulse output group of EM devices, it was not tested biologically. The evidence presented at the hearing on the biological effects of similar devices led to the implication that THE ELIMINATOR would have no biological effects.

Table 1

STATUS REPORT - ELECTROMAGNETIC DEVICE PROGRAM

Manufacturer/Distributor Name and Address	Device Name(s)	Action taken
Mira Manufacturing Company Box 15 Pine Valley, CA 92005	AMIGO ELECTRONIC REPELLER	SSURO.
	AMIGO ELECTRONIC REPELLER PHASE 2, Model C-100	SSURO.
	AMIGO, AMIGO PHASE 2, AMIGO PHASE 2 RODENT CONTROL, and AMIGO PHASE 2 RABBIT CONTROL	SSURO.
Key Milling Company Clay Center, KS	AMIGO ELECTRONIC REPELLER PHASE 2 Model C-100	Formal recall.
Unity Systems Gulf, Inc. 3101 37th St. Suite 142 Metairie, LA 70001	AMIGO ELECTRONIC REPELLER PHASE 2 Model C-100	SSURO.
	AMIGO Model 75-C	Device examined by Bureau of Standards; referred to Region for action.
R. B. Amigo, Inc. Downs, KS 67437	AMIGO	Believed to be same device as above.
Ecology Systems, Inc. Oklahoma City, OK	ECOLOGY MACHINE	SSURO.

Manufacturer/Distributor Name and Address	Device Name(s)	Action Taken
Ron Wilson 654 N. Shephard Houston, TX	AMIGO PHASE 2	SSURO.
Sentry Manufacturing, Inc. 3rd and E Streets Box 14 Fairbury, NB 68352	AVIS RODENT CONTROL	SSURO; voluntary recall; civil complaint issued.
LNL, Inc. 3513 Ryder St. Santa Clara, CA 92626	COUNTDOWN B-100	SSURO; voluntary recall.
Electronic Pest Controls, Inc. 4001 W. Devon Chicago, IL 60646	EPC MARK V	SSURO; voluntary recall; referred to U.S. Attorney for criminal action; civil complaint issued.
The VRP Corporation P.O. Box 1134 10936 Portal Drive Los Alamitos, CA 90720	ERGON	Civil complaint issued; company testing device and no longer selling.
Electronic Exterminators, Inc. Box 2787 West Palm Beach, FL 33402	EXTERMA PULSE and NOFLEEZ	SSURO; civil complaint issued; hearing conducted, awaiting decision.
Solara Electronics, Inc. 1591 Sunland Lane Costa Mesa, CA 92626	NATURE SHIELD	SSURO; voluntary recall; civil complaint issued; company out of business.

Manufacturer/Distributor Name and Address	Device Name(s)	Action Taken
Area Sales Office Solara Electronics, Inc. Suite 300 National Press Bldg. 529 14th Street N.W. Washington, DC 20045	NATURE SHIELD	SSURO.
Piper Products, Inc. P.O. Box 7, W. Midland Drive Norwich, NY 13815	PIED PIPER	Referred to Region.
Orgolini Manufacturing Company, Inc. 260 Freeport Blvd. Sparks, NV 13815	SIGMA	SSURO.
International Trade Specialists, Inc. 711 W. 17th Street P.O. Box 661 Costa Mesa, CA 92627	TERRA-TROL	Enforcement letter; company out of business.
DAL Industries, Inc. 3954 NE 5th Avenue Fort Lauderdale, FL 33334	THE ELIMINATOR and MAGNA PULSE	Company out of business.
RAM Magnetic Pest Control Systems 5254 East Beverly Blvd. Los Angeles, CA 90072	RAM	Enforcement letter; company out of business.
Bell Products 696 Watson Way Sparks, NV 89431	MAGNA PULSE	SSURO; voluntary recall.

Manufacturer/Distributor Name and Address	Device Name(s)	Action Taken
A.M.I. 8020 West 47th Street Lyons, IL 60634	MARK V ELECTRONIC PEST CONTROLLER (similar to PEST SHIELD)	SSURO; voluntary recall.
American Products 5550 North Elston Avenue Chicago, IL 60630	PEST SHIELD (similar to MARK V)	SSURO; voluntary recall.
Moulton Company Somerset, WI 54025	RODENT CONTROL	Company out of business.
Monty's Environmental Services, Inc. 315 W. Alabama Houston, TX 77006	HAPPY PET FLEA CONTROL, MAGNA PULSE, and THE ELIMINATOR	SSURO. SSURO. SSURO; civil complaint issued; hearing conducted, decision issued, penalty collected.
LaEsSCo, Inc. Suite B-1 1703 Belle View Blvd. Alexandria, VA 22307	THE EXECUTOR II COMMERCIAL, THE ELIMINATOR RESIDENTIAL, and MAGNA PULSE	Company out of business.
S.P.S. Ecology Corporation 129-15 92nd Avenue Richmond Hill, NY 11418	SPS 100	Sample requested.
Magna Wave, Inc. 8137 North Austin Morton Grove, IL	PEST-X	SSURO.

Manufacturer/Distributor Name and Address	Device Name(s)	Action Taken
Mr. Robert M. Larson Tech-Trol System 13100 West Center Street Brookfield, WI	PEST-X	SSURO.
X-Pel Company, Inc. 2455 University Ave. St. Paul, MN 55114	X-PEL PEST CONTROL	Sample reouested

ENFORCEMENT SUMMARY OF ACTIONS REGARDING ELECTROMAGNETIC DEVICES

Number of Known Manufacturers/Distributors	28
Criminal Referrals	1
Civil Complaints Issued	6
SSURO's Issued	21
Recalls Issued	8
Total Actions Taken	36
Referrals to Region/Action Pending	2
Enforcement Letters	2
Reported Out-of-Business	6
Samples Requested/Still Outstanding	2
Hearings Conducted	2

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ELECTROMAGNETIC PEST CONTROL DEVICES

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ELECTROMAGNETIC PEST CONTROL DEVICES

1.0 Executive Summary

At the request of the Environmental Protection Agency (EPA), the National Bureau of Standards, Center for Consumer Product Technology, evaluated eight models of electromagnetic pest controllers provided by EPA. The units were evaluated to characterize any detectable electromagnetic output but no judgment of the effectiveness of the devices as pest controllers was made.

Visual and X-ray inspection and electromagnetic measurements showed the units can be grouped into two categories based on characteristics of the output signal--the principal characteristics being either a pulse output or a 60 Hz AC output. For the pulse output devices, no significant external electromagnetic field was found. The 60 Hz units were found to generate detectable magnetic fields. For all units, the fields detected would be less than the earth's magnetic field at distances of three meters or more. Some common electrical equipment was found to generate electromagnetic fields of the same order of magnitude as that produced by these pest controllers.

2.0 Introduction

The National Bureau of Standards (NBS) was requested by the Environmental Protection Agency, Office of Enforcement, Pesticides, and Toxic Substances Enforcement Division, to perform a limited evaluation of eight models of electromagnetic pest controllers provided by EPA. Two samples of some models were provided. These controllers are electrical or electronic devices intended to rid an area of pests such as rodents, rabbits, roaches, termites, and fleas depending on the particular unit. NBS was requested to 1) characterize any measurable electromagnetic output, but was to make no judgment of the effectiveness of the devices as pest controllers; 2) determine if models have any commonality of their outputs which would allow grouping or classifying of similar units for biological testing; and 3) determine the feasibility of developing a standard test method for measuring and classifying units based on the nature of the output. Due to the time and resources available, the work was primarily directed to characterize and provide comparative measurements of the outputs, and to identify commonality between outputs. To the extent practical, quantitative measurements were made and operating principles or circuit components identified.

Nondestructive evaluation techniques were requested by EPA since limited samples were obtained and several were subsequently used by EPA for biological experiments to determine the effects on animals or insects. The units were to remain operable should further measurements be requested. The measurements were to use readily available equipment, where possible, so that further measurements could be made by independent laboratories if necessary.

The EPA was responsible for obtaining test samples and contacts with manufacturers. The EPA requested technical information and circuit diagrams but received only catalog or advertising type literature. It was assumed that the manufacturers did not choose to reveal this information. Many units were either potted or assembled with rivets, adhesive, or by other methods making nondestructive disassembly difficult. This construction limited the information obtained on circuits and components. Some units are battery-operated and their cases were opened to perform tests and inspect the battery supplies since batteries would be replaced in the field.

A review of literature at the beginning of the evaluation did not identify any published quantitative data on the electromagnetic fields from these devices. A subsequent paper by Wagner (1978)[1] reports data on several units.

3.0 Units Evaluated

The EPA furnished to NBS eight different types of electromagnetic pest controllers for evaluation. Two samples each of six of the types were furnished. A list of these electromagnetic pest controllers with an NBS assigned code for reference in data reporting and the EPA assigned sample number is given in Table 1. The letter refers to the type while the number designates the sample of that type. The NBS code is also used to identify the X-ray photographs in Appendix 2 and photographs of the outside of each unit in Figures 1 through 7. Units E1 and E2 were returned to EPA before photographs were obtained.

Table 1

Electromagnetic Pest Controllers

NBS Code	EPA No.
A1	Sample 131918 (03213)
A2	Sample 131918 (03199)
B1	Sample 131978A
B2	Sample 131978B
C1	Sample 168054
C2	Sample 168054
D	Sample 131901
E1	Sample 131902
E2	Sample 131903
F1	Sample 131905A
F2	Sample 131905B
G1	Sample 131906A
G2	Sample 131906B
H	Sample 123831

The units A1, A2, and B1, B2 are battery-operated. These units were received with batteries installed and the units operating. They have no on-off switch and operation is indicated by the periodic flashing of a small red light emitting diode (LED) in the center of the top of each case. Instructional material supplied with these units indicates that they should run for approximately six months at which time the batteries are to be replaced.

The other six types all operate from a 115 volt, 60 Hz, AC power supply. These likewise do not have an on-off switch but start immediately when plugged in. Units C, D, and E have a circuit fuse. Units F and G have both a circuit fuse and a small light to indicate when they are connected to the power supply. Unit H has an LED which periodically flashes to indicate when it is on.

4.0 Evaluation Procedure

Each unit was visually examined to the extent possible without destruction. One sample of each type was X-rayed to reveal hidden components, and each sample was subsequently

FIGURE 1 SAMPLE A1

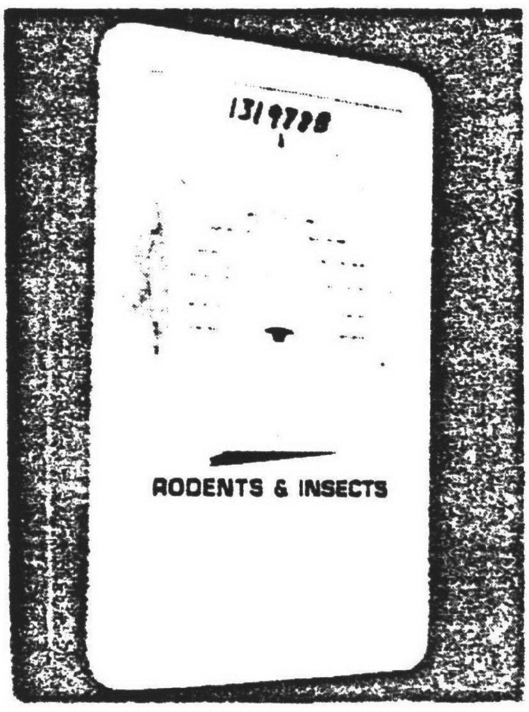

FIGURE 2 SAMPLE B2

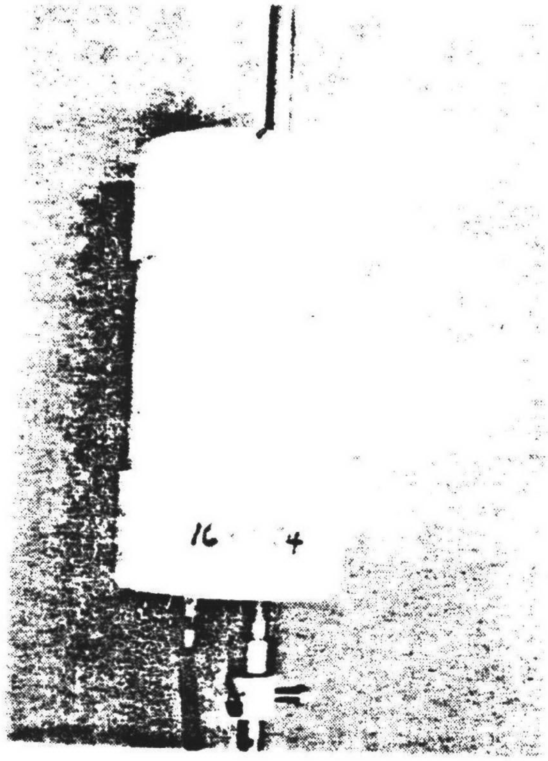

FIGURE 3 SAMPLE C1

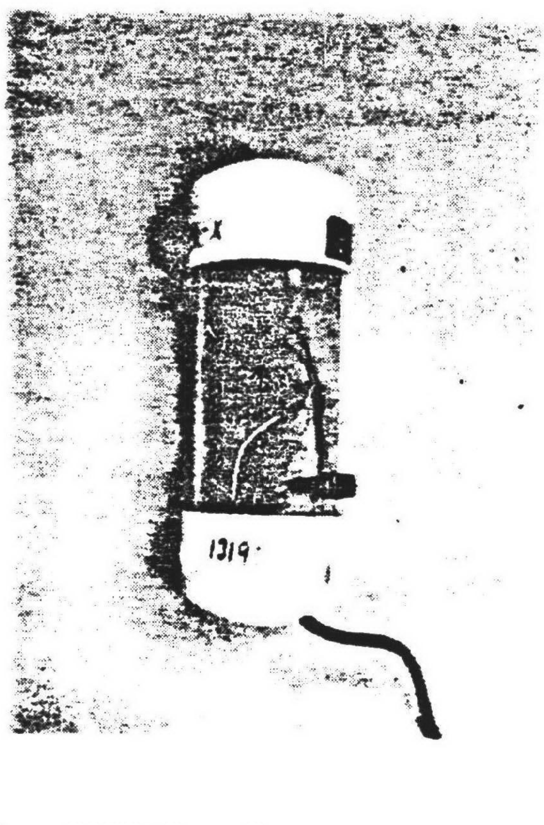

FIGURE 4 SAMPLE D

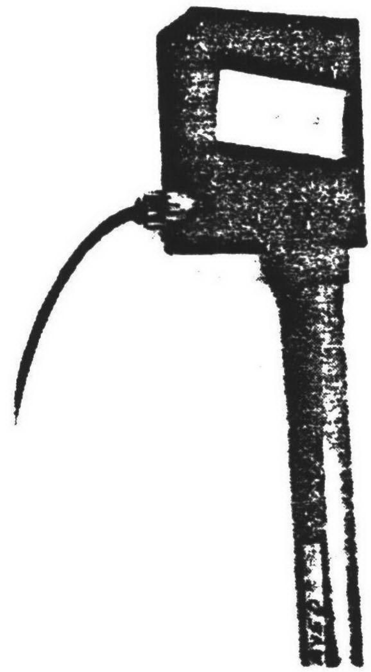

FIGURE 5 SAMPLE F1

FIGURE 6 SAMPLE G1

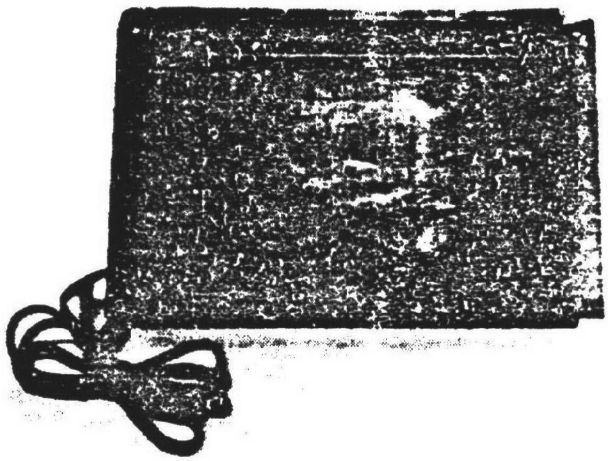

FIGURE 7 SAMPLE H

measured to characterize and, when possible, quantify any measurable electromagnetic field emitted.

4.1 X-Ray and Visual Examination

X-ray photographs (Appendix 2) were made of one sample of each of the types received. In most cases when a unit was X-rayed, three different photographs 90° apart were made to reveal all possible internal parts. The photographs at different angles (1) assist in revealing hidden parts, (2) reveal internal construction and parts location, (3) expose encapsulated (potted) integrated circuits, etc., and (4) assist in determining principles of operation. X-raying the units was considered to be nondestructive. Each unit was tested before and after X-raying and for six types, the X-rayed unit was compared to the non-X-rayed unit to verify that no change had occurred.

The visual examination was limited to outside inspection of the sealed units except for unit C2. Since A1, A2, B1, and B2 were battery-operated and the batteries had a finite life expectancy, the case screws were removed to inspect the battery packs and measure the operating current. It was also determined that it was necessary to open these units and make internal connections to the metal case and the battery to detect any signal. Unit C2 was opened for visual inspection. Its operation was found to be the same after opening as before opening.

4.2 Electromagnetic Measurements

Electromagnetic measurements for DC fields were made using a Schonstedt Model HSM-11 Station Magnetometer. This instrument can detect a field of 0.5 nanotesla and ambient fields can be neutralized to within 0.5 nanotesla (nT). The earth's field is approximately 50,000 nT or 0.5 gauss (10^5 nanotesla = 1 gauss). AC magnetic field measurements were made using a search coil as a detector. The coil consists of 250 turns of No. 34 insulated wire wound with close spacing in a single layer on a nonmagnetic form (phenolic) of 2-inch diameter. The overall length is approximately 2 inches. For sinusoidal steady state magnetic fields, the magnitude of the field can be calculated from the voltage output of the coil and the period of the waveform. Two of these search coils were used at times to make simultaneous measurements at different locations around the AC operated units. A dual-trace oscilloscope was used to display, measure amplitude, and analyze the AC or pulse type signals. With this equipment the outputs from two search coils to the unit under test could be examined and analyzed simultaneously. A dual channel DC amplifier-recorder was used in conjunction with the oscilloscope to make permanent records of the magnitude and frequency of the random or programmed on-off operation of certain units. The recorder input was from a search coil.

For magnetic fields at 60 Hz, this equipment can resolve less than 100 microtesla (1 gauss) peak-to-peak. The sensitivity increases in proportion to frequency. This coil is useable up to about 100 kHz which is in excess of any frequency measured or anticipated based on the size of the coils in the units which are visible in the X-rays. For the search coil used, the peak-to-peak magnetic field in microtesla is equal to 0.31 times the peak-to-peak voltage (V) in millivolts times the period (T) of the waveform in milliseconds, 16.7 ms for 60 Hz.

[magnetic field (μT) = 0.31 x V(mV) x T(ms)]

5.0 Results of Evaluation

General results on each unit examined are given in this section. More detailed results are given in Appendix 1.

5.1 Results of X-Ray and Visual Examination

Visual inspection and examination of the X-ray photographs and the electromagnetic measurements show similarities between different units. Units A1, A2, B1, B2, and H are similar except that the A's and B's are each powered by four 12-volt lantern-type batteries in parallel and H operates from 115 volts AC. The X-rays show that each has three coils and nine integrated circuits on a printed circuit board. The electronics all are encapsulated preventing further nondestructive circuit determination. In the A and B units, the coils and electronics are contained within sheet metal cubes: in the A units totally enclosed, in the B units with one side open which faces the ground when normally installed. The metal cube in A appears to be aluminum, the metal in B is magnetic. The cube in the A units is contained along with the batteries in a totally closed aluminum case. The metal in these units would act as an electrostatic shield. Only low frequency magnetic fields of any magnitude would be expected to penetrate the metal, particularly from the A unit's totally-closed case. Unit H does not have any metal shield.

The C, D, E, F, and G units appear similar. Each has multiple coils, from 2 to 6, which appear to be mounted on a magnetic core. The two coils in E are side by side, the others are all axial. Unit F1 appears to have three thryristor semiconductor switches which control the coil currents and Unit G2 appears to have a thermal switch mounted against each coil. Fuses and pilot lights are the only other significant components identifiable.

5.2 Results of Electromagnetic Measurements

DC Magnetic Field. The DC magnetic field measurements made using the magnetometer were confined to units B1 and B2. At any position of the probe relative to the unit, and before any data was taken, the ambient external fields were neutralized to about 1/2 nT. Then the unit was placed next to the probe and lined up as indicated by the instructions with the N (north) mark pointing north. A continuous chart recording was made of the change in the magnetic field due to the operation of the unit. The magnetometer probe was positioned in several locations around the unit to obtain the distribution profile of the field generated by the unit. Chart 1 shows a portion of a recording for unit B1 and chart 2 shows a recording for unit B2. The detectable change in the magnetic field is approximately 8-12 nT. During the testing, the opening of a laboratory door produced more field change than was recorded due to unit B1. There is a periodic shifting of the magnetic field that most likely is caused by the different internal digital type integrated circuits operating to produce pulses. The higher frequency components are discussed in a later paragraph. The magnitude of the detected changes of DC magnetic field are about 1/5000 of the earth's magnetic field.

The magnetometer recordings of the output of units B1 and B2 showed no significant differences between these units. Since the X-ray and visual examination showed that units A1 and A2 and H were very similar in construction, in parts and layout to B1 and B2, these were not checked using the magnetometer. They are covered in the following section, where higher frequency measurements are described.

AC Magnetic Field. The A, B, and H units were examined with the search coil and oscilloscope. No detectable output was found from any of these units. Therefore, other techniques were used to examine these units.(2)

The covers were removed from units B1 and B2. The oscilloscope high input lead was connected to the metal can and the ground lead connected to the negative battery terminal. Curves 1 and 2 are photographs of the oscilloscope patterns for units B1 and B2 respectively. These outputs appear to be digitally generated because of the low frequency and exact pattern repetition. Similar patterns were measured in units A1 and A2 between the metal box and the battery negative terminal. These are shown in curves 3 and 4 respectively. No metal can or box is used in unit H, as in A and B. The oscilloscope was connected between one of the coil leads and the negative side of the internal power supply. A similar pattern, shown in curve 5, was measured. Any external fields resulting from these internally measured signals was not determined by analysis and none were measured.

The other five units, C, D, E, F, and G, all produce 60 Hz magnetic fields measurable with the search coil. All units switch the fields on and off in a generally random pattern. The various coils may be energized at different times resulting in several levels of field strength depending on the number of coils energized. The coils are energized from several seconds up to several minutes depending on the particular unit. The long intervals and random patterns indicate some type of thermal sensor determines the switching. The outputs from these units are shown in charts 3 through 11.

The maximum fields were measured at various distances from each unit. The search coil voltage and the calculated magnetic fields are given in Table 2 for each unit. The largest fields were from unit C2 mounted on a 2.4 meter iron pipe.

Examination of the data in Table 2 shows a very rapid decrease in field strength as the search coil is moved away from each pest controller under test. At distances which are large compared to the diameter of the coil, the magnetic field from a current carrying coil decreases as the third power of the distance.(3) That is at 10 meters the field will be 1/1000 of the field at one meter. The measurements at the 0.15 and 0.3 meter distances are not far enough from the coils to follow this inverse cube relationship. Doubling the distance of the search coil from 0.15 m to 0.3 m from the unit reduces this detected field strength over a range of 3 to 18 times. These units are claimed to be effective over an area of 2 to 12 hectares(4) (5 to 30 acres). From the measurements at 0.3 m in Table 2, it can be calculated that at 3 m the fields from various units will be from 1/5 to 1/500 of the earth's field. The data in Table 3 shows the earth's magnetic field strength throughout the United States for a comparison. Figure 8 is a plot of the decrease in the electromagnetic field strength with distance from the C2 unit. The points at 0.3 m and 0.6 m (1 and 2 ft) are laboratory measurements. From 3 meters to 12 meters (10 to 40 feet) are calculations based upon the field decreasing as the third power of the distance. That is at 12 m the field will be $(1/4)^3$ times that at 3 m or approximately 0.3 microtesla (0.003 gauss).

6.0 Fields From Other Electrical Equipment

As a comparison between the 60 Hz fields generated by the pest controllers and those encountered from everyday 115 volt 60 Hz equipment, the field from several common items was measured and is shown in Table 4. A comparison between data in Table 2 with that in Table 4 indicates some common shop and household electrical equipment produce 60 Hz fields in the same order of magnitude as those generated by the pest controllers. The principal difference between those of the same magnitude is that the pest controllers are turned on and off in a fixed pattern or in a random pattern while the shop and household units usually operate for longer periods. These motor units can be random in their on-off operation.. Some of the 115 volt 60 Hz motors showed pulses with larger magnitudes. Figure 9 is a bar graph of data from Table 4 showing a comparison of the electromagnetic fields of pest controllers and common 115 volt 60 hz equipment when examined at a distance of 0.3 m (1 ft) to the

Table 2
EMF Versus Distance

Code	Coil[1] Distance	Signal mV (V)	Period ms (T)	Constant .31	Peak-to-Peak Microtesla .31 VT	Gauss	Commen
C2	closest[2]	15 000	16.7	.31	77 700	777	top[3]
	0.15 m (6 in)	500	16.7	.31	2 600	26	
	0.3 m (12 in)	60	16.7	.31	300	3	
C2	closest	18 000	16.7	.31	93 000	930	end[4]
	0.15 m (6 in)	6 800	16.7	.31	35 000	350	8 ft pip
	0.3 m (12 in)	2 300	16.7	.31	12 000	120	on unit
	0.6 m (24 in)	200	16.7	.31	1 000	10	
D	closest	150	16.7	.31	780	8	
	0.15 m (6 in)	30	16.7	.31	160	2	
	0.3 m (12 in)	10	16.7	.31	50	.5	
E2	closest	2 750	16.7	.31	14 000	140	
	0.15 m (6 in)	110	16.7	.31	600	6	
	0.3 m (12 in)	10	16.7	.31	50	.5	
F1	closest	1 250	16.7	.31	6 000	60	
	0.15 m (6 in)	200	16.7	.31	1 000	10	
	0.3 m (12 in)	60	16.7	.31	300	3	
G2	closest	3 500	16.7	.31	18 000	180	
	0.15 m (6 in)	360	16.7	.31	1 900	19	
	0.3 m (12 in)	20	16.7	.31	100	1	

(1) Search Coil; 250 turn, #34 insulated wire, 2-inch diameter, 2-inch lengt

(2) Closest; search coil in contact with case of unit under test.

(3) Top; search coil located on top of unit.

(4) End; search coil located on end of unit

100 μT = 1 gauss

Table 3

Earth's Magnetic Field
(Geomagnetic Information, NOAA, Boulder, CO)

State	Microtesla (avg)	State	Microtesla (avg)	State	Microtesla (avg)
Alabama	53	Maryland	56	Rhode Island	56
Alaska	57	Massachusetts	56	South Carolina	54
Arizona	52	Michigan	59	South Dakota	59
Arkansas	55	Minnesota	60	Tennessee	55
California	51	Mississippi	54	Texas	52
Colorado	55	Missouri	57	Utah	54
Connecticut	56	Montana	58	Vermont	57
Delaware	56	Nebraska	57	Virginia	56
Florida	51	Nevada	53	Washington	57
Georgia	53	New Hampshire	57	West Virginia	57
Hawaii	36	New Jersey	56	Wisconsin	59
Idaho	57	New Mexico	53	Wyoming	57
Illinois	57	New York	57		
Indiana	57	North Carolina	55		
Iowa	58	North Dakota	60	U.S. Average	55 (.55 gauss)
Kansas	56	Ohio	57		
Kentucky	56	Oklahoma	55		
Louisiana	52	Oregon	55		
Maine	57	Pennsylvania	57		

100 microtesla = 1 gauss

Table 4

EMF From Electrical Equipment

Item	Coil Distance	Signal mV (p-p)	Period ms	Constant .31	Peak-to-Peak Microtesla = .31 VT	Gauss
Soldering Gun	close for max.	40	16.7	.31	207	2.1
Soldering Iron	close	10	16.7	.31	52	.5
Lab Power Supply	for maximum (close)	40	16.7	.31	207	2.1
Nonvented heater fan	for maximum (close)	20	16.7	.31	104	1.0
Transformer unloaded	for maximum (close)	80	16.7	.31	414	4.0
Bandsaw 1/4 HP motor	for maximum (close)	30	16.7	.31	155	1.6
Shop grinder	for maximum (close)	200	16.7	.31	1035	10.4
Hand drill 1/4 HP	for maximum (close)	1500	16.7	.31	7766	77.7
	.3 meter (1 ft)	20	16.7	.31	103.5	1.04
1/4" hand (different brand)	for max. (close)	100	16.7	.31	518	5.18
Kitchen Blender	.3 meter (1 ft)	10	16.7	.31	50.1	.5
Kitchen Blender(1)	.3 meter (1 ft)	400	16.7	.31	2070	20.7

(1) This is 60 Hz envelope of higher frequency pulses, probably brush noise, and would be similar to the pulse generating units A, B, and H1.

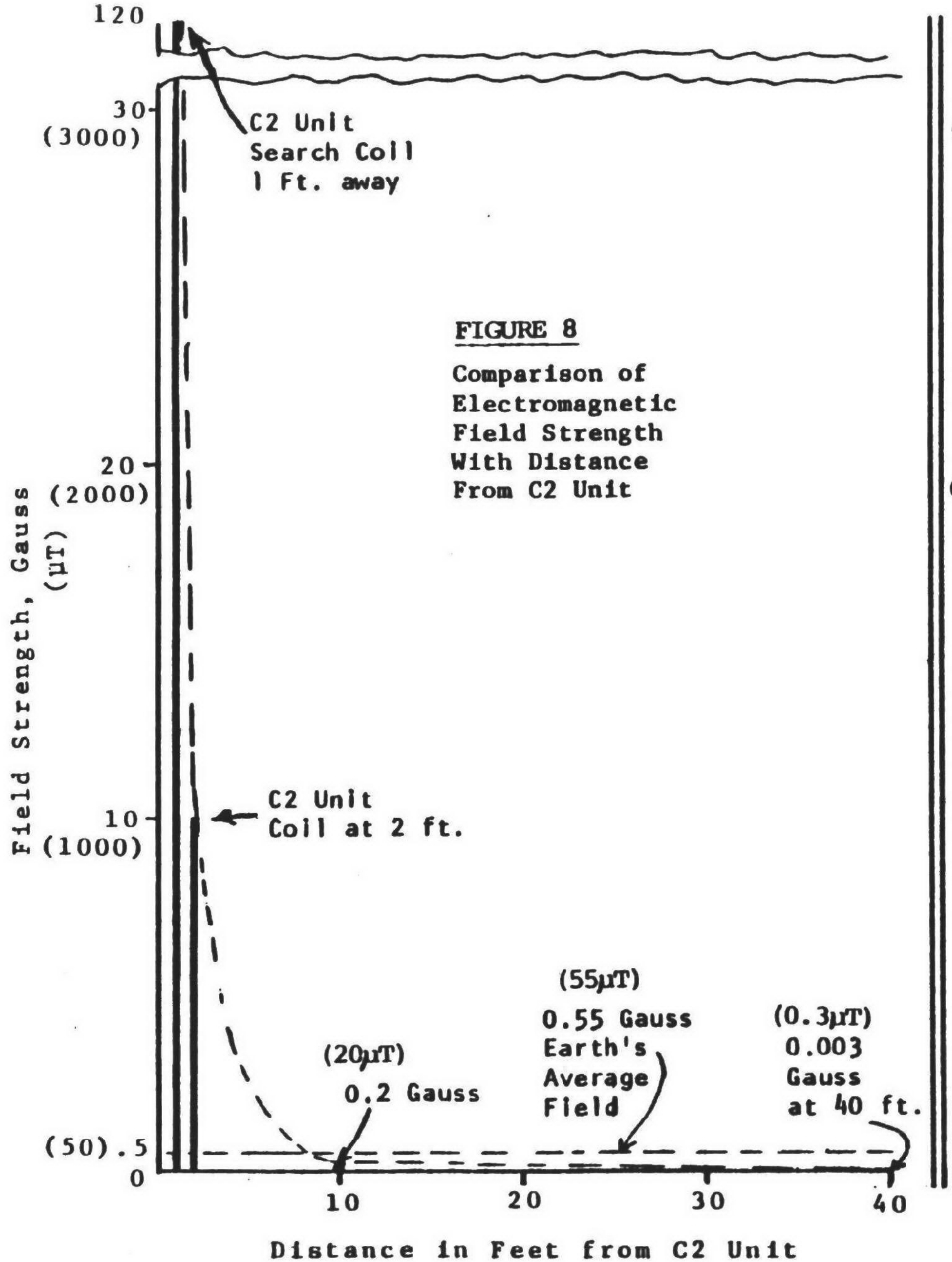

FIGURE 8

Comparison of Electromagnetic Field Strength With Distance From C2 Unit

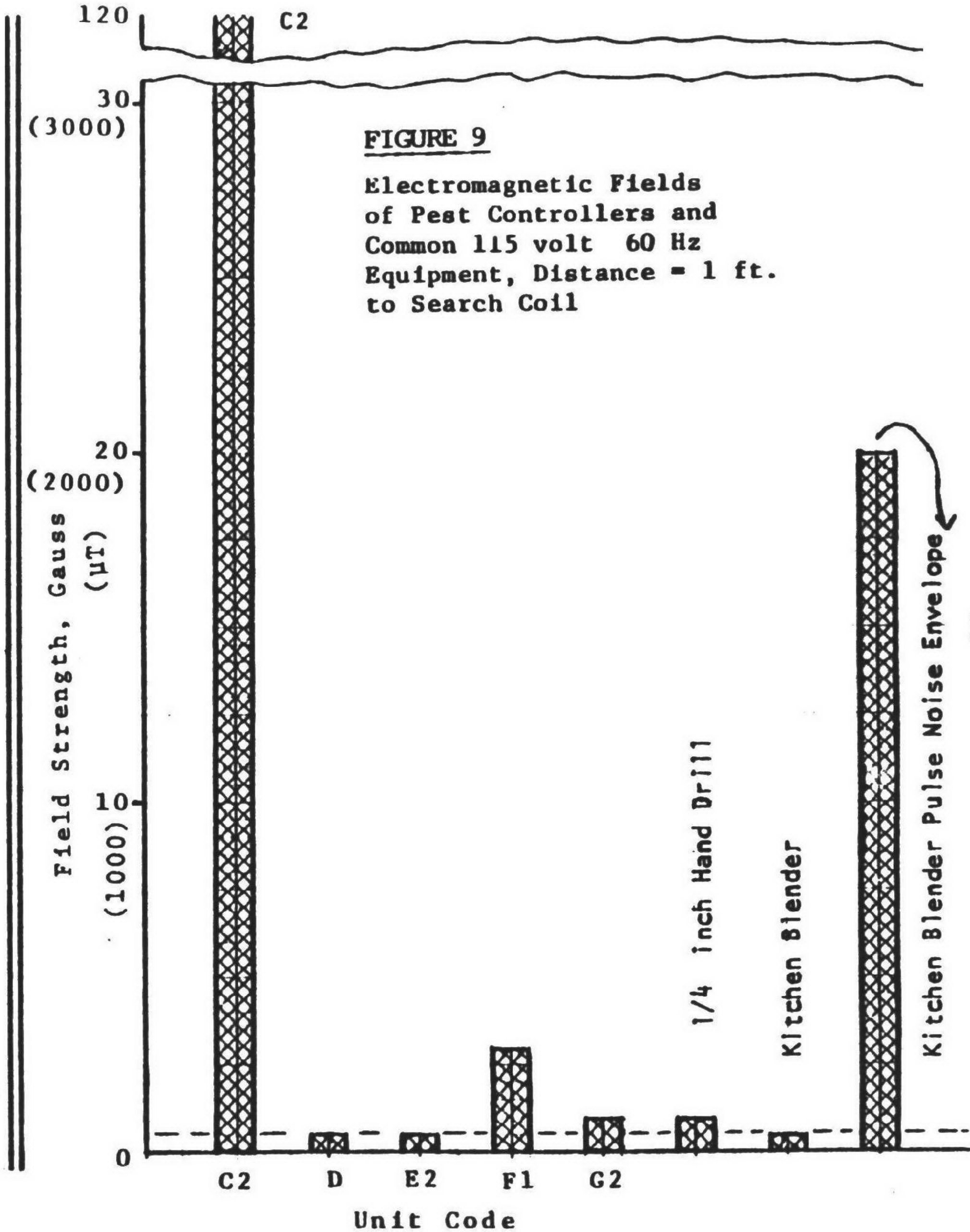

FIGURE 9

Electromagnetic Fields of Pest Controllers and Common 115 volt 60 Hz Equipment, Distance = 1 ft. to Search Coil search coil detector. The kitchen blender showed a 60 Hz envelope of high frequency pulses from the motor brushes and commutator in addition to a 60 Hz sine wave field.

7.0 Conclusions

The eight types of electromagnetic pest controllers furnished by EPA were examined. The NBS evaluation indicates these can be separated into two categories based on characteristics of the output signal: group 1, pulse output; group 2, 60 Hz sine wave output. Of the units evaluated, three (A, B, and H) are in group 1 and five (C through G) are in group 2.

Group 1 characteristics: 1) the units generate a low level, repetitive pulse pattern which was measurable by direct connection to the internal circuitry with an oscilloscope; 2) low power drain; 3) digital integrated circuits used to generate pulse pattern output. Evaluation of group 1 units resulted in no significant detectable external electromagnetic field with either a magnetometer or a search coil used as a detector with an oscilloscope. The only measurable signal from these units was found by direct connection to the metal case of two of the units and to the coil lead of the other unit with an oscilloscope. The short duration of both the positive and negative pulses for the units would produce very low average power radiated signals.

Group 2 characteristics: 1) output is a 60 Hz electromagnetic field; 2) operates from 115 volt, 60 Hz AC power; 3) have a random or repetitive on-off pattern; 4) appear to operate by driving various numbers of coils with 60 Hz AC.

The field generated by group 2 units was readily detectable by the search coil and oscilloscope. The electromagnetic fields from the 60 Hz units decrease very rapidly with distance from the unit as shown in Table 2. These fields will be less than the earth's magnetic field at three meters from any of the units. Figure 8 illustrates the rapid decrease of the electromagnetic field strength with distance. For a circular area of 2 to 12 hectares (5 acres and 30 acres) for which various units are claimed to be effective, the radius is approximately 76 meters and 200 meters (250 and 650 feet) respectively. For all units, the magnetic field emitted will decrease with the third power of the distance from the unit. For distances larger than 3 m, the earth's field would significantly exceed these emitted fields. These units transmit alternating fields which may vary in amplitude and "on" time. Figure 9 shows that some common 115 volt 60 Hz equipment generates electromagnetic fields in the same order of magnitude as produced by these pest controllers.

The NBS evaluation of this group of electromagnetic pest controllers indicates a standard test procedure can be developed for the group 2 devices to characterize their output. This would utilize standard laboratory equipment such as the volt-ohmmeter, oscilloscope, magnetometer, and chart recorders. For group 1 devices, a standard test procedure can be developed to determine if any significant external electromagnetic field is emitted.

The biological effects of the electromagnetic fields on rodents, insects, and other animals were not evaluated by NBS.

NOTES

(1) Wagner, R.E., "Outputs of Electromagnetic Devices, Their Effects on Drywood Termites," Pest Control, September 1978, p. 20.

(2) The TEM cell at NBS, Boulder, CO, was considered for additional measurements but was unavailable at the required time.

(3) Robert Plonsey and Robert E. Collin, Principles and Applications of Electromagnetic Fields, p. 242, McGraw-Hill Book Co., 1961.

(4) 2 hectares are contained within a circle of 80 meters in radius.

8.0 Appendix

1. Details of Evaluation by Unit

At least one type of each unit was measured for maximum current consumption during operation. These results are summarized in Table 5.

Unit A: Visual inspection was made of units A1 and A2. Since these were battery-operated, their cases were opened. Four 12-volt lantern type batteries in parallel supply power to the electronics which is contained in a metal cube in the center of a spun aluminum case. The case separates into two halves of upper and lower approximately equal sections. X-ray photographs of A1 show nine integrated circuits in the potting compound (three 16 pin and six 14 pin), several resistors and capacitors, and three coils mounted in a delta layout on top of the potting block. The coil's axes are parallel to the ground when the unit is installed as recommended. Laboratory testing and these photographs indicate that this unit uses digital circuitry to generate a pulse pattern output. The top portion of the case was removed to attach the oscilloscope probe to the metal box housing the electronics with the scope ground probe being connected to the negative terminal of the unit's battery power supply. The top of the metal box was placed back on the unit, but not screwed into place, being careful not to short out the oscilloscope connections to the case. This procedure reduced the 60 Hz pickup present and produced a noise-free pattern on the oscilloscope for analysis and the photographs, curve 3 (unit A1) and curve 4 (unit A2). Both units show a definite pattern repetition rate of approximately 6.4 seconds. This repetition rate coincides with the flashing of the LED indicator on top of the metal housing cover. The units are obviously operated from digital circuitry due to the exactly repeated output pattern. The units are supposed to be identical in output but there is significant variation between units A1 and A2 in the amplitude of the positive pulses within a pattern. This could be due to quality control problems or one unit not operating within design specifications.

Unit B: The X-ray photographs of unit B2 show that it also contains integrated circuits (six 14 pin and three 16 pin packages). Four 12-volt lantern batteries in parallel supply power for the unit. A metal cube with one side open houses the integrated circuits which are potted in an opaque material. Three coils in a delta form extend through the surface of this material. The coil's axes are parallel to the ground when the unit in its installed position. Likewise laboratory tests and these photographs indicate this unit uses digital circuitry to generate a pulse pattern output. This unit is housed in a plastic case with an LED mounted in the top to indicate the unit is operating. This LED flashes about every nine seconds.

The covers were removed from units B1 and B2. The oscilloscope was connected to the internal metal box for the high input lead and ground lead was connected to the negative battery terminal. Curves 1 and 2 are photographs of the oscilloscope pattern for units B1 and B2 respectively. This type of output is obviously digitally-generated because of the low frequency and exact pattern repetition. Units B1 and B2 have an equal number of positive pulses (24). Unit B1 has 26 negative pulses. Unit B2 shows two extra negative pulses of small amplitude between the normal spacing for the other negative pulses. These are probably due to a defective integrated circuit (IC) and not due to variation in the design since according to the manufacturer both units are supposed to be the same. The pulse pattern repeats approximately every 17.5 seconds. The small LED light on the top to indicate the unit is operating flashes approximately every nine seconds or twice for each pattern of pulses.

The two battery operated units, A2 and B2, were tested for output when installed in the ground. These were buried to 1/2 of their height (thickness) in the earth as recommended by the manufacturer. The oscilloscope was connected to the internal metal can and battery common terminal as in the laboratory tests. Unit A2 showed approximately a 40% decrease in output signal when the unit was in the earth relative to when it was tested in the laboratory.

For the other battery-operated unit, B2, installed in the earth, there was no change in the output signal relative to that measured in the laboratory.

Unit C: The unit C2 was X-rayed in two pieces because of its length. Both the top and base ends were photographed with approximately 45° rotation to reveal hidden parts. The photographs indicate six coils along a center rod with associated modular type circuitry printed circuit boards. There are three printed circuit boards. This unit was opened and inspection showed the six coils are connected as parallel pairs. Each pair is driven by one of the potted modules. There is some end-play between the coil retainers on the bottom and top of rod so the coils can slide along the rod when driven by opposing magnetic fields. From the chart recordings, photographs, and visual inspection of this unit, it is not possible to identify the type of components used to produce the output pattern shown in charts 3, 4, and 5.

Chart 3 is of unit C1 with a search coil[1] located around the top rod and one located around the bottom rod which was connected to a 2.4 meter iron pipe. From these the top search coil indicates a large amplitude 60 Hz (max. 15 V peak-to-peak) magnetic field of about four seconds duration that repeats every one minute and fifty seconds and a corresponding small field detected by the bottom search coil. Within this pattern, but not at uniform times, the top search coil indicated several reduced amplitude, four-second duration fields and the lower coil detected, at corresponding times, a larger amplitude field of approximately four seconds duration. Also in addition to these maximum fields in the bottom search coil, reduced fields were detected of approximately four seconds duration corresponding to similar detections in the top coil.

Similar recordings of unit C1 were made of unit C2. These are shown in charts 4 and 5. Chart 4 shows the calculations of the relative amplitudes from each coil for each approximately four second "on" time of the unit (max. 15.5 V peak-to-peak).

Chart 5 shows the output from the top search coil only for the period between 11 and 15 minutes after turn on. The top pair of coils is designed No. 3, middle pair No. 2, and lower pair No. 1. The pattern repeats every one minute and 50 seconds, but the operation of pairs 1 and 2 are not consistent in order of operation within the pattern. The difference in amplitude between the 1, 2, and 3 pairs of coils is due to the difference in each coil-pair distance from the search coil on the stub. The coil is closest to the No. 3 pair. The reason for the random on-off time of coil pairs 1 and 2 within the time pattern cannot be identified without more circuitry information or destructive examination of the encapsulated modules.

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(1) The search coil described was used to examine the characteristics of each unit for oscilloscope analysis and paper chart recording. Charts 3 through 11 are typical records of the outputs from the 115 volt 60 Hz units when detected by a search coil or coils. The chart speed in all recordings is 1 sec/mm with the smallest chart division equal to 1 mm. The minute marks are indicated down the center of the chart. The oscilloscope was used to determine that these units had 60 Hz outputs. The maximum amplitude detected by the search coil was determined from the oscilloscope calibration and indicated on each channel of recording. This reduced the time and confusion of adjusting the pen recorder to a specific level. All charts are a portion of a recording taken after each unit was turned on and run for some time. Recordings lasted from 15 minutes to nearly one hour to analyze the characteristics of each output.

When the unit C2 is initially turned on, all three coils are energized and the upper No. 3 pairs separate from the No. 2 and No. 1 pairs by the amount of travel possible for the coils along the rod, about 12 mm. This is accompanied by an audible vibration during the "on" time of about four seconds. This audible vibration also occurs when the 1 and 2 pairs are "on" simultaneously. Smaller audible vibrations were noticed when a single pair of coils was driven or for other combinations of pairs.

The driving signal to each pair of coils from its associated encapsulated module was measured as 115 volts 60 Hz during the four seconds period. When a pair of coils is being driven, they induced 60 Hz signal into the adjacent undriven pairs.

Unit D: Two X-ray photographs were made of unit D because of its length. This unit has a clear plastic center section. Visual inspection shows three coils mounted on a metal rod with some space between the coils so they can slide on the rod. A retainer on each end limits the travel. The X-ray photographs of unit D reveal very little additional identifiable circuitry. The random output pattern could be controlled by a thermostatic type switch which turns different coils on.

A paper chart recording was made of unit D (chart 6). The search coil was placed as near as possible along the clear plastic side, parallel to the center coil of the three coils mounted on the center rod. After initial startup, the unit turns off, but then operates in a random mode as shown in the chart. The output is low (0.26 volts peak-to-peak) as detected by the search coil. The duration of "on" time is variable. This unit appears to be controlled by a thermostatic type switch that is sensitive to the temperature of the unit which would also be affected by the ambient environment. This could produce the variation in time of operation and duration. The radiated field is always 60 Hz and can be less than one second in duration and up to several seconds after the initial startup. The lower amplitude signals are due to the random operation of the other coils which are not coupled as closely to the search coil as the center coil. This type of variable operation of different coils in a multi-coil unit was observed when testing units C1 and C2.

Unit E: The X-rays of unit E1 show two coils mounted adjacent to each other with their center axis spaced 75 mm apart. The coil centers are such that two units could be bolted together to increase the output fields. Each unit has a fuse. Other circuitry appears limited. The unit is also possibly controlled by a thermostatic switch.

The units E1 and E2 are also 115 volts 60 Hz powered pest controllers. Both are supposed to be identical and they operated essentially the same after the initial startup. Each was examined with two search coils placed on top with their axes on line with the axes of the internal coils as revealed by the X-rays. When unit 1 was turned on, a 60 Hz field was present from one coil for 15 minutes and then went off for 12 minutes. The other coil was on for 12 minutes and then off for 15 minutes. After the "off" time, the unit E1 produced a 60 Hz, 2.6 volt peak-to-peak sine wave. Duration of each transmission varied from less than one second to several seconds. Both of the coils would frequently be on simultaneously but would not necessarily start or stop at the same time. Examination of chart 7 reveals the random nature of the operation after warm-up between the time of 27 minutes and 31 minutes after turn-on. A very sensitive heat element that detects the temperature of each coil could produce this pattern. The ambient temperature would be a factor affecting the operating pattern.

Unit E2 exhibited similar characteristics as unit E1 except on startup each coil operated for approximately 3-1/2 and 2-1/2 minutes respectively, then both were off for 8-1/2 minutes. After this the random pattern shown in chart 8 began. All detected signals are 60 Hz sine waves and from 2.6 to 2.8 volts peak-to-peak at the search coils. This is the same amplitude as unit E1.

<u>Unit F</u>: The unit F1 consists of a metal box with an attached pipe. The X-rays show the box most likely contains three thyristor semiconductor switches and the pipe section contains several coils. The pipe and unit heat up with extended time of operation. Thermostats could be used to activate the thyristors to produce the pattern recorded in charts 9 and 10.

The output of units F1 and F2 were examined around the case with a search coil and the oscilloscope. Both are 115 volts 60 Hz powered units and radiate 60 Hz sine waves of varying amplitudes with time. Two search coils were used for charts 9 and 10, one located at the end of the unit and the other at the base of the case where the extension pipe exits. The coils were located for maximum output in these positions. The unit operated for approximately seven minutes at a constant amplitude, then the output dropped to a lower but constant amplitude (see chart 9). After approximately 11 minutes the unit went off. The detected amplitude at the higher level was 1.3 volts peak-to-peak at the base search coil and only 0.4 V p-p at the end search coil. Chart 10 shows the pattern of detected output after several minutes of operation (21 to 25 minutes). Other portions of the recording show reversal of low and high amplitudes but starting, stopping, and magnitude changes occur simultaneously with the two search coils in these positions. X-rays of the upper extension indicated circuitry in the upper sections and coils in the pipe. Even though the output is 60 Hz sine wave, this unit has a different on-off characteristic than the previous units which were on for much shorter times and more frequently.

Unit G: The G1 and G2 type units are designed to be clamped to a water pipe. They also are 115 volt 60 Hz powered. The unit G2 X-rays show two coils around a common center rod. They are spaced about 30 mm apart. The X-rays indicate a thermal activated switch is mounted against each coil. After initial turn on the temperature reaches the switching level of the heat sensor which turns off the associated coil. Thereafter, when the coil cools down, each coil is activated when its switch closes and runs until the switch opens.

Two search coils were also used to analyze unit G1, one located on top and the other on the side. Its output is a 60 Hz sine wave of 4.3 volts peak-to-peak from the top search coil and 2.5 volts peak-to-peak from the side search coil. After initial turn on the unit operated for nearly 25 minutes at its maximum peak amplitude at the side coil. After that the operation becomes random with various amplitudes and off times. Each amplitude change or off time was simultaneously reflected by the two search coils. Like the unit F1, all G1 "on" operations were longer than the other 115 V 60 Hz units (see chart 11).

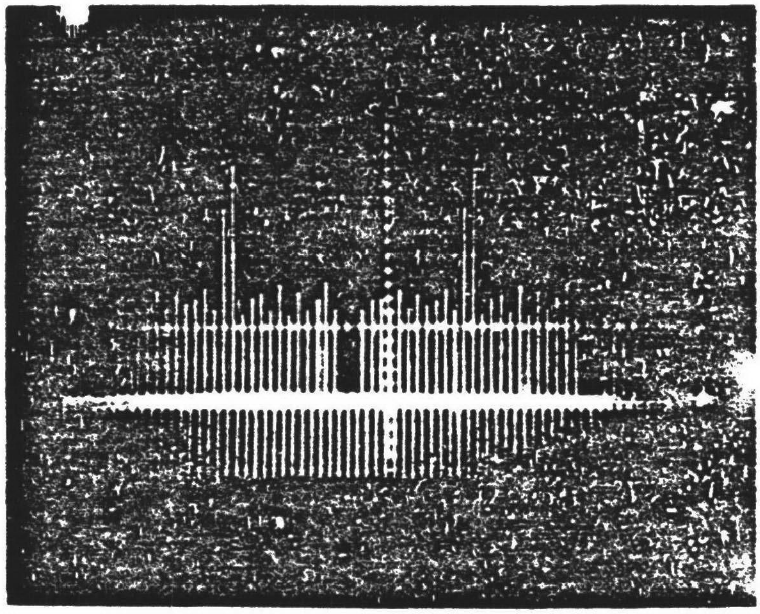
Unit H: The unit H is enclosed in a plastic case consisting of a base section containing all of the electronic circuitry either molded in place or bonded by other means. A top plastic piece is bonded to the base flange. On top of this cover is mounted an LED. The case is open along one side permitting inspection of the unit. The encapsulated electronics, transformer, and three coils are visible here. This opening was used to makè electrical connections for the laboratory testing and measurements.

The X-ray photographs of the H unit shows a power supply, three coils coupled to the encapsulated module, and the module of six 14 pin and three 16-pin integrated circuits and other components.

The H unit is 115 volt 60 Hz powered. It contains a power supply to convert to 12 volts DC. The small light emitting diode on the case flashes about every six seconds (similar to Type A units) to indicate the unit is operating. The X-ray photographs revealed that the unit H contains electronic components similar to those in the A and B units except for the DC power supply. Therefore, it was tested for pulse output. No output was detectable using the search coil. The oscilloscope common lead was connected to the negative of the 12 volt supply. No metal case or box is used in the H unit as in A or B units. The oscilloscope probe was connected to one of the coil leads from the encapsulted electronic components to investigate any pulse output. The output is shown in the sketch, curve 5. The pulse pattern is repeated approximately every 12 seconds. This type of output is also obviously digitally generated because of the low frequency, exact pulse pattern repetition, and the integrated circuits used as shown by X-ray photographs. The maximum positive pulse output is over twice that of the B units but the intermediate low amplitude pulses are significantly less. The average power radiated is very low due to the short pulse duration and small amplitudes which likewise is characteristic of the A and B pulse units.

Table 5
Operating Voltages and Currents

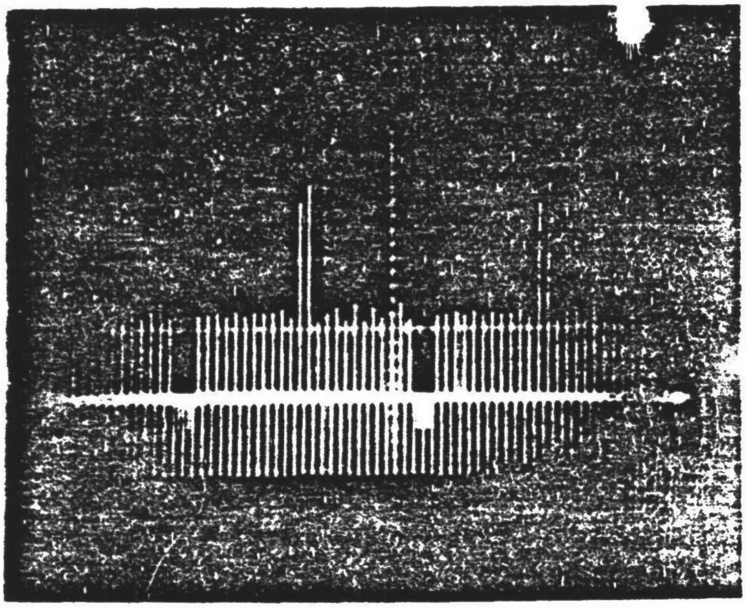
Code	Operating Volts	Max. Current
A1	12 V DC	6.2 mA
A2	12 V DC	2.2 mA
B1	11 V DC	2.3 mA
B2	11.2 V DC	3.1 mA
C2	115 V AC	3.1 A
D	115 V AC	9.4 A
E1	115 V AC	3.1 A
F1	115 V AC	2.6 A
G2	115 V AC	5.3 A



UNIT B 1: 6/8/78

MAXIMUM POSITIVE PULSE	:	2.3 V
NEGATIVE PULSE	:	.675 V
SWEEP RATE	:	5 SEC/CM
PULSE RATE	:	.35 SEC
PATTERN REP. RATE	:	17.5 SEC
GAIN	:	.675 V/CM

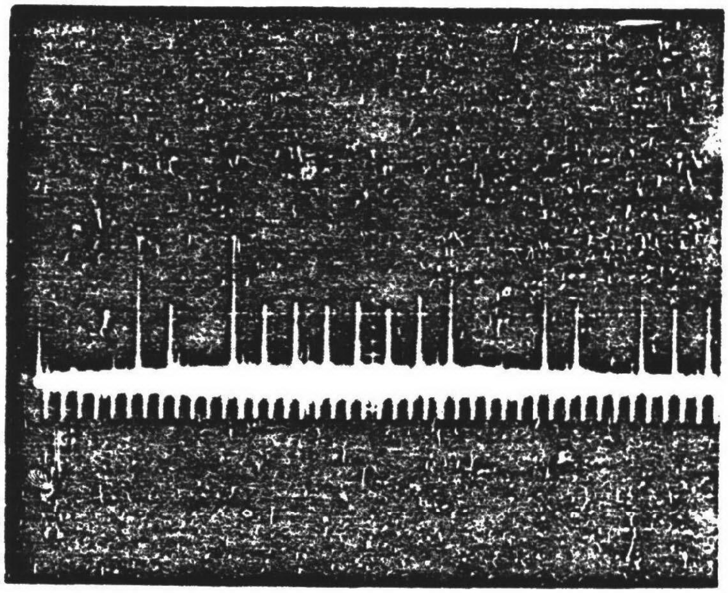
CURVE 1



UNIT B 2: 6/8/78

MAXIMUM POSITIVE PULSE	:	2.25 V
NEGATIVE PULSE	:	.825 V
SWEEP RATE	:	5 SEC/CM
PULSE RATE	:	.35 SEC
PATTERN REP. RATE	:	17.5 SEC
GAIN	:	.75 V/CM

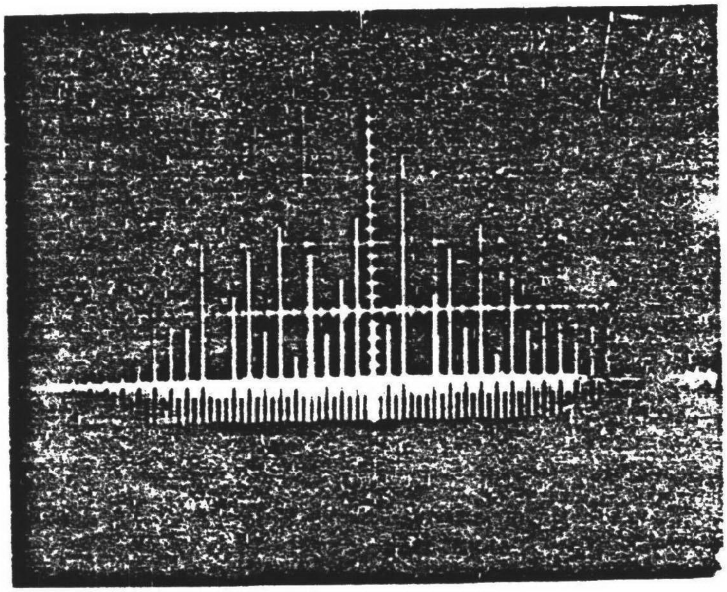
CURVE 2



UNIT A 1: 6/7/78

MAXIMUM POSITIVE PULSE	:	.51 V
NEGATIVE PULSE	:	.09 V
SWEEP RATE	:	1 SEC/CM
PULSE RATE	:	.18 SEC
PATTERN REP. RATE	:	6.4 SEC
GAIN	:	.183 V/CM

CURVE 3



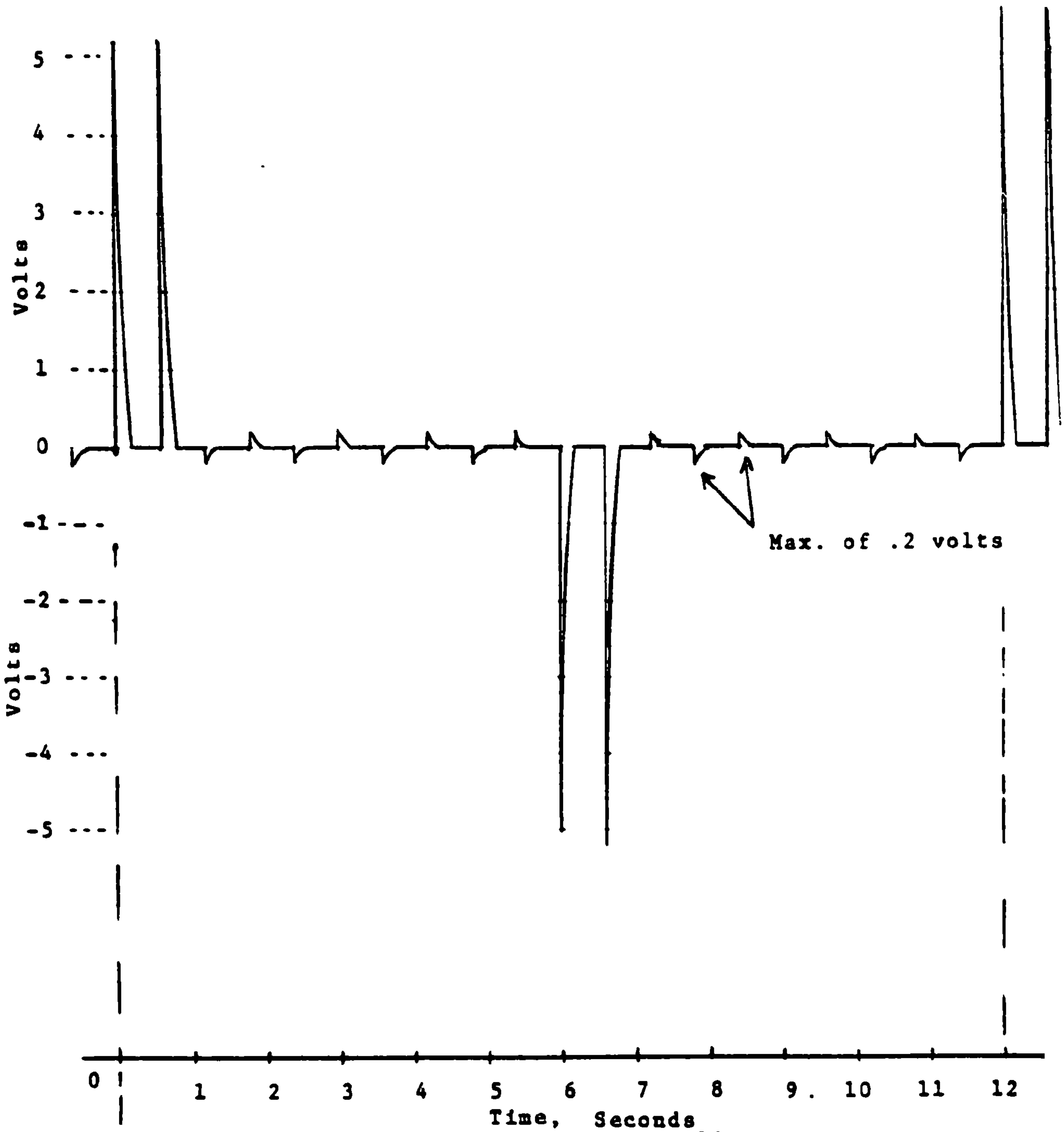
UNIT A 2: 6/8/78

MAXIMUM POSITIVE PULSE	:	.64V
NEGATIVE PULSE	:	.12V
SWEEP RATE	:	2 SEC/CM
PULSE RATE	:	.18 SEC
PATTERN REP. RATE	:	6.4 SEC
GAIN	:	.183 V/CM

CURVE 4

Curve 5: 10/23/78

Sketch of Output of Unit H 1
as shown on the Oscilloscope Display



Pattern Repeats ≃ Every 12 Seconds

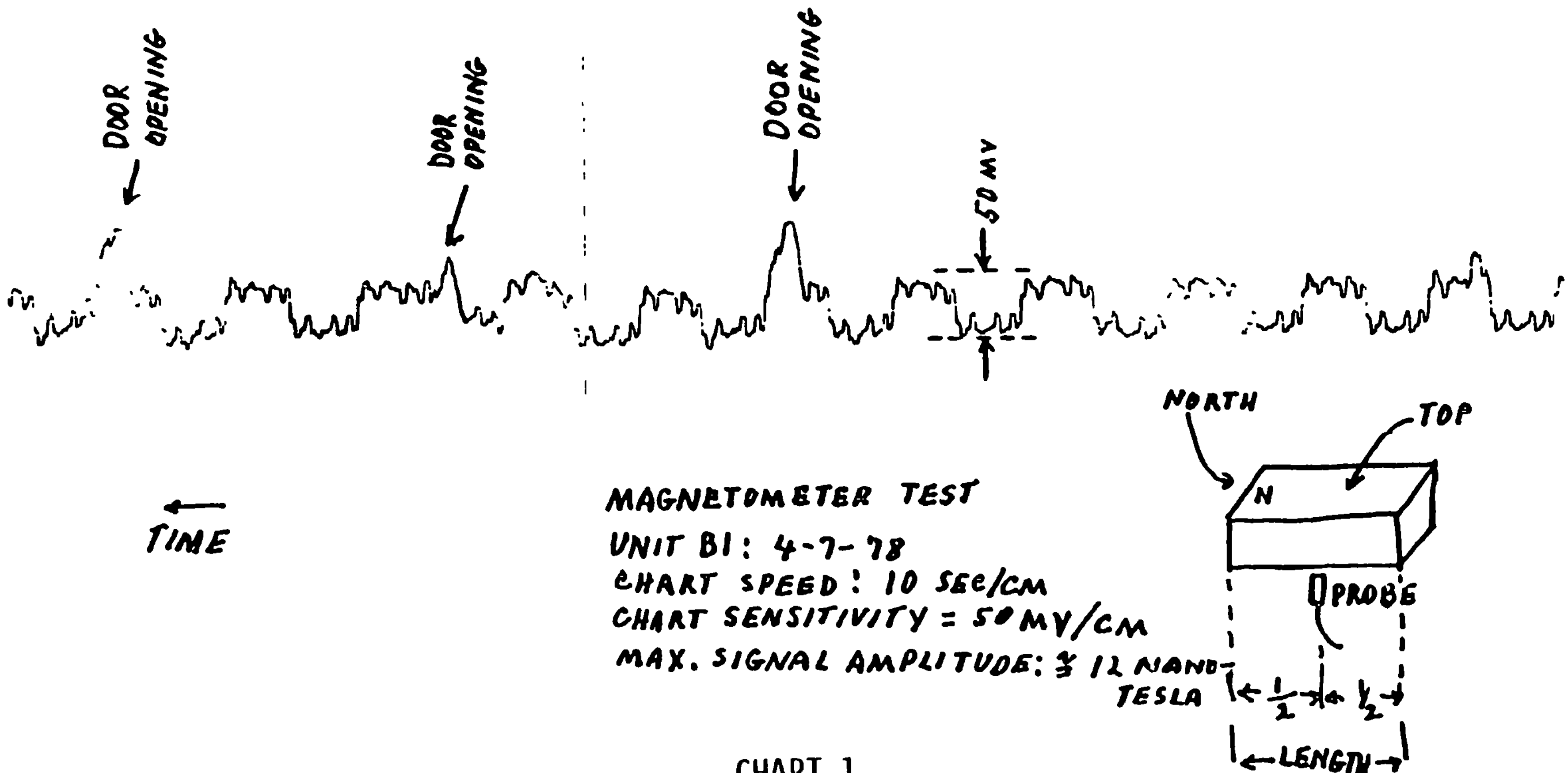

DOOR OPENING
DOOR OPENING
DOOR OPENING
50 MV
TIME
NORTH
TOP
N
PROBE
LENGTH
MAGNETOMETER TEST
UNIT B1: 4-7-78
CHART SPEED: 10 SEC/CM
CHART SENSITIVITY = 50 MV/CM
MAX. SIGNAL AMPLITUDE: ≤ 12 NANO-TESLA

CHART 1

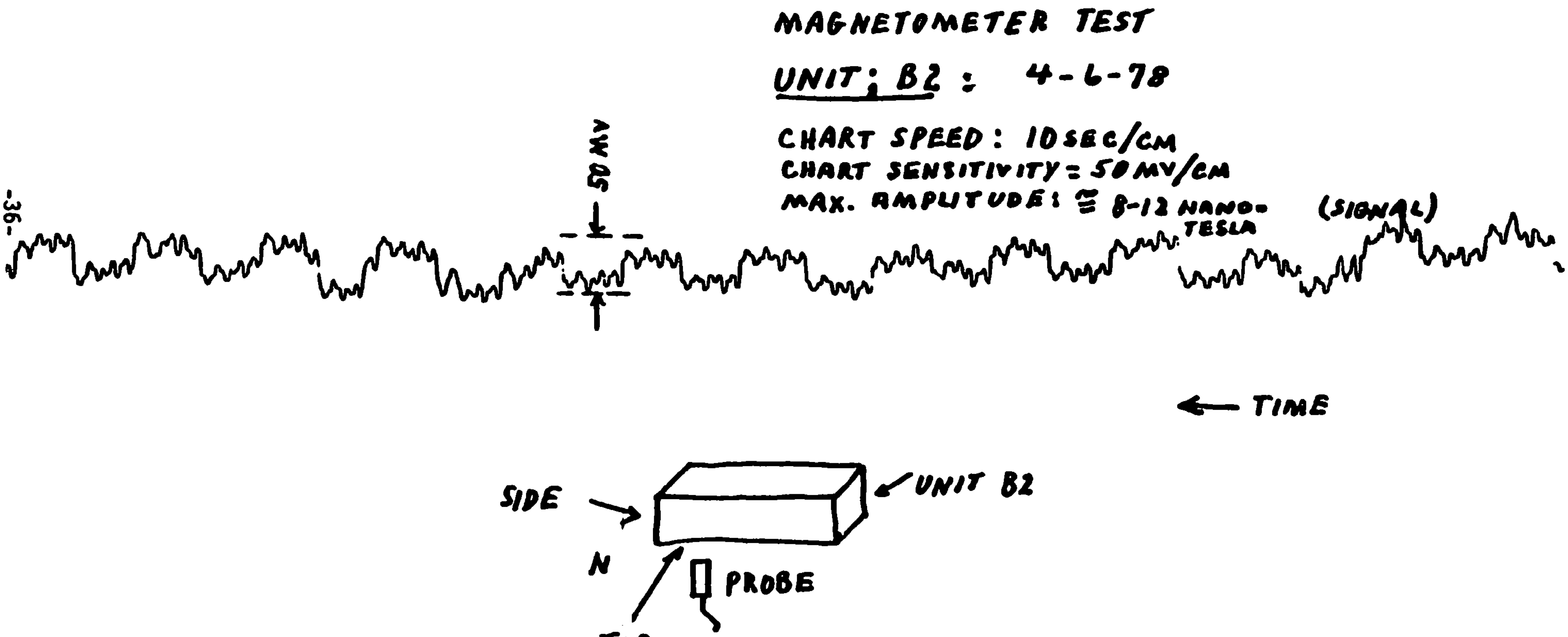

MAGNETOMETER TEST
UNIT; B2 : 4-6-78
CHART SPEED: 10 SEC/CM
CHART SENSITIVITY = 50 MV/CM
MAX. AMPLITUDE: ≅ 8-12 NANO-TESLA
(SIGNAL)
50 MV
← TIME
SIDE
UNIT B2
N
PROBE
TOP

CHART 2

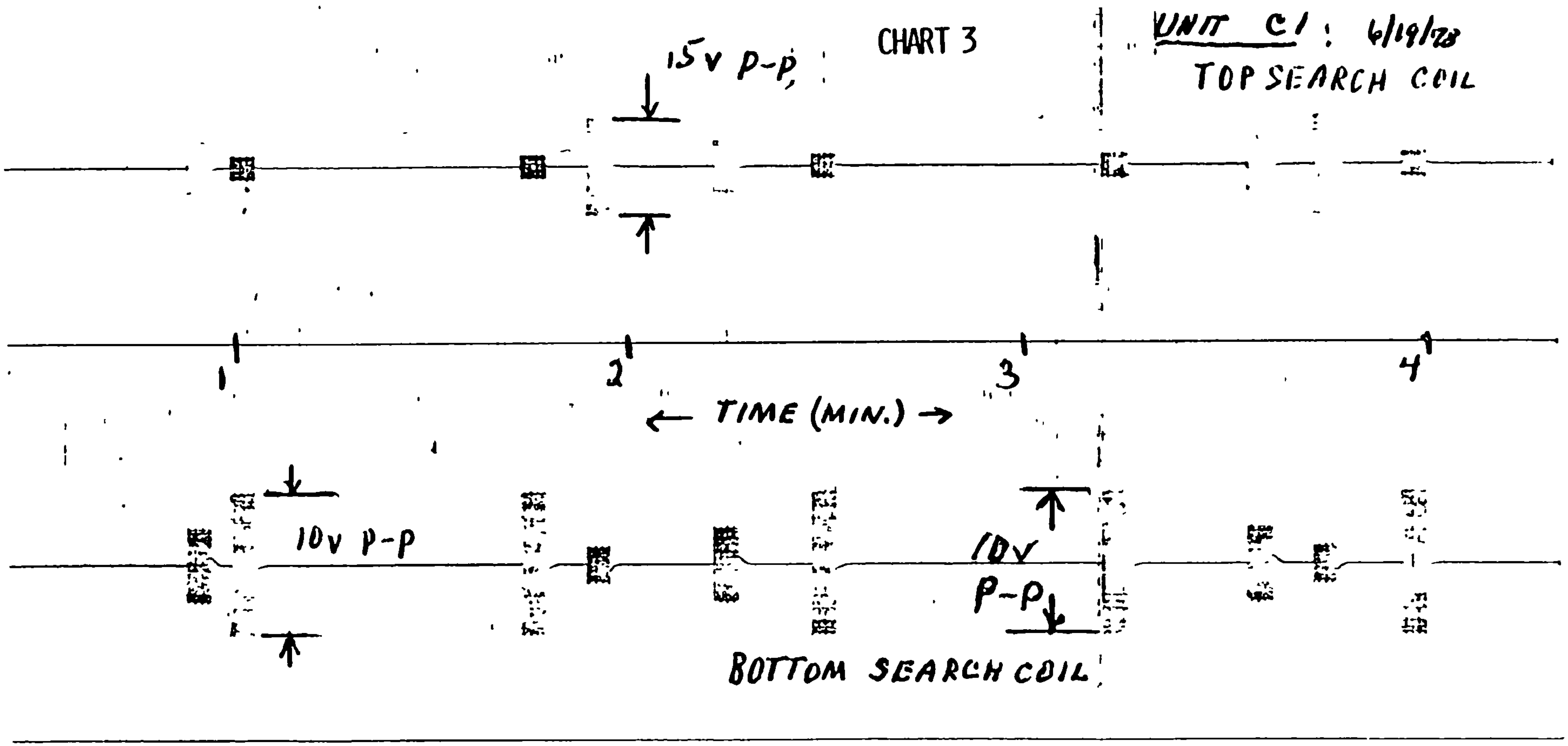


CHART 3
UNIT C1 : 6/19/78
TOP SEARCH COIL
15v p-p
1
2
3
4
← TIME (MIN.) →
10v p-p
10V P-P
BOTTOM SEARCH COIL

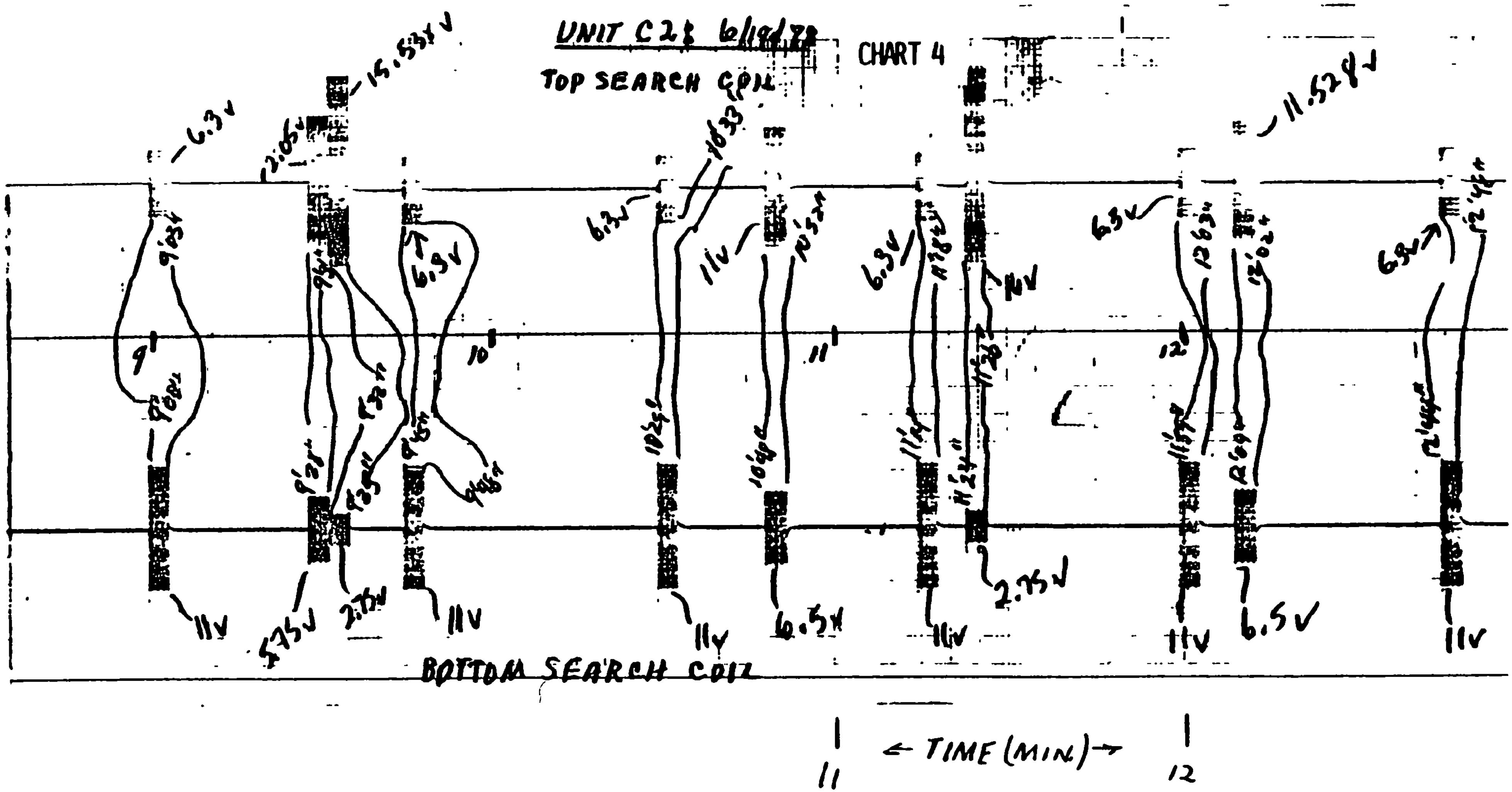
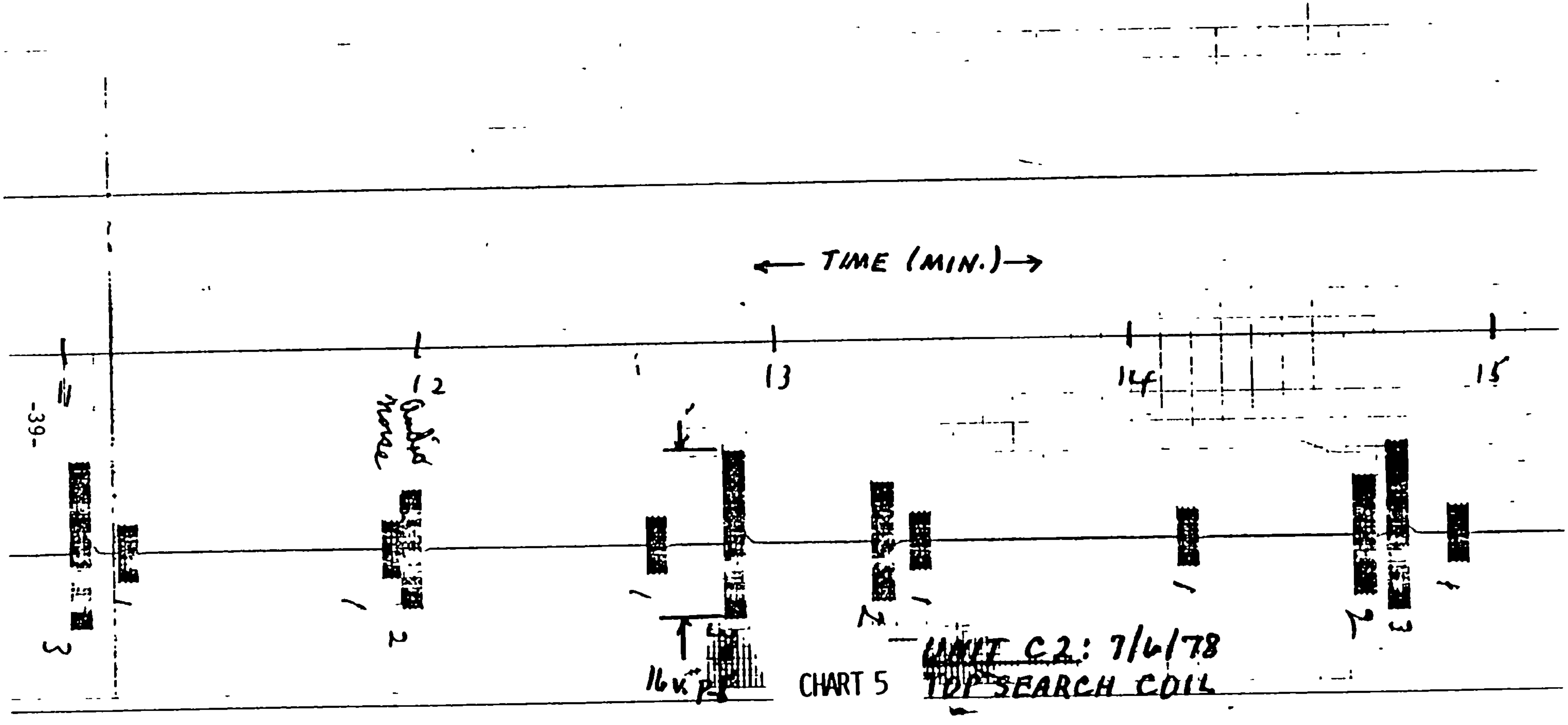


CHART 4
TOP SEARCH COIL
6.3v
11v
2.75v
6.5v
BOTTOM SEARCH COIL
11
← TIME (MIN) →
12



← TIME (MIN.) →
11
12
13
14
15
Audio Noise
16 kV
UNIT C2: 7/6/78
TOP SEARCH COIL

CHART 5

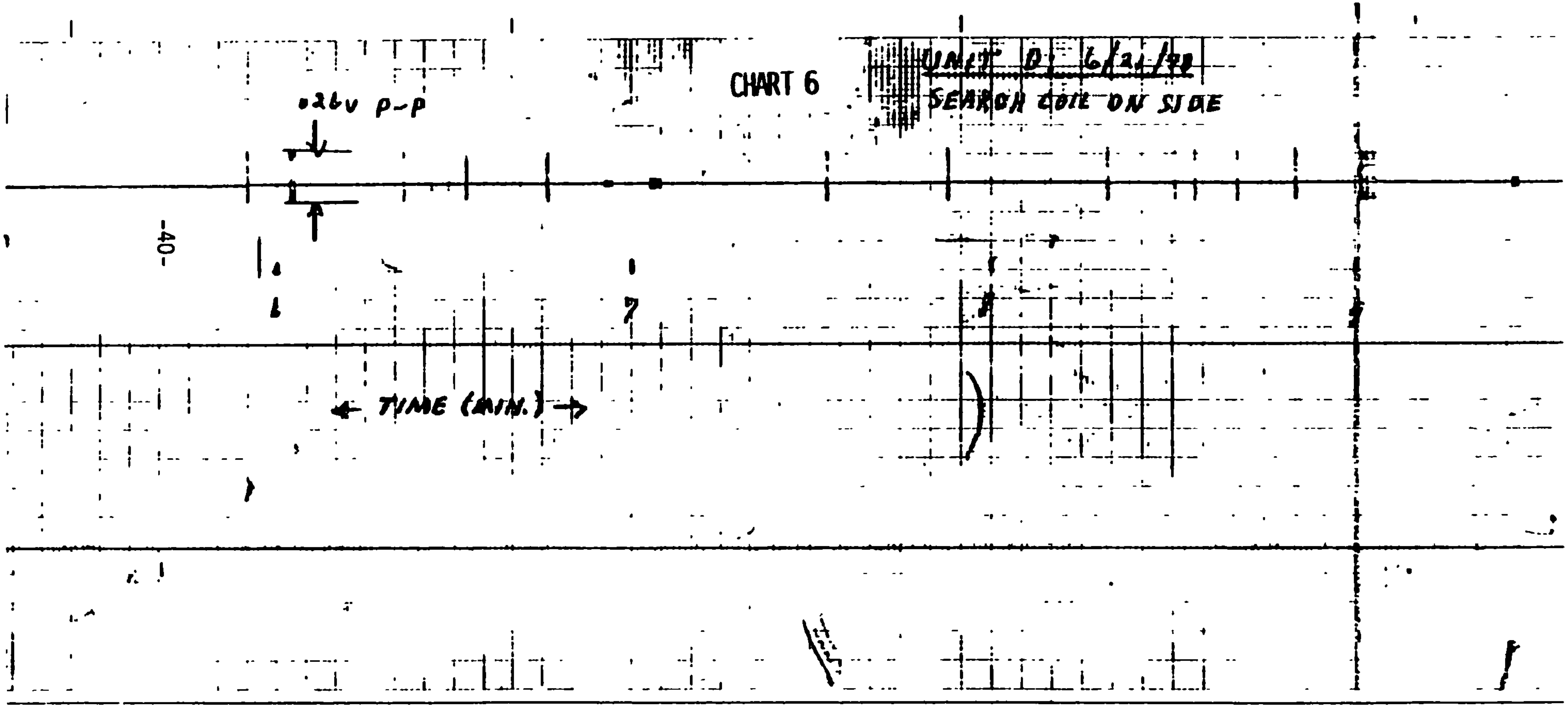
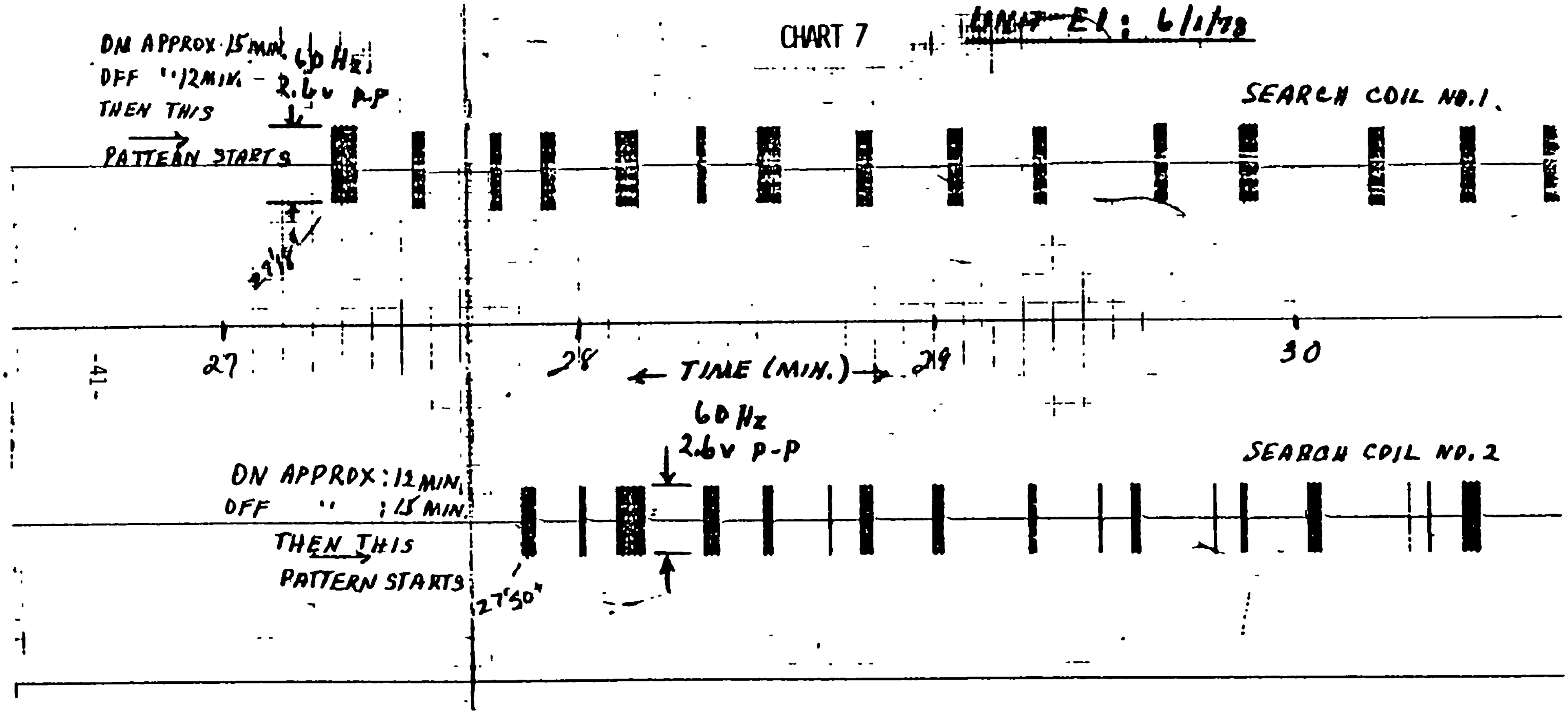


CHART 6
UNIT D
SEARCH COIL ON SIDE
.26v p-p
TIME (MIN.)

CHART 7


E1: 6/1/78
SEARCH COIL NO.1
ON APPROX 15 MIN
OFF " 12 MIN
THEN THIS PATTERN STARTS
60 Hz
2.6v P-P
27
28
29
30
TIME (MIN.)
SEARCH COIL NO.2
ON APPROX: 12 MIN
OFF " : 15 MIN
THEN THIS PATTERN STARTS
27'50"
60 Hz
2.6v P-P

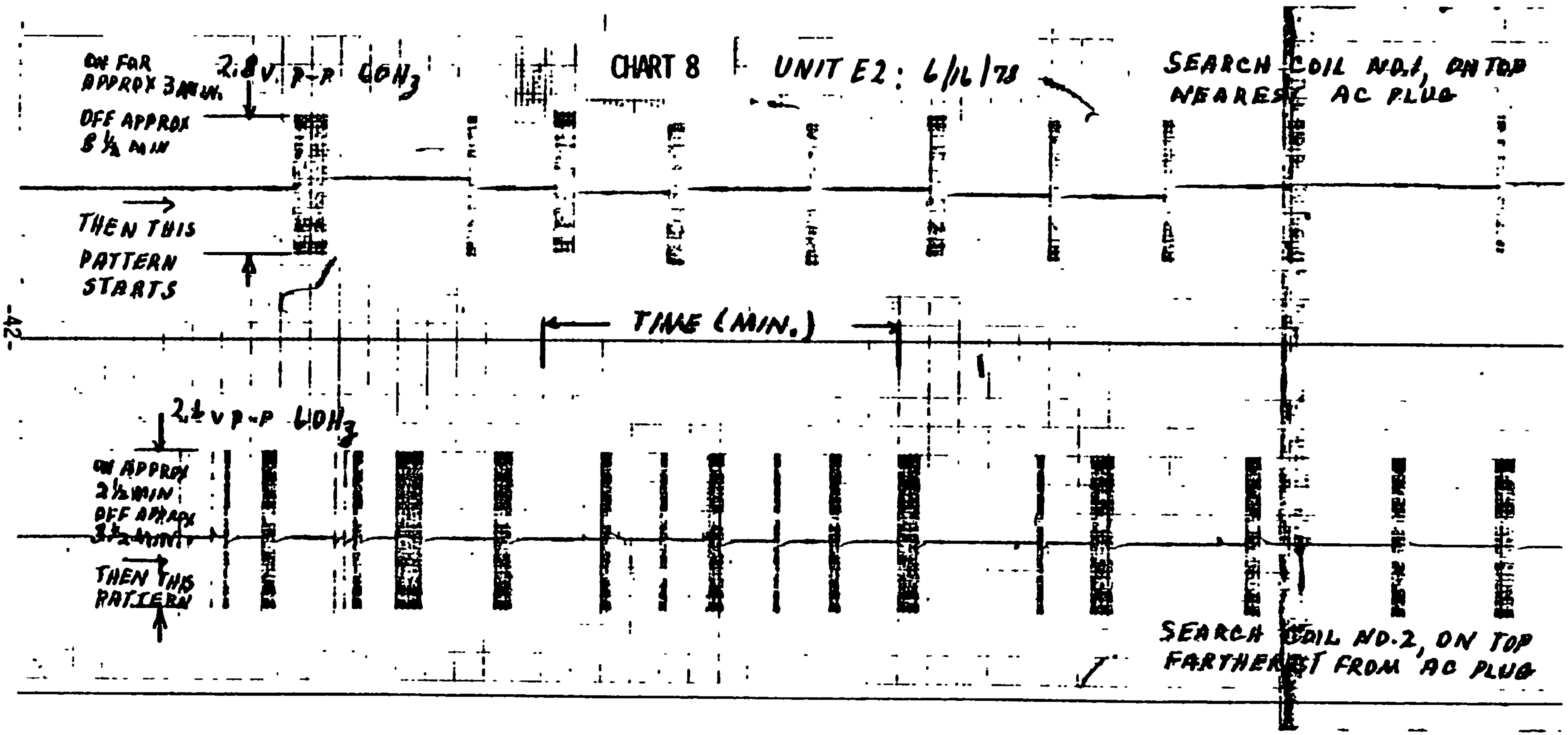


CHART 8
UNIT E2: 6/16/78
SEARCH COIL NO.1, ON TOP NEAREST AC PLUG
ON FOR APPROX 3 MIN.
2.8 V P-P 60Hz
OFF APPROX 8 1/2 MIN
THEN THIS PATTERN STARTS
TIME (MIN.)
2.4 V P-P 60Hz
ON APPROX 2 1/2 MIN
OFF APPROX 3 1/2 MIN
THEN THIS PATTERN
SEARCH COIL NO.2, ON TOP FARTHEREST FROM AC PLUG

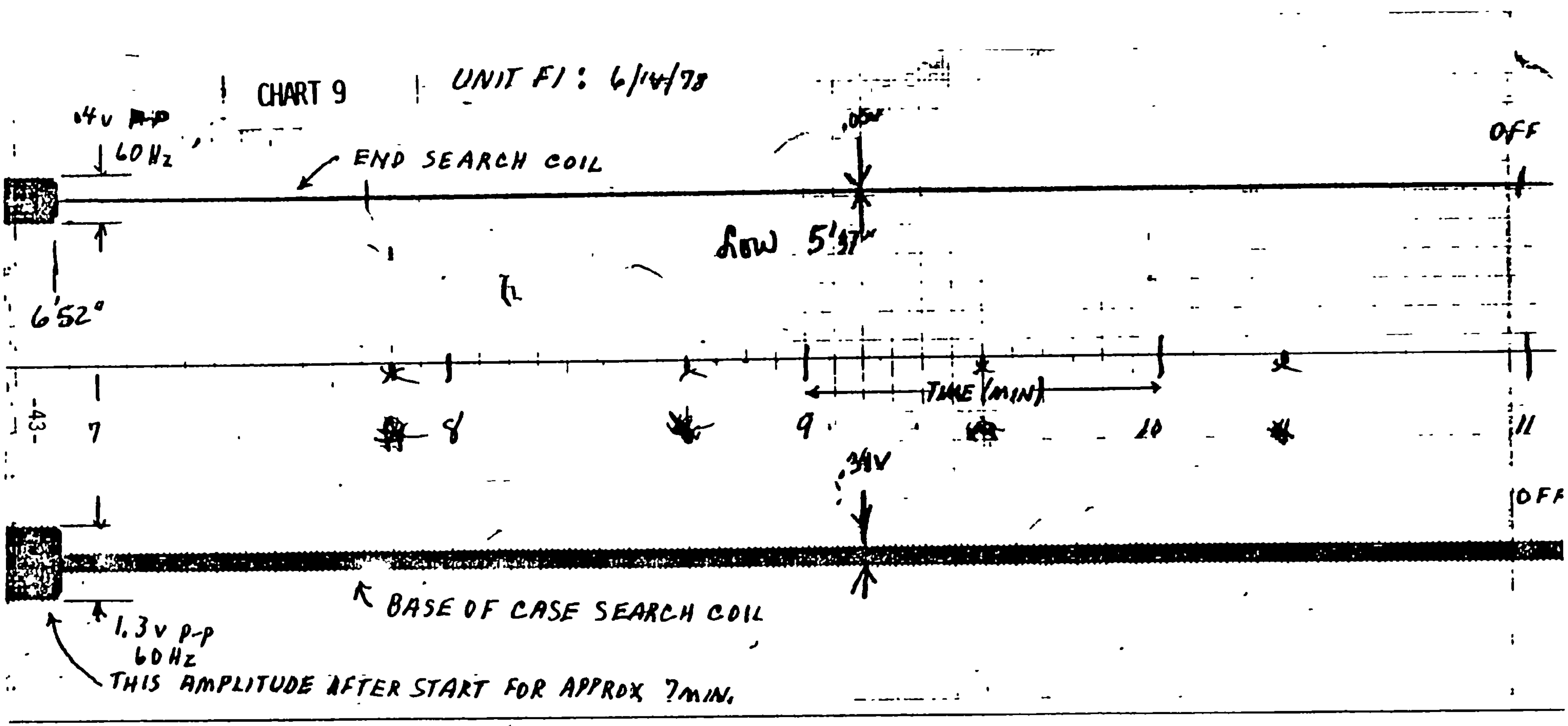


CHART 9
UNIT F1 : 6/14/78
.4v p-p
60 Hz
END SEARCH COIL
.05v
OFF
6'52"
5'57"
TIME (MIN)
7
8
9
10
11
.34V
OFF
BASE OF CASE SEARCH COIL
1.3 v p-p
60 Hz
THIS AMPLITUDE AFTER START FOR APPROX 7 MIN.

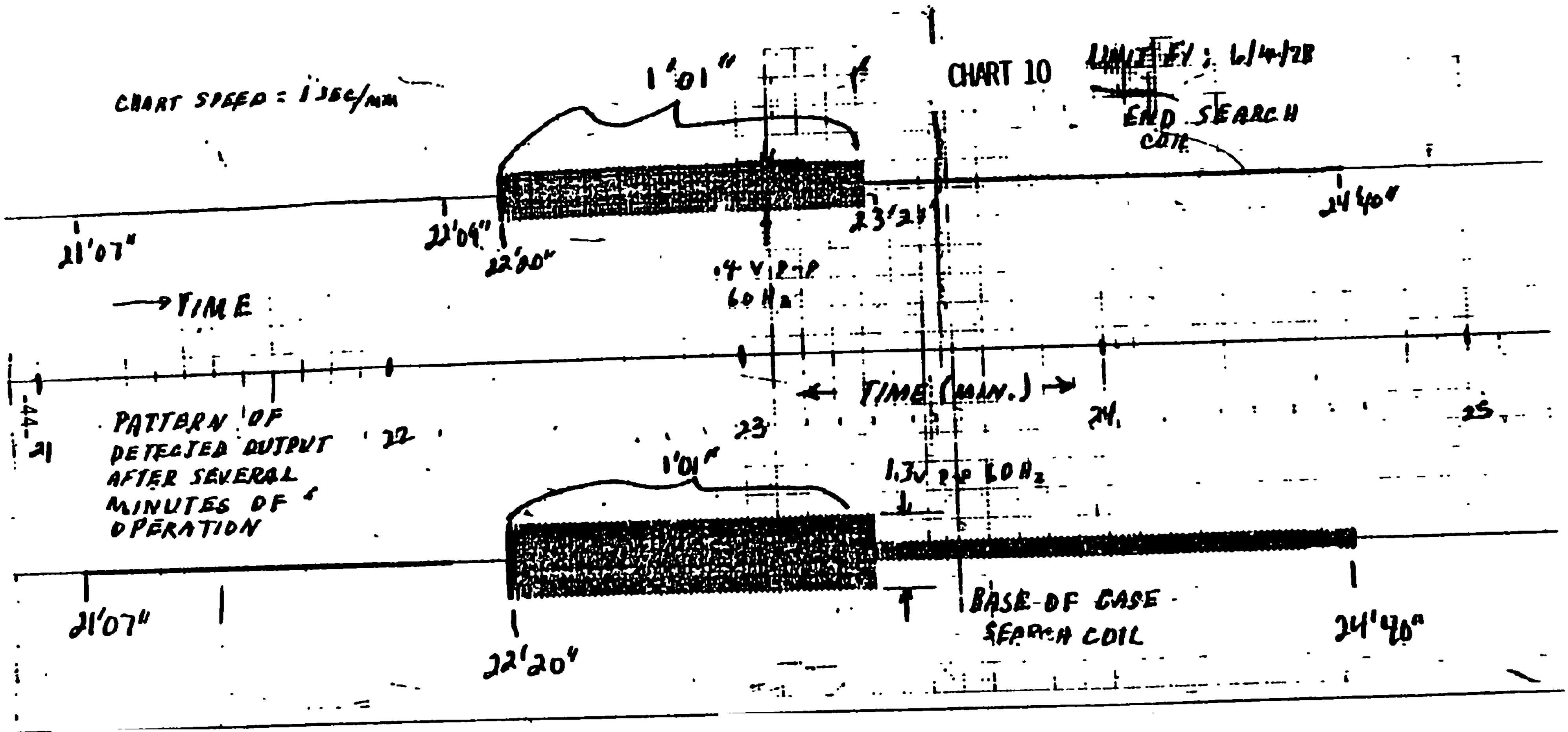
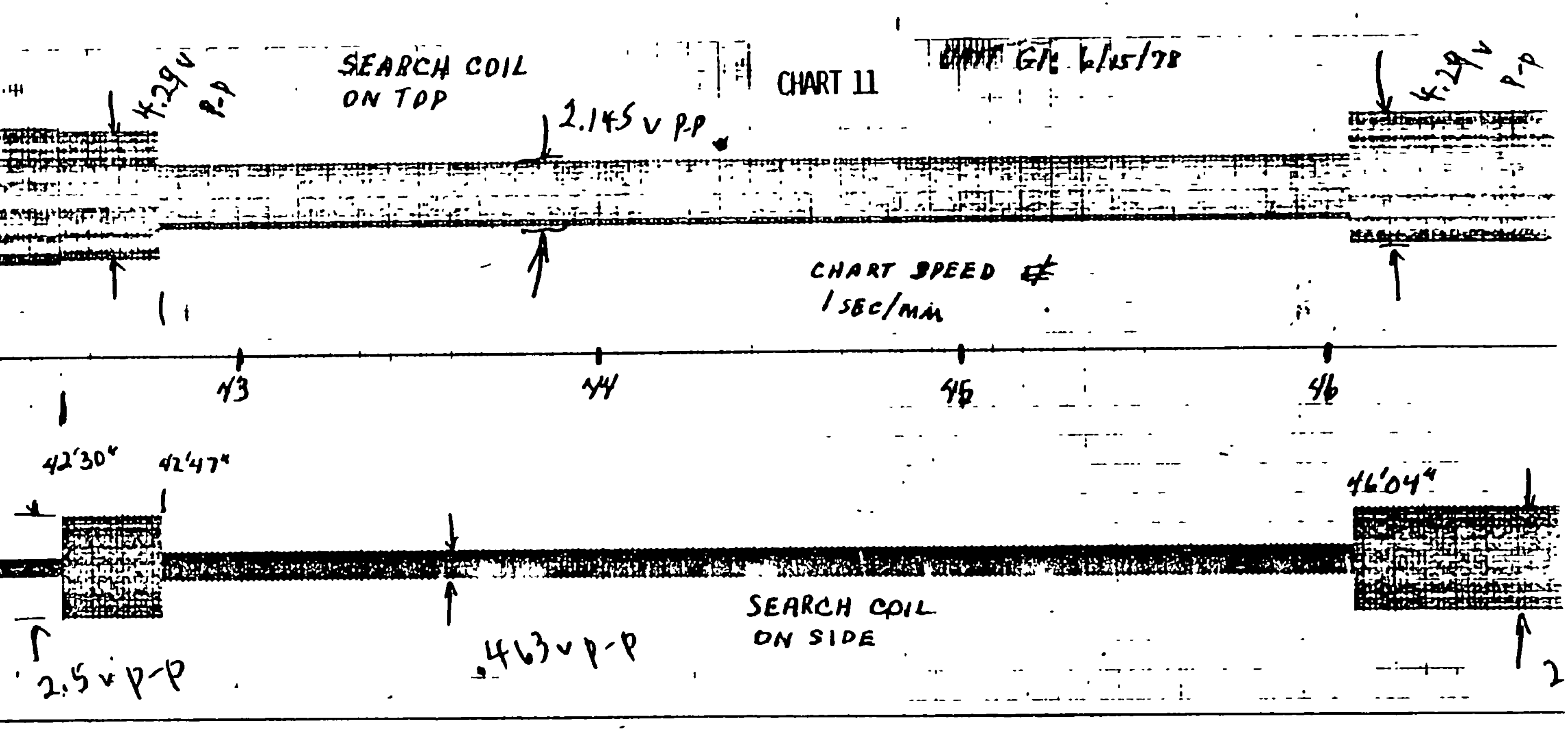
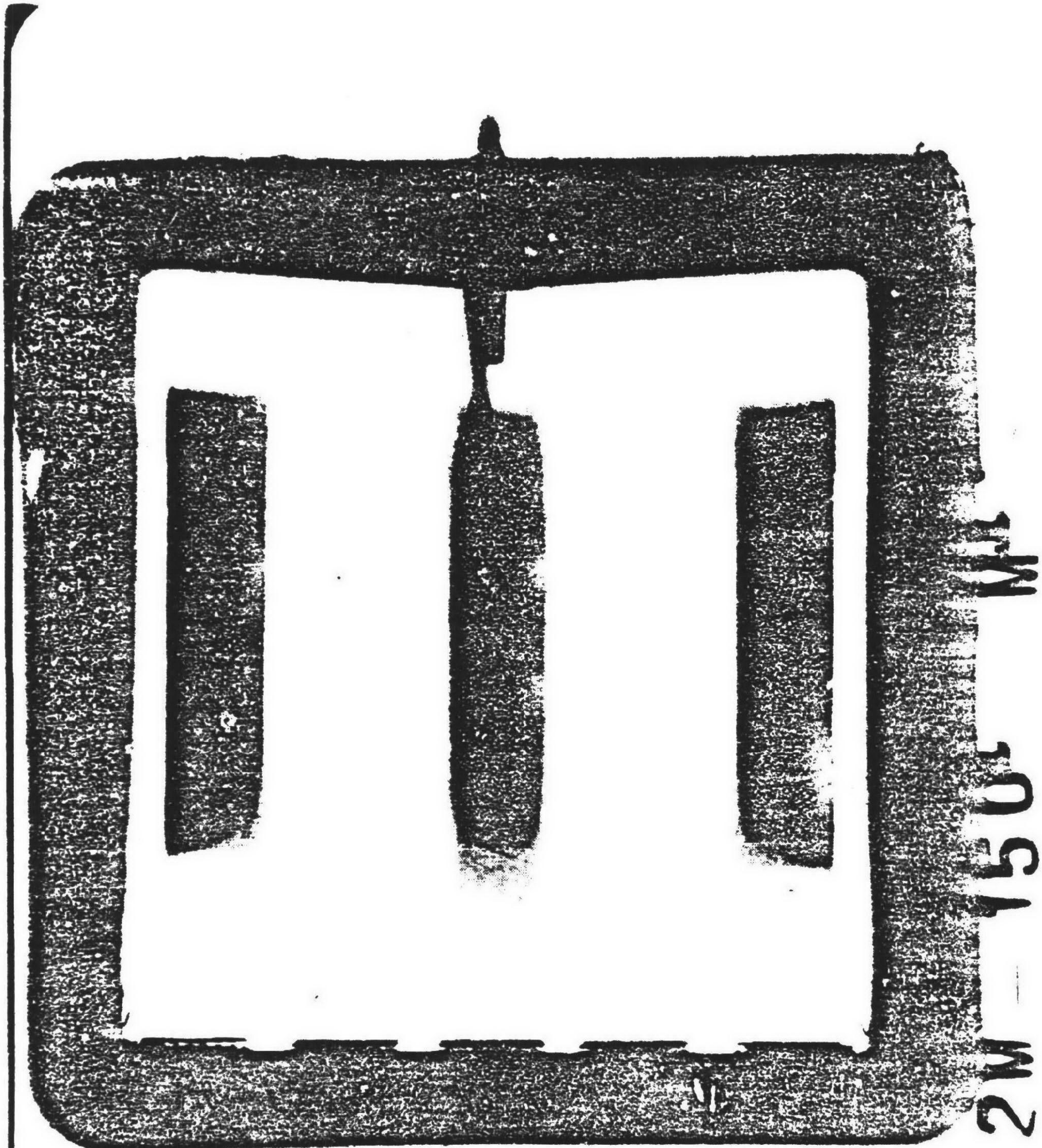


CHART 10
CHART SPEED = 1 SEC/MM
END SEARCH COIL
1'01"
21'07"
22'09"
22'20"
23'21"
24'40"
.4 V P-P
60 Hz
→ TIME
← TIME (MIN.) →
21
22
23
24
25
PATTERN OF DETECTED OUTPUT AFTER SEVERAL MINUTES OF OPERATION
1'01"
1.3V P-P 60 Hz
BASE OF CASE SEARCH COIL
21'07"
22'20"
24'40"

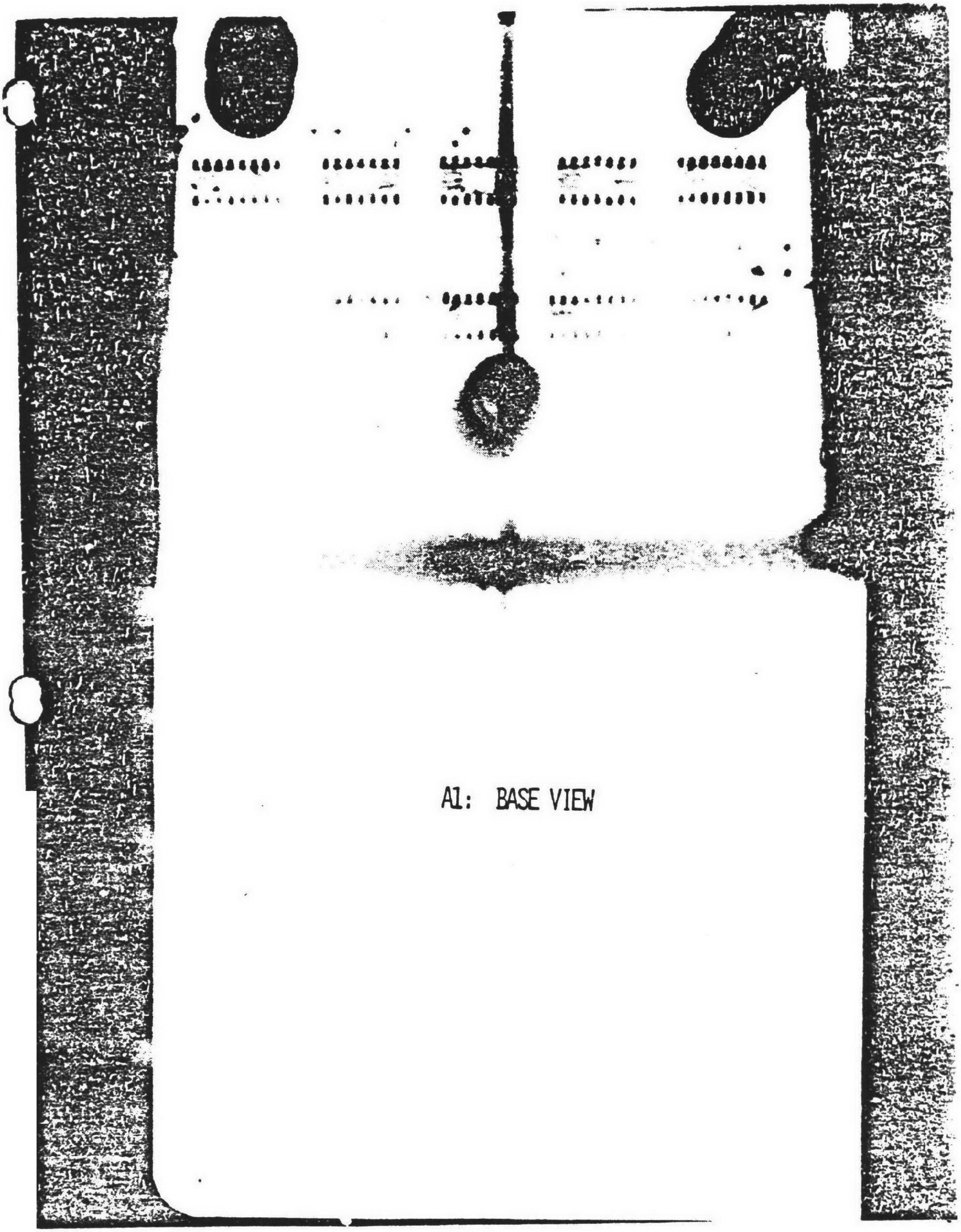

4.29 v p-p
SEARCH COIL ON TOP
CHART 11
2.145 v p-p
4.29 v p-p
CHART SPEED
1 SEC/MM
43
44
45
46
42'30"
42'47"
46'04"
SEARCH COIL ON SIDE
2.5 v p-p
.463 v p-p
2

8.0 A P P E N D I X

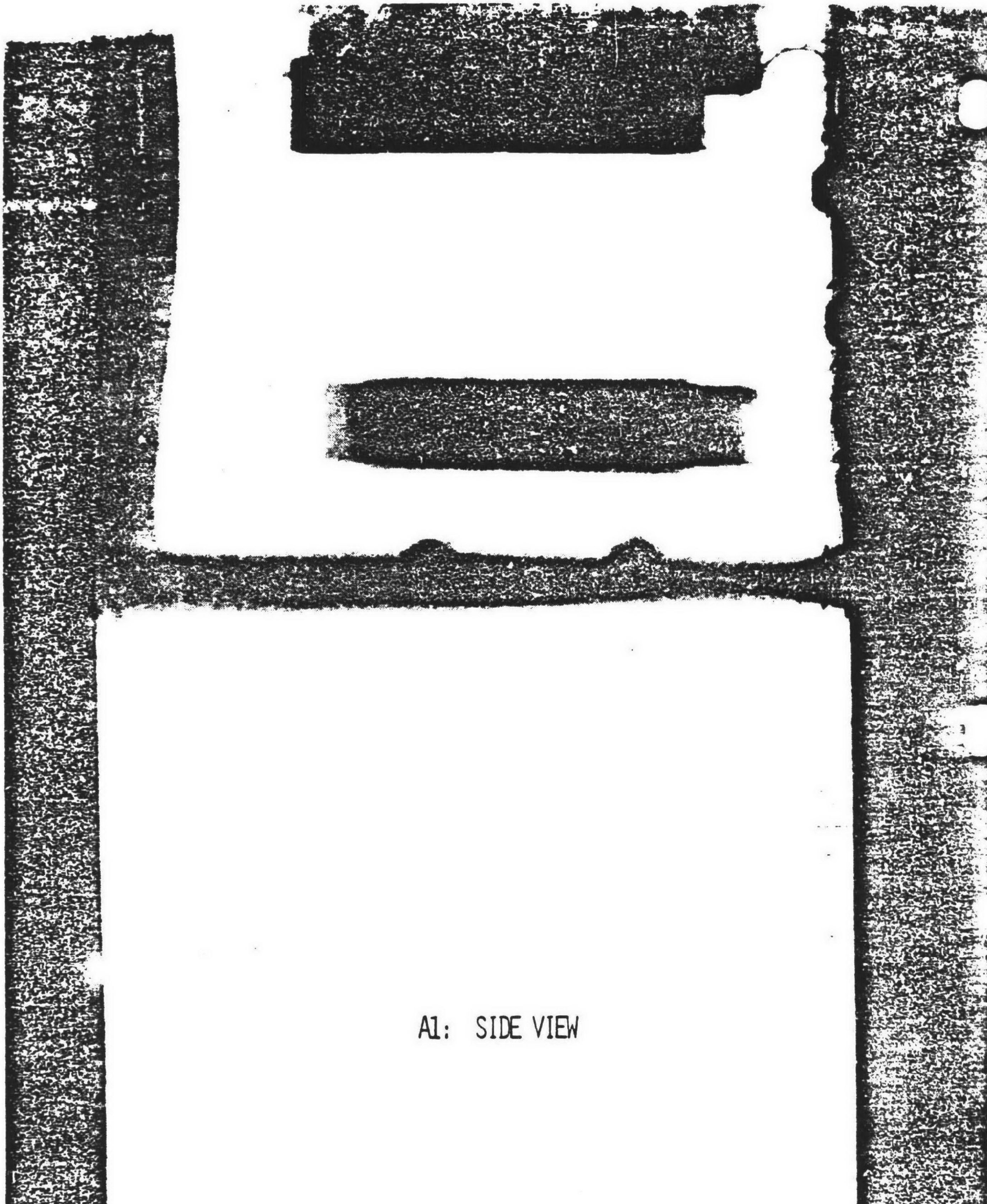
2. X-Ray Photographs



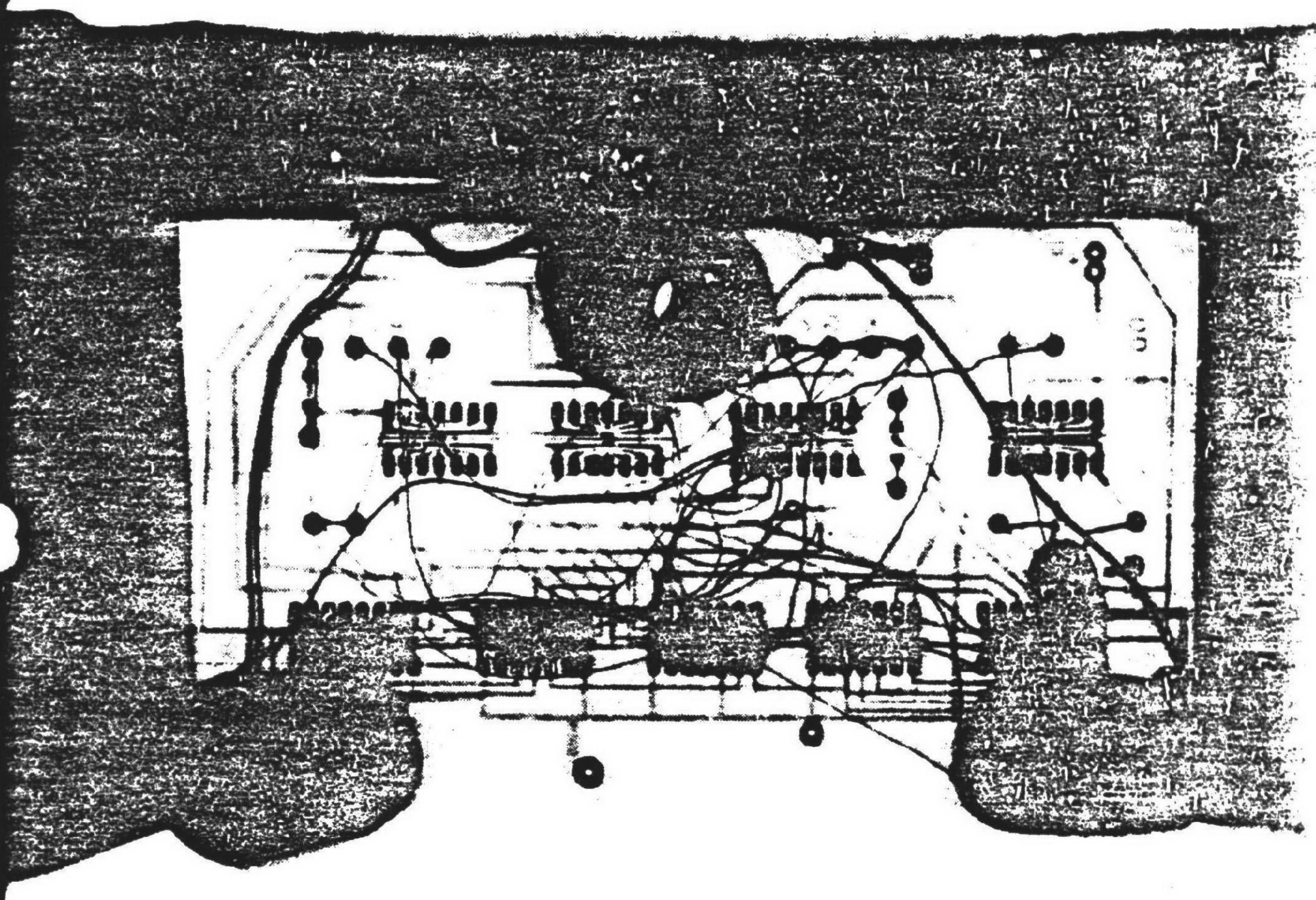
A1: TOP VIEW



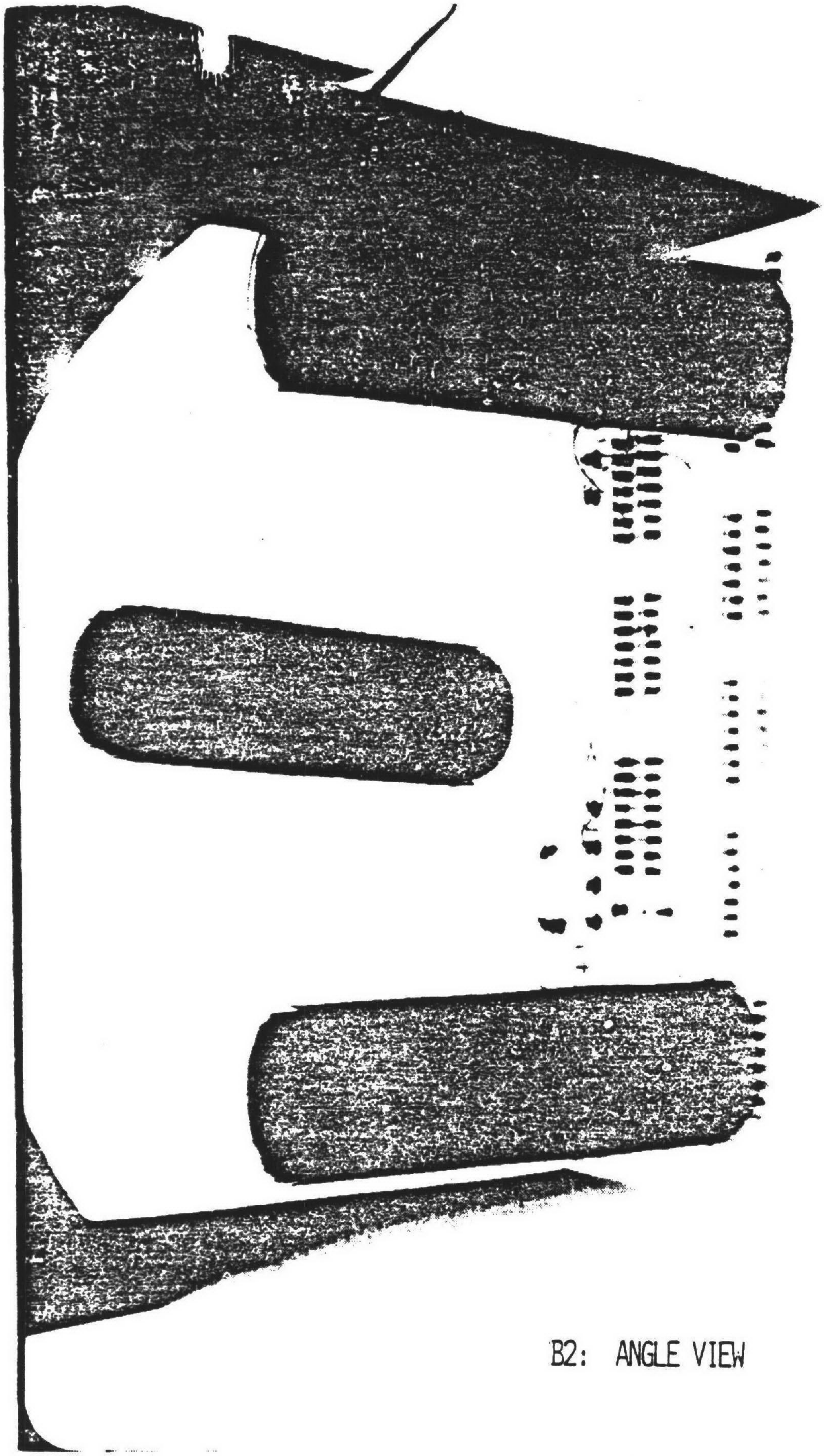
A1: BASE VIEW



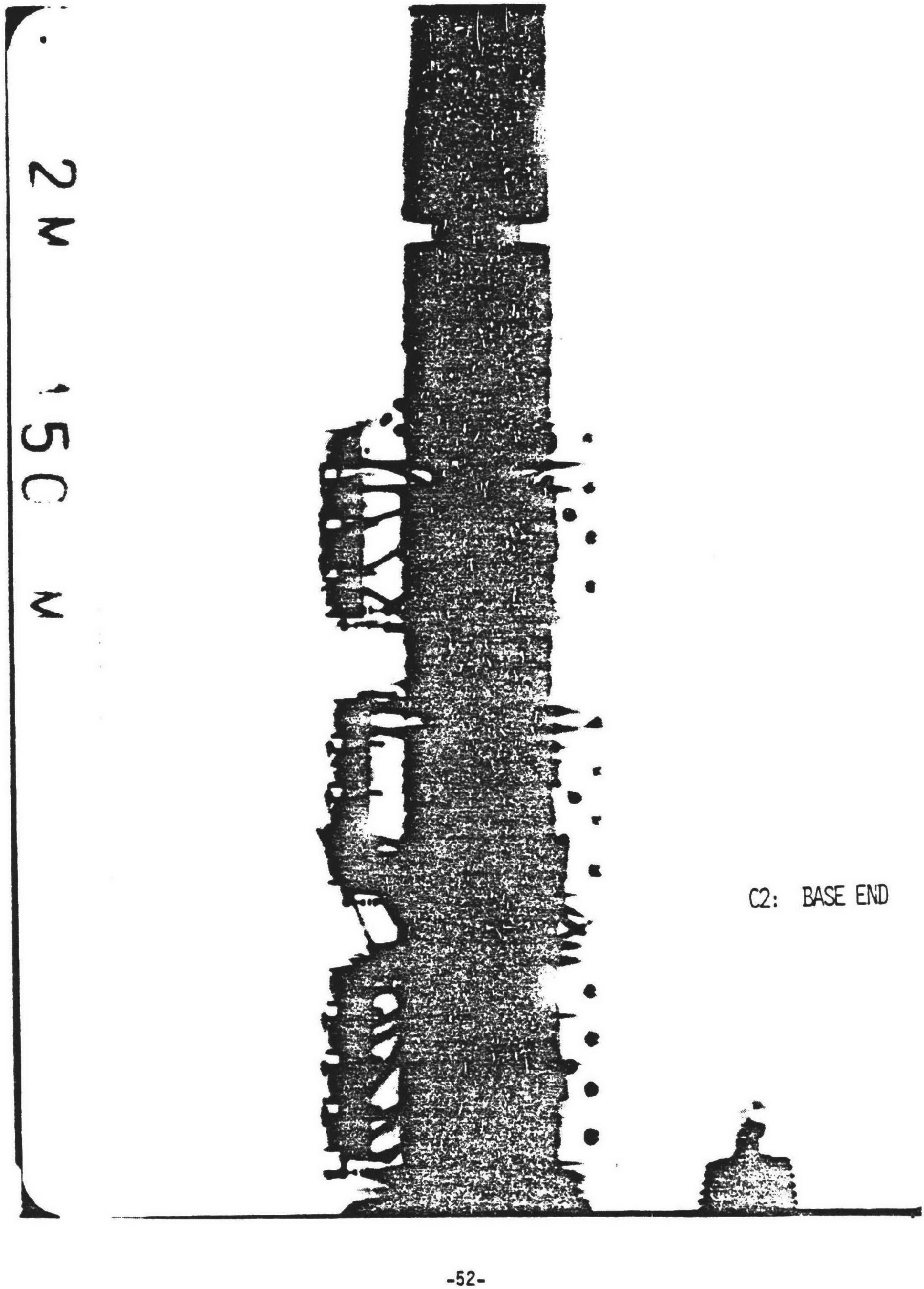
A1: SIDE VIEW



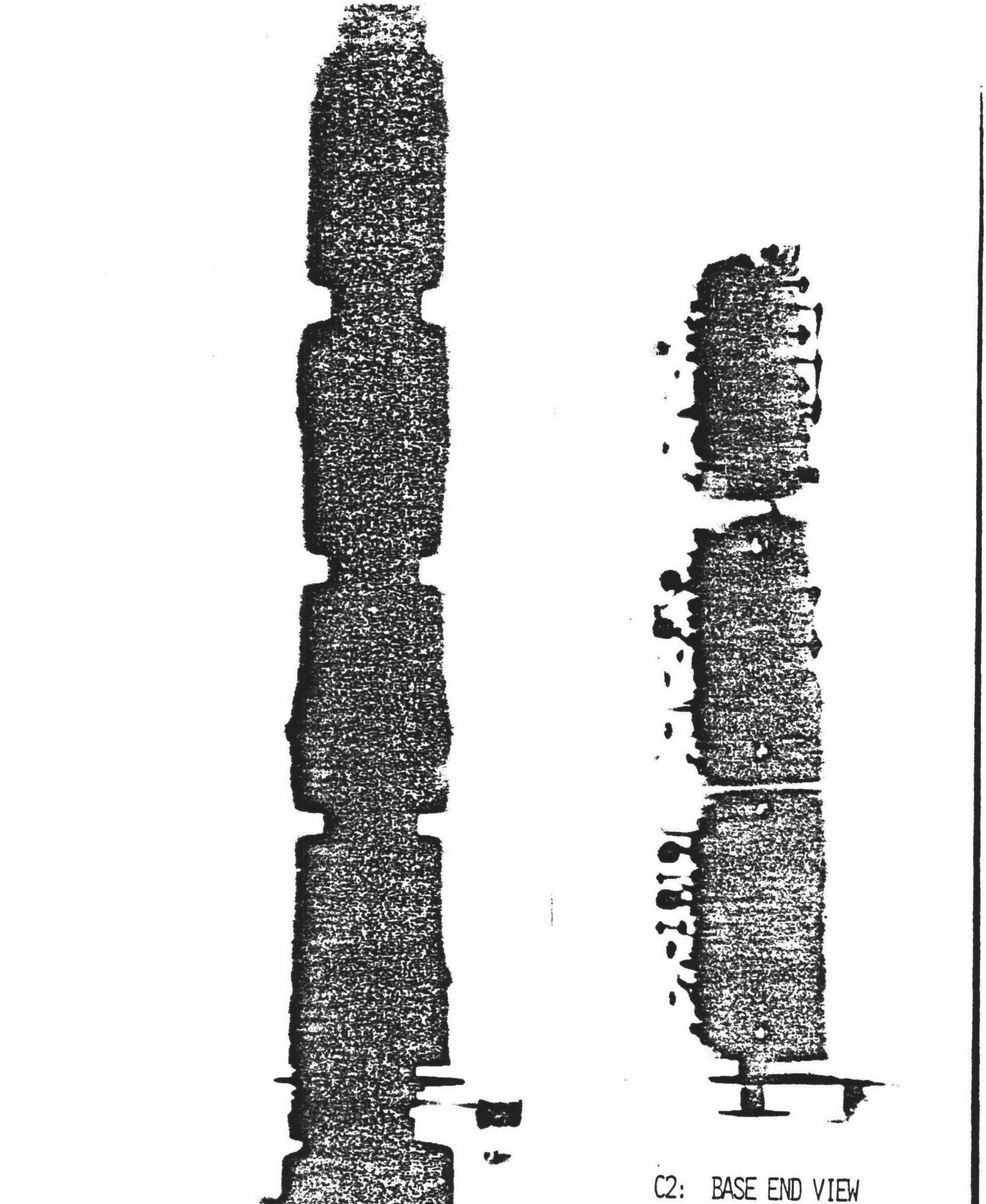
B2: BASE VIEW



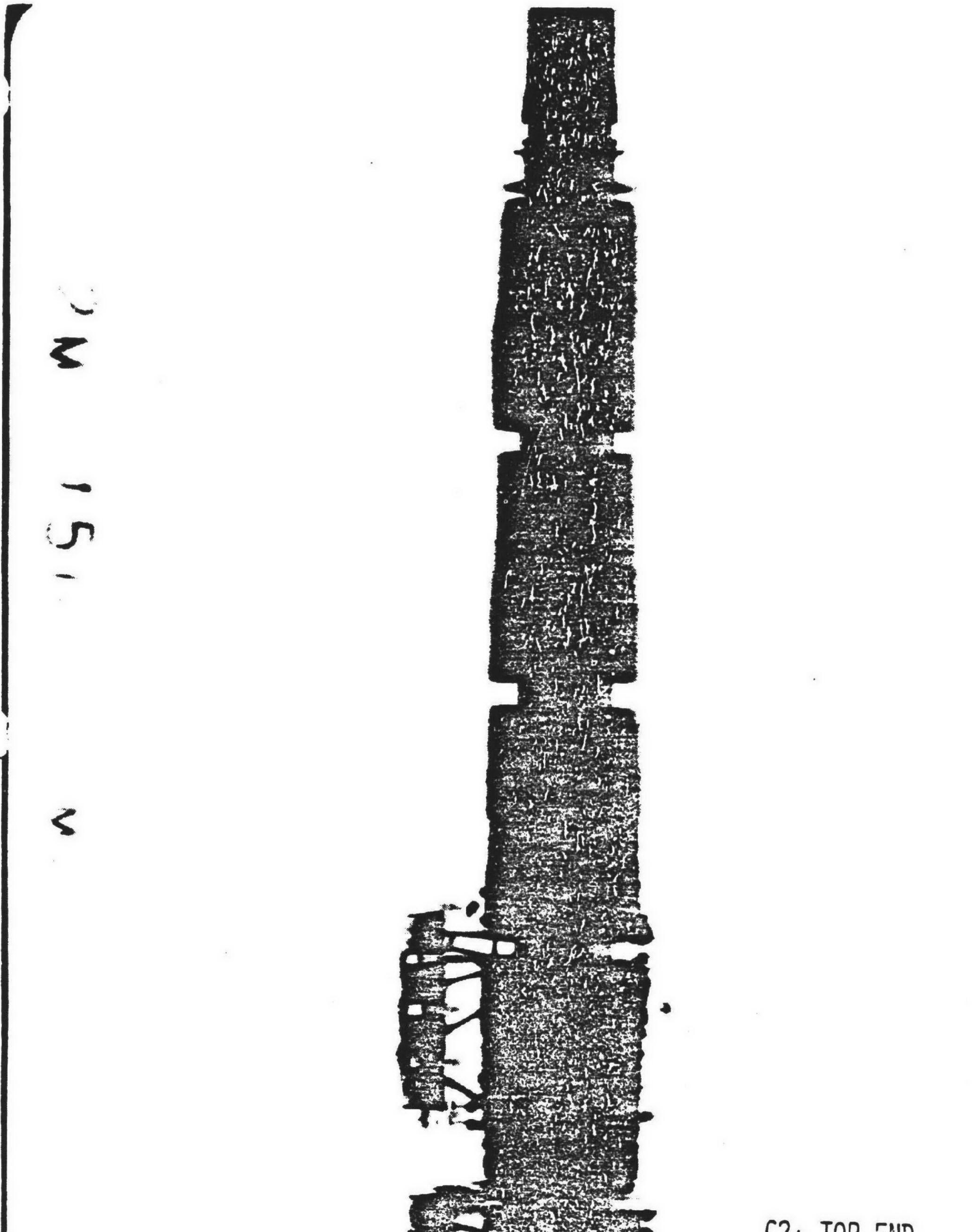
B2: ANGLE VIEW



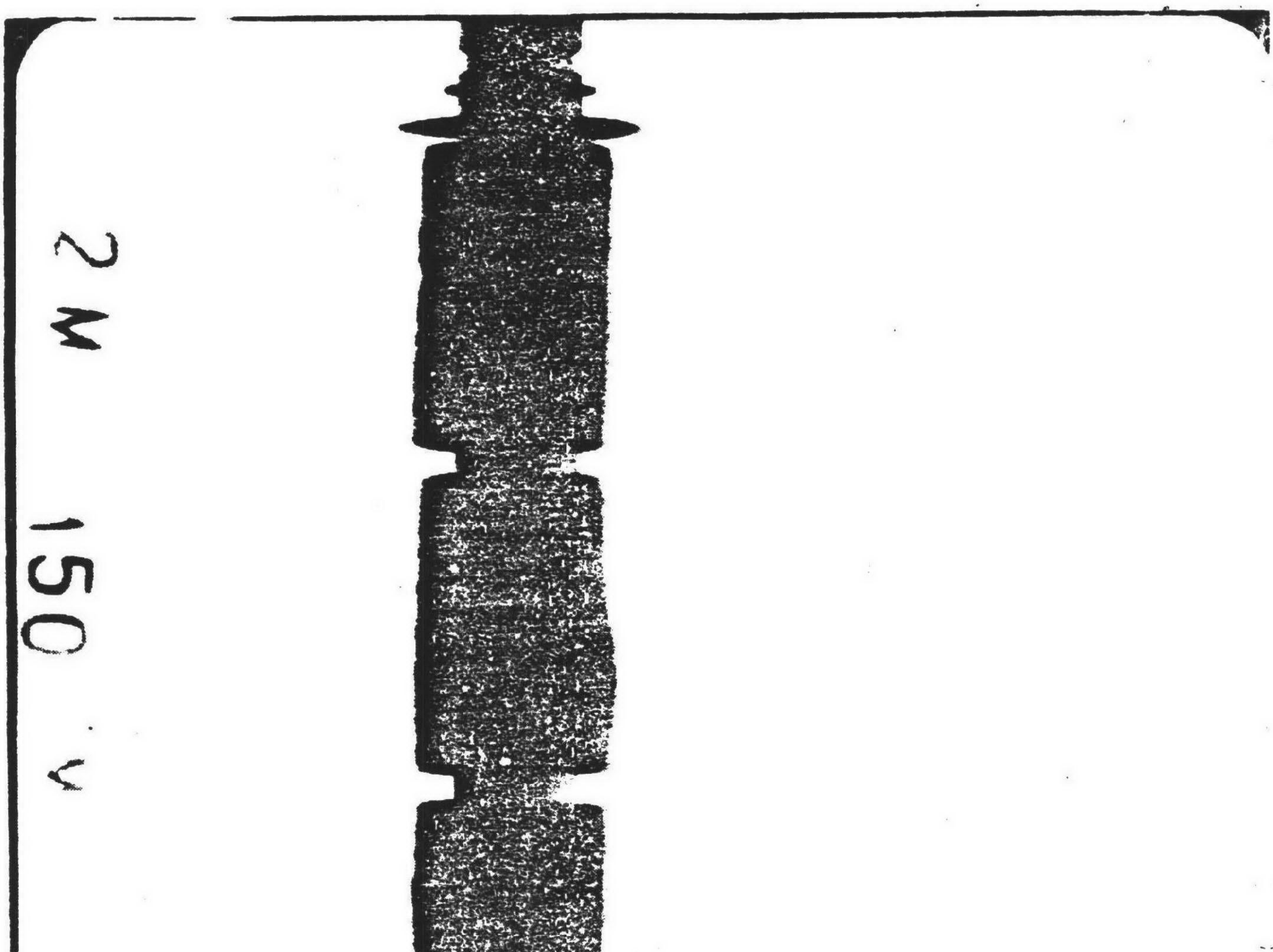
C2: BASE END



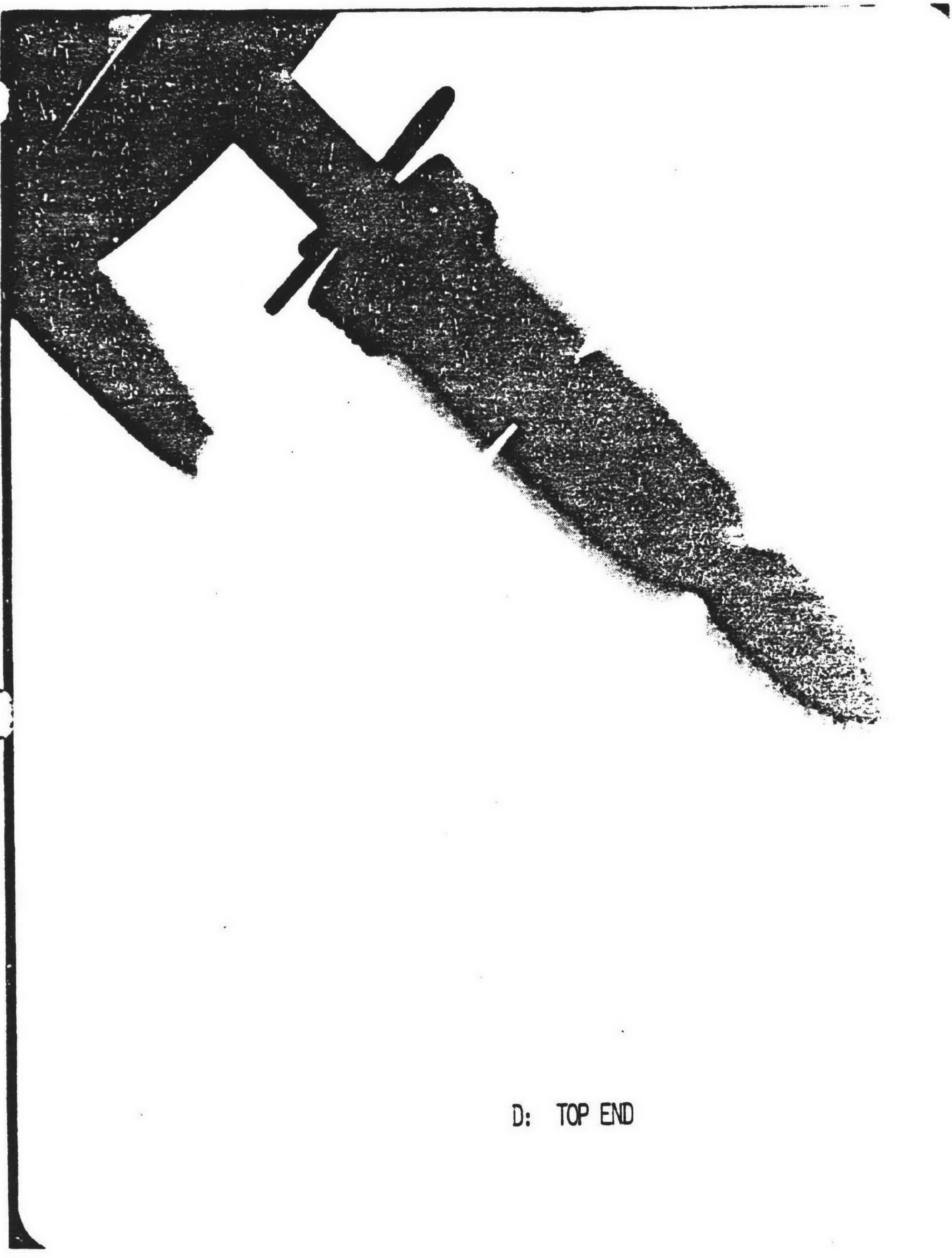
C2: BASE END VIEW
(45^{O} ROTATION)



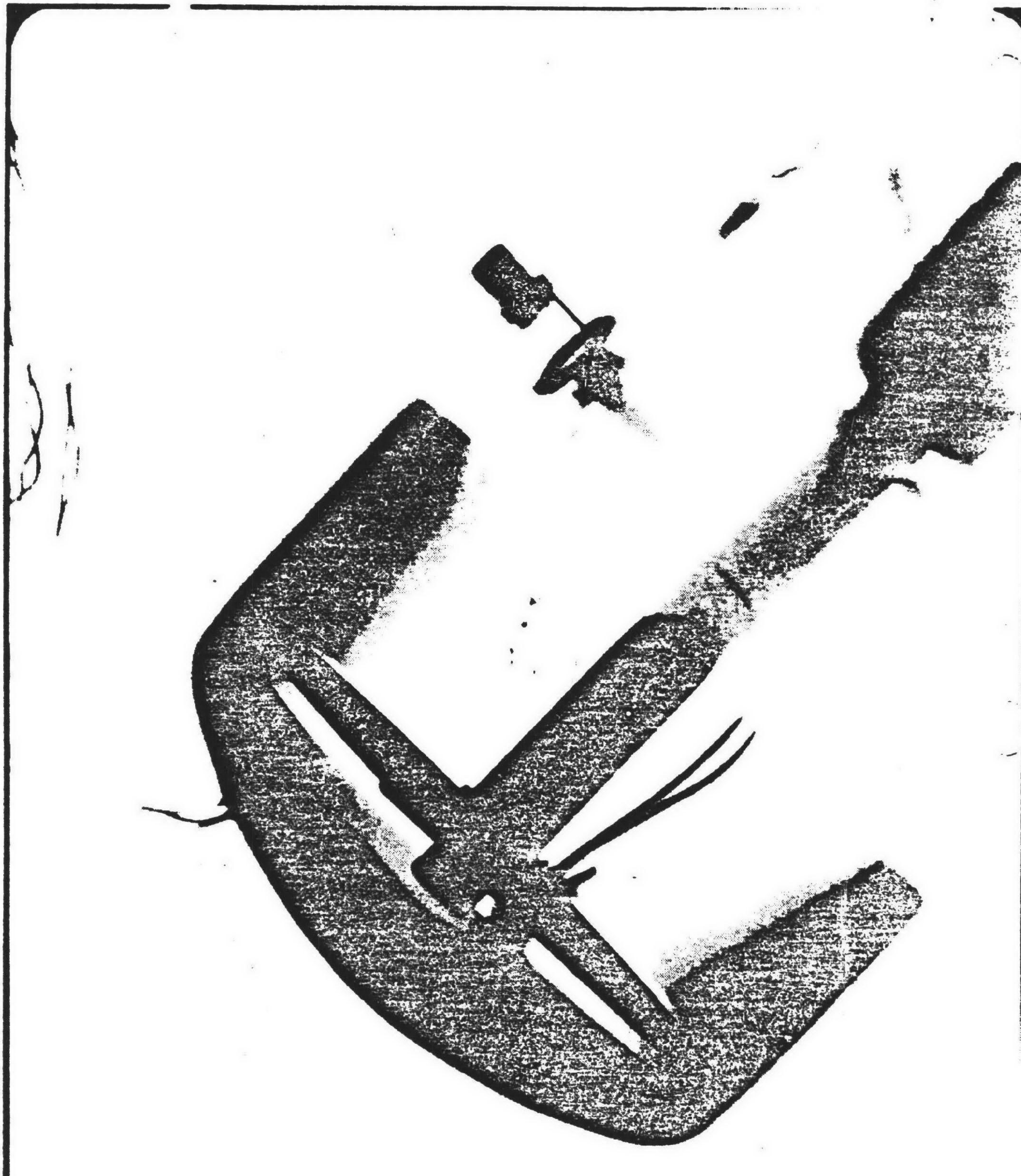
C2: TOP END



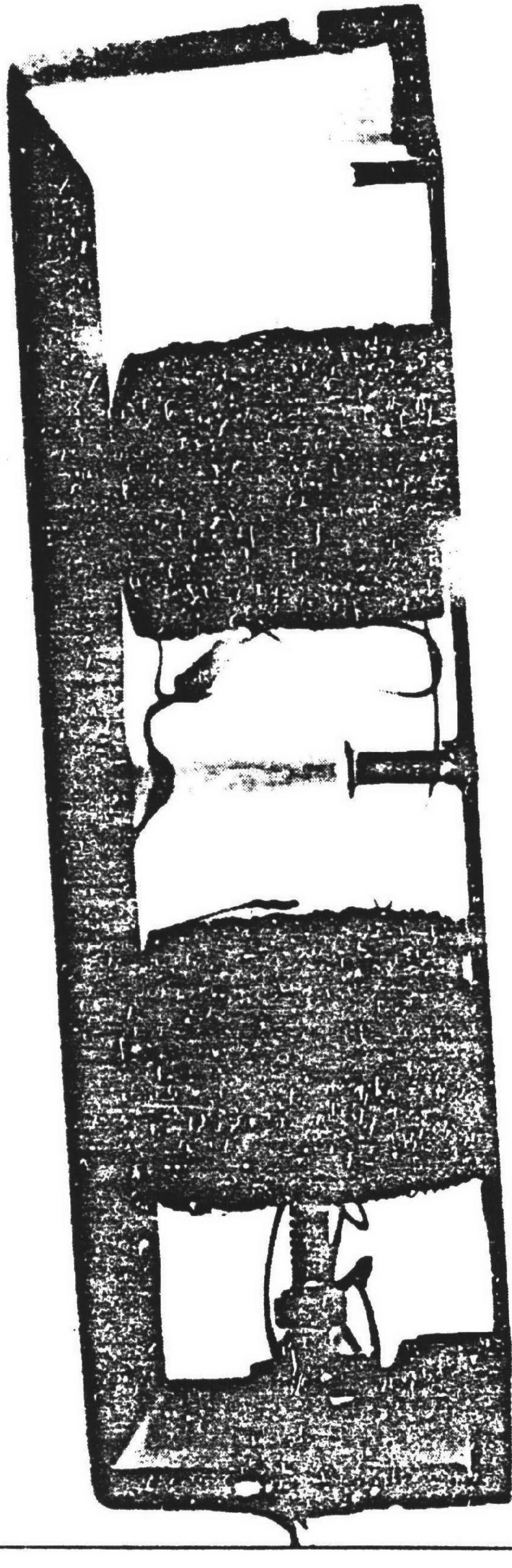
C2: TOP END
(45° ROTATION)



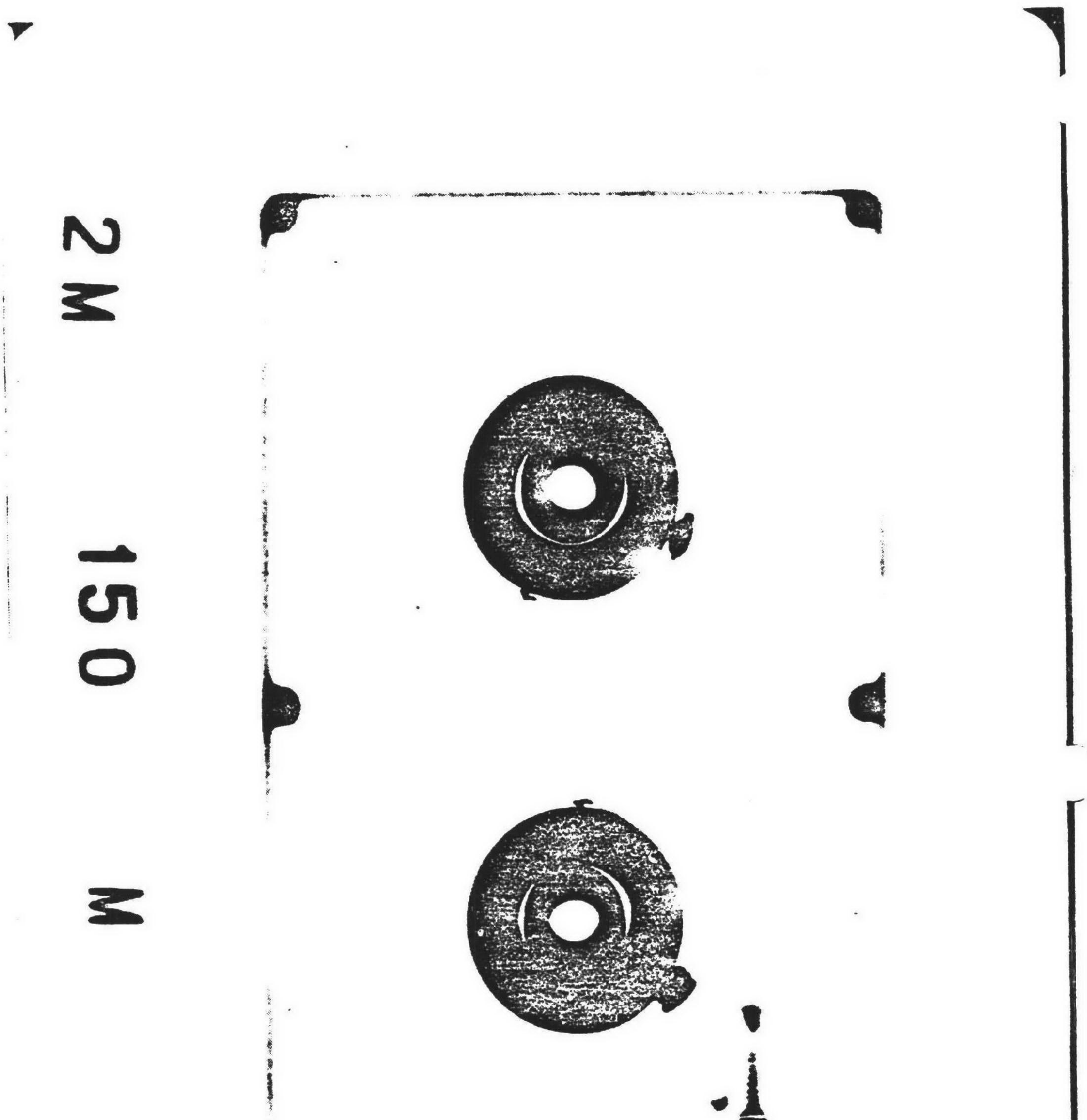
D: TOP END



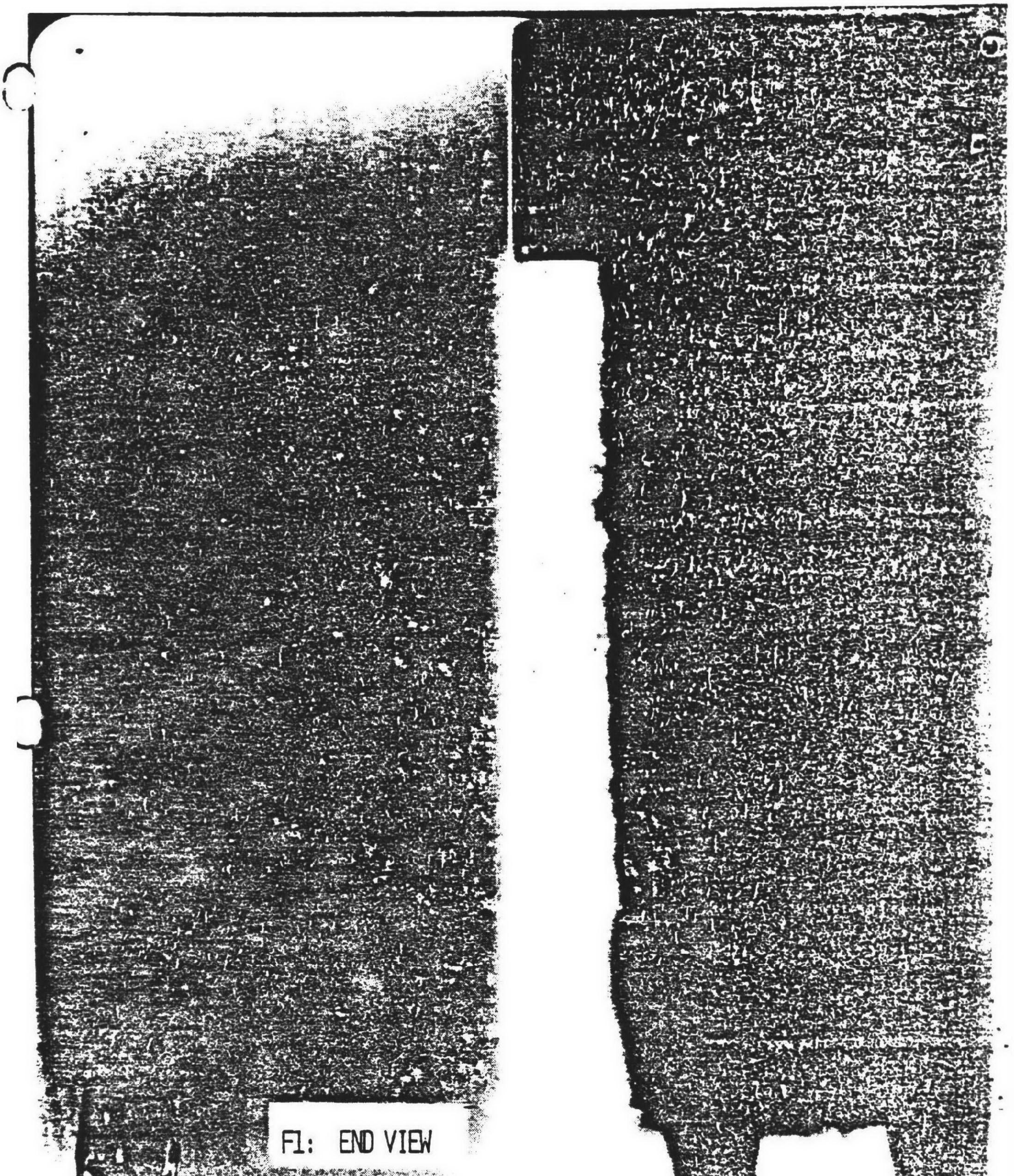
D: POWER INPUT END



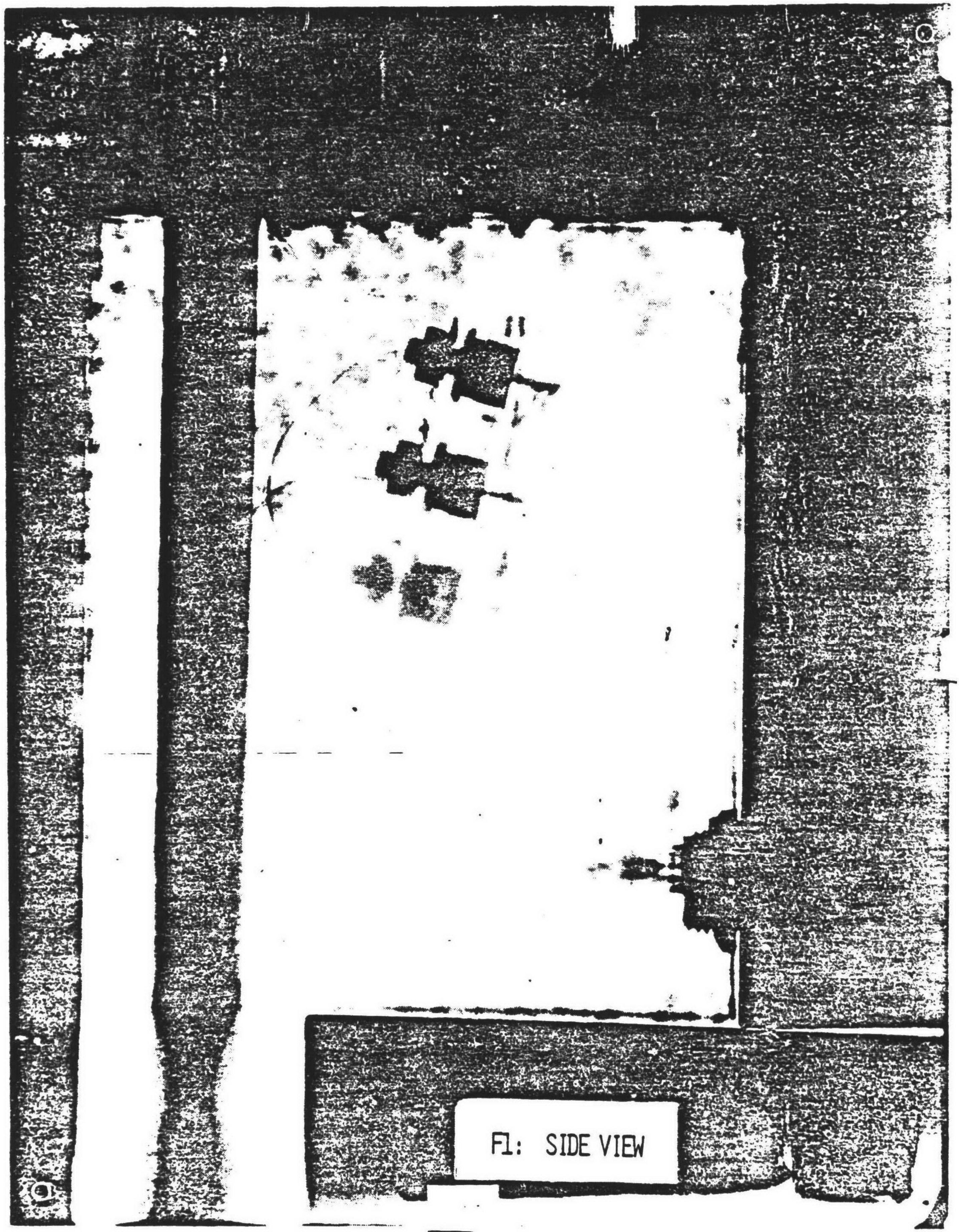
E 1: SIDE VIEW

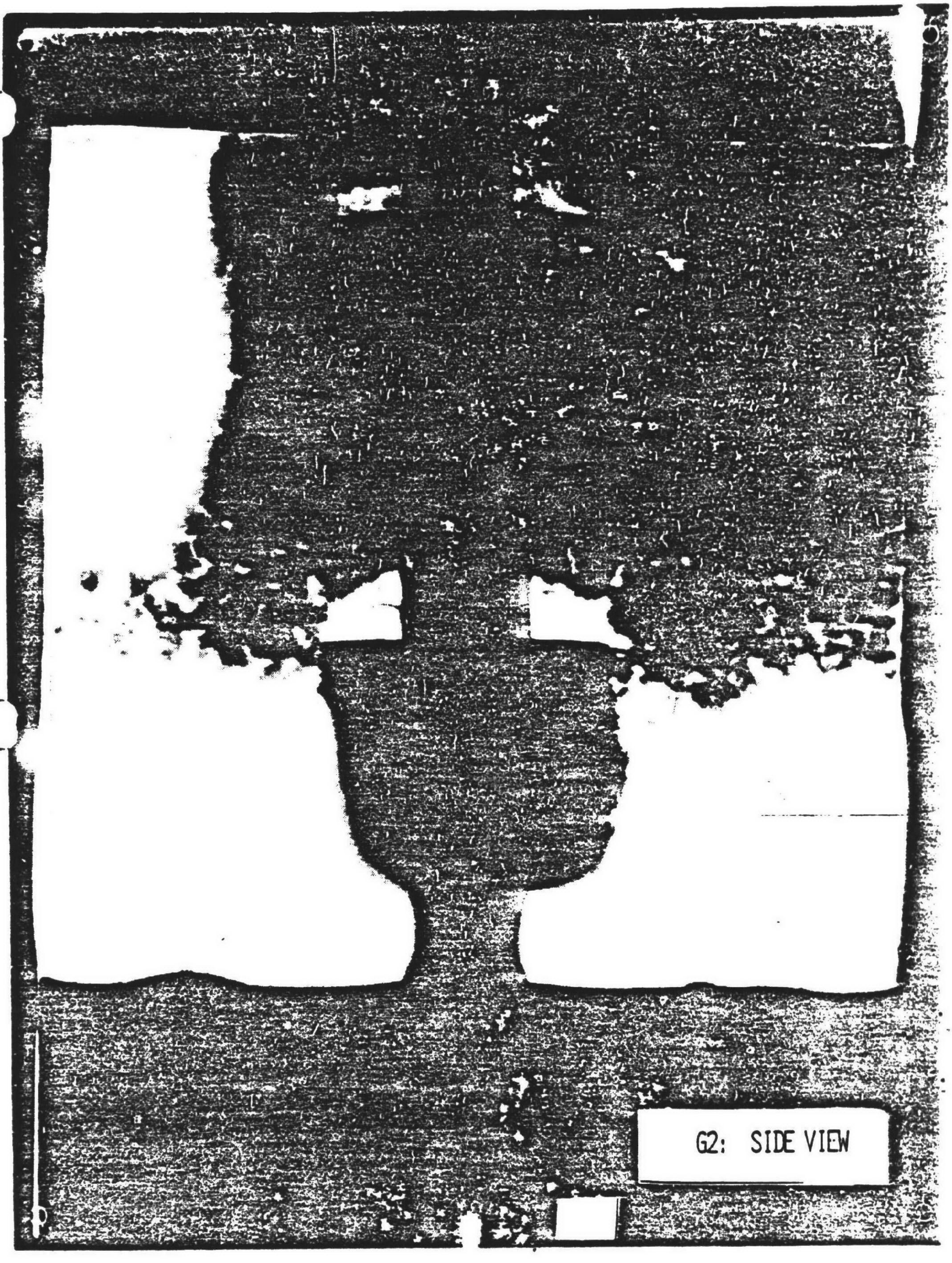


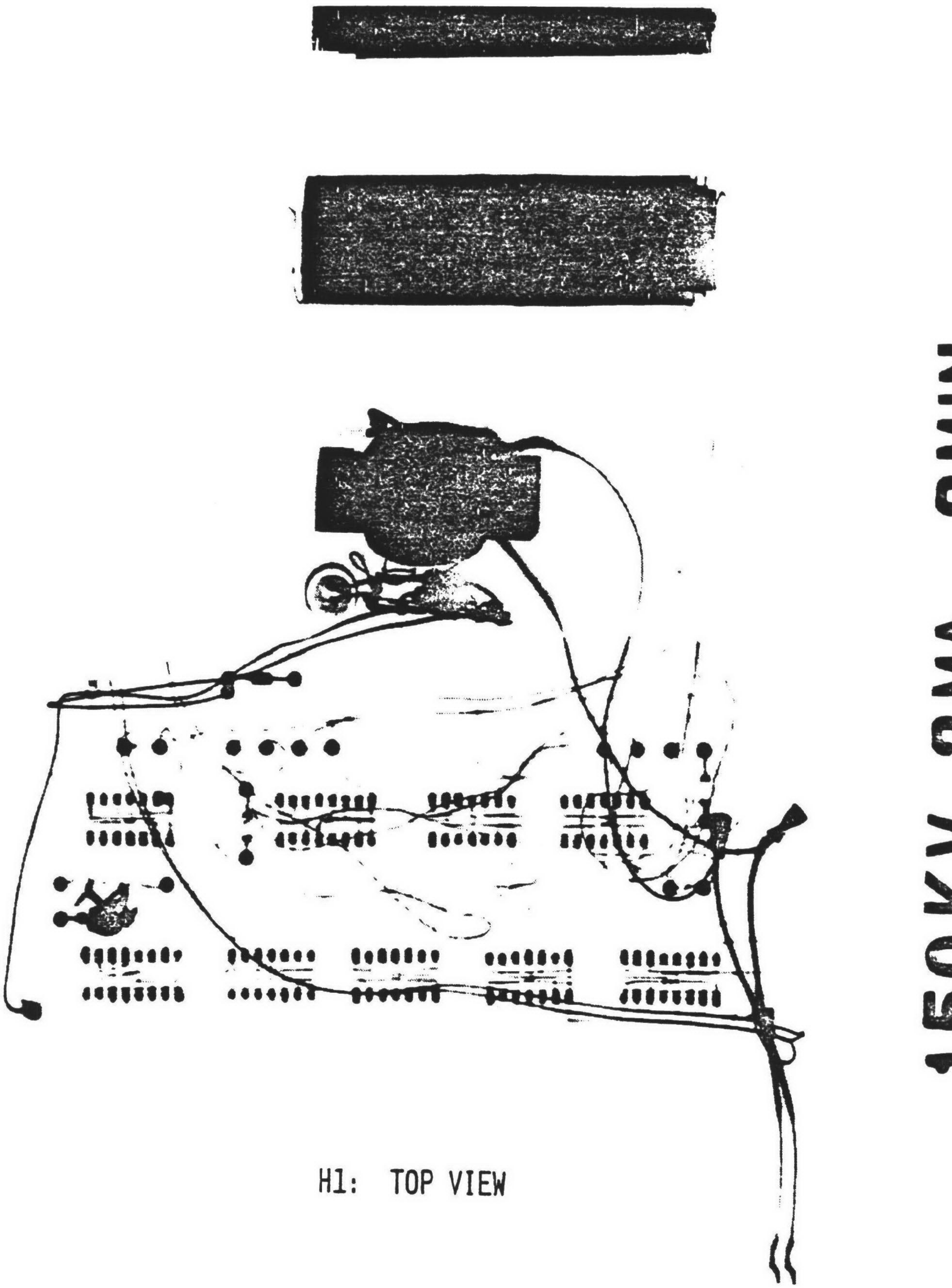
E 1: TOP VIEW



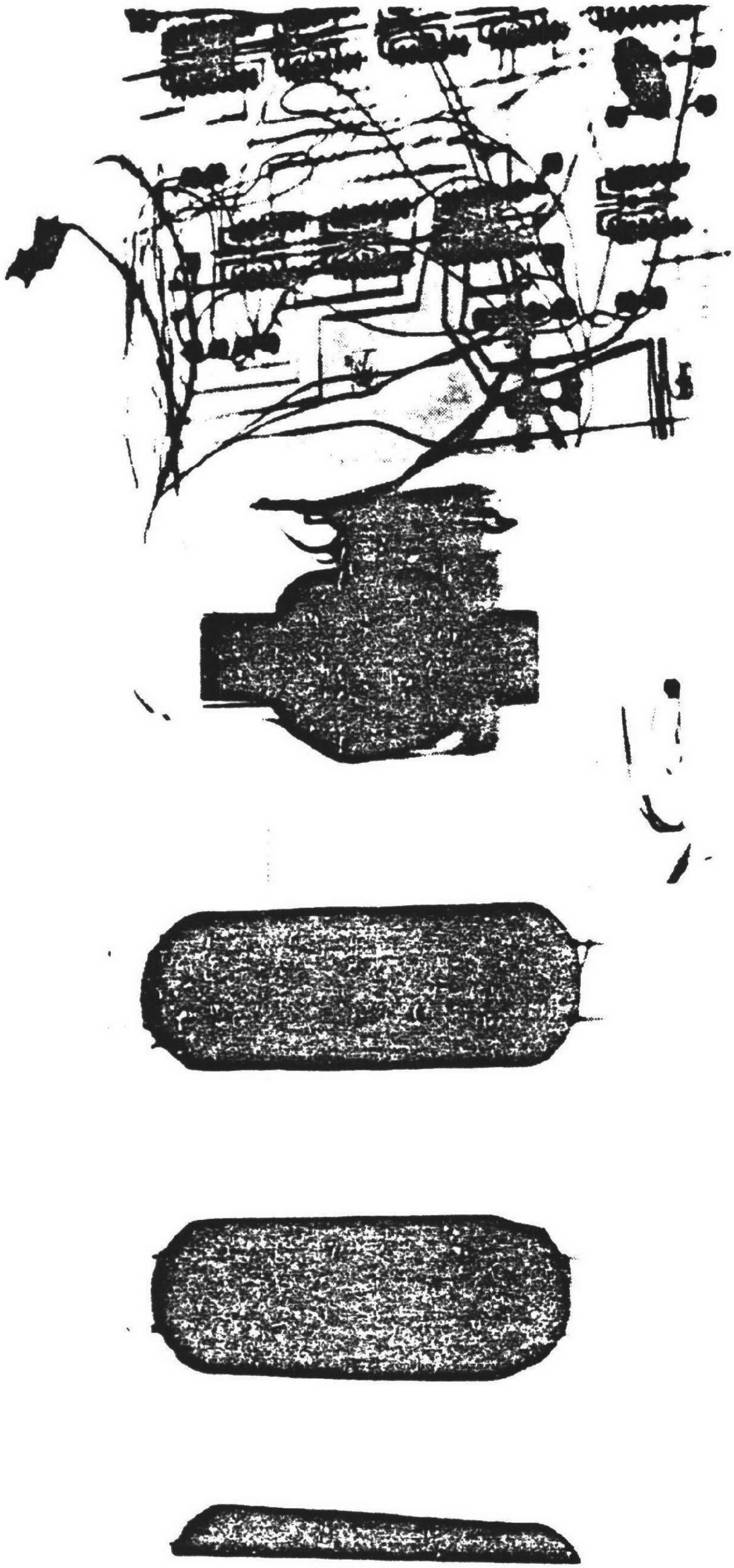
F1: END VIEW


F1: SIDE VIEW


G2: SIDE VIEW

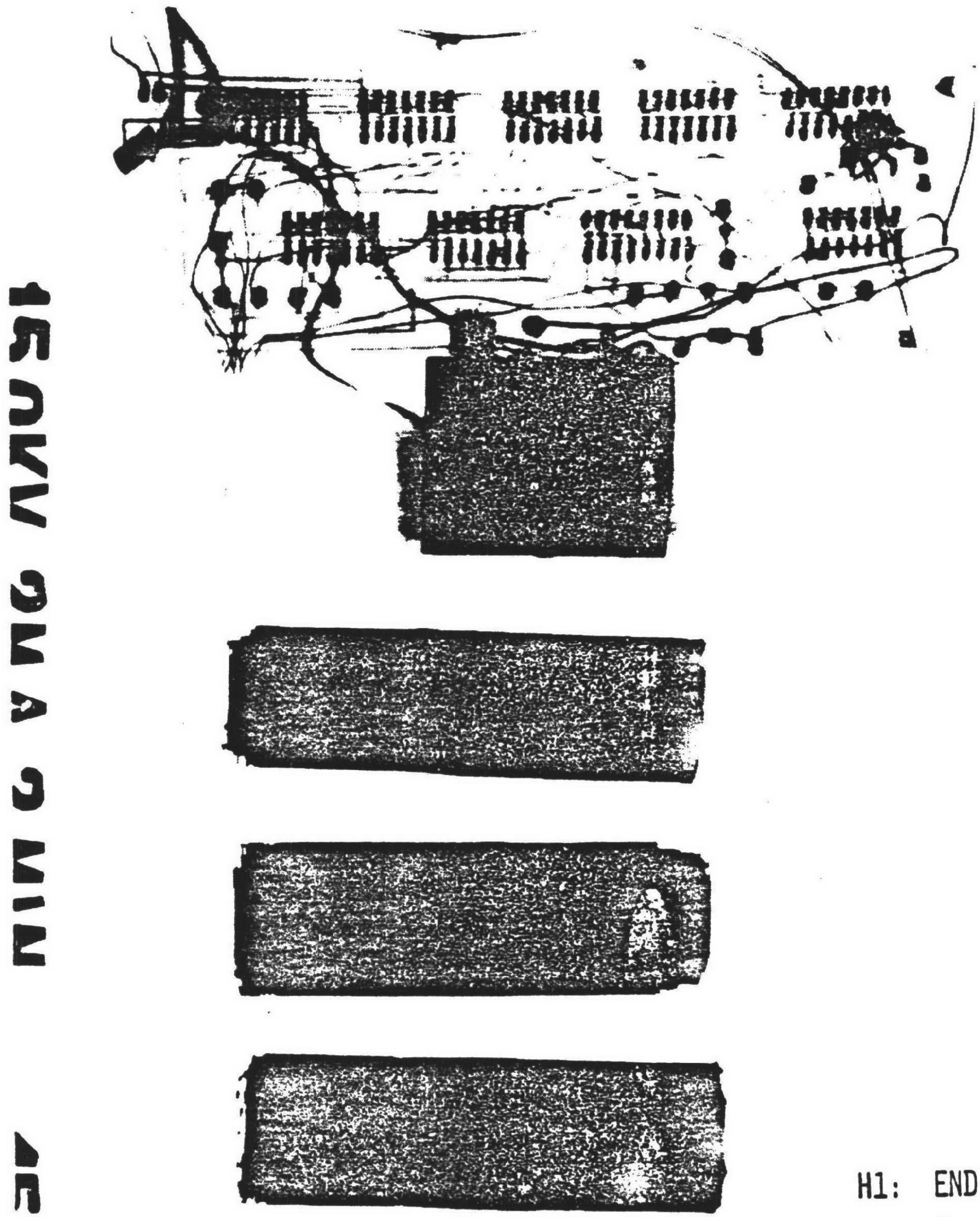


H1: TOP VIEW



H1: EDGE VIEW
(45° ANGLE)

150KV 2MA 2MIN 45



H1: END VIEW
(45° ANGLE)

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13. Type of Report & Period Covered

14. Sponsoring Agency Code

15. SUPPLEMENTARY NOTES

☐ Document describes a computer program; SF-185, FIPS Software Summary, is attached.

16. ABSTRACT *(A 200-word or less factual summary of most significant information. If document includes a ...)*

At the request of the Environmental Protection Agency (EPA), the National Bureau of Standards evaluated eight models of electromagnetic pest controllers provided by EPA. This evaluation was performed by the Center for Consumer Product Technology. The units were evaluated to characterize any detectable electromagnetic output but no judgment of the effectiveness of the devices as pest controllers was made.

Visual and X-ray inspection and electromagnetic measurements showed the units can be grouped into two categories based on characteristics of the output signal--the principal characteristics being either a pulse output or a 60 Hz AC output. For the pulse output devices, no significant external electromagnetic field was found. The 60 Hz units were found to generate detectable magnetic fields. For all units, the fields detected would be less than the earth's magnetic field at distances of three meters or more. Some common electrical equipment was found to generate electromagnetic fields of the same order of magnitude as that produced by these pest controllers.

17. KEY WORDS *(six to twelve entries; alphabetical order; capitalize only the first letter of the first key word unless a proper name; separated by semicolons)*

Electromagnetic Pest Control Deivces
Electromagnetic Field Strength of Pest Control Devices
Pulse Type Pest Control Devices

18. AVAILABILITY ☐ Unlimited

[X] For Official Distribution. Do Not Release to NTIS

☐ Order From Sup. of Doc., U.S. Government Printing Office, Washington, DC 20402, SD Stock No. SN003-003-

☐ Order From National Technical Information Service (NTIS), Springfield, VA. 22161

19. SECURITY CLASS (THIS REPORT)

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20. SECURITY CLASS (THIS PAGE)

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21. NO. OF PRINTED PAGES

22. Price

USCOMM-DC

Subsequent to the February 1979 report entitled "Electromagnetic Pest Control Devices", the National Bureau of Standards examined other pest control devices which were brought to the attention of the Agency, and suspected of operating on the electromagnetic priniciple. A list of the names of these devices and the Bureau's classification as to group follows:

Name	Group
EXTERMA-PULSE	1
NOFLEEZ	1
AMIGO Model 75-c	2
The ELIMINATOR	1
COUNT-DOWN B-100	2
PEST-X	2
PIED PIPER	Neither
EPC MARK V	2
ERGON	2

REPORT OF EFFICACY STUDIES OF THE NATURE-SHIELD RODENT CONTROL DEVICE

Principal Investigators

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Division of Wildlife and Fisheries Biology
University of California
Davis, California 95616

(September 1, 1978)

In Cooperation with the Environmental Protection Agency and the California Department of Food and Agriculture (Contract No. 7061)

INTRODUCTION

Norway rats, Rattus norvegicus, and house mice, Mus musculus, are pests because they are adaptable to such a variety of situations. The ability of rats to survive apparently unchanged on the Eniwetok Atoll of the Marshall Islands following the detonation of the atomic bomb (Jackson, 1967) is a good example of their resiliency. House mice have been reported to be living 1,800 feet below ground in a coal mine in England (Elton, 1936). Sprock et al. (1967) failed to produce any lasting effect on rats subjected to a variety of high frequency sounds. What is normally viewed as a stressful situation in the way of extreme physical changes seems to be tolerated by both rats and house mice.

The tests reported herein were conducted with a Nature-Shield rodent control device to determine if either wild Norway rats or wild house mice would respond in a manner detrimental to their well-being when subjected to a device which the manufacturer claims utilizes "contro-clusive magnetism." It is supposed to "weave patterns above and below ground by stirring the existing magnetic field." The manufacturer's explanation of how the device actually affects rodents is not supported by any logical scientific explanation nor by any research data.

The following statement as to how the device supposedly works appears in a brochure (Appendix I) circulated by the company: "How does NATURE-SHIELD work? NATURE-SHIELD utilizes 'Contro-clusive magnetism'T.M. developed by Solara Electronics, Inc. CCM T.M. establishes a circular perimeter of protection. It weaves patterns above and below ground by stirring the existing magnetic field (it does not add any electric or similar force into the environment). These changes created in the environment provide a null effect in a pest's nervous system eliminating the ability for normal response systems to register a survival reaction to take place. Without the capacity for the survival responses, the creature 'shuts down'. It stops eating, drinking and reproducing."

Concentrating on two of the statements--"Without the capacity for survival responses, the creature 'shuts down'" and "It stops eating, drinking and reproducing"--tests were established to evaluate the validity of portions of this statement in a controlled experiment.

Laboratory tests and a simulated field study were established, with adequate controls, to measure the food and water consumption and mortality of two important rodent pests when exposed to the device. Both wild Norway rats and wild house mice were used in the laboratory tests, but only Norway rats were monitored under simulated field conditions.

Since the manufacturer claims that rats and mice are effectively controlled in from 10 to 14 days, the duration of exposure to the device was arbitrarily established at about twice that time, i.e., 4 weeks.

The food and water intake of rodents may fluctuate somewhat from day-to-day and week-to-week depending on several factors such as age of rodent, ambient temperature, humidity, changes in nutrient value of food, etc.

However, for rodents to be controlled by some self-regulated starvation in 10 to 14 days would require a rather drastic decrease in food and water intake over a short period of time (i.e., a few days). Commensal rats and house mice, unlike some other rodent species such as ground squirrels, do not go into hibernation and hence cannot live for extended periods on accumulated fat.

Decreases or increases in food or water consumption is a readily measurable value which can be quantified over a period of time. Weight gain or loss over time and mortality can also be measured to test the validity of the claims for the device's efficacy.

Test Device

The Nature-Shield rodent control device used in this study was obtained from the manufacturer (Solara Electronics) by Judy Cook of the Environmental Protection Agency, Region IX (215 Fremont Street, San Francisco) and shipped to the investigators. The Nature-Shield device was marked Official Sample #131918. The device was unsealed and installed (it is always turned on) on June 19, 1978 and removed and resealed on July 17, 1978.

Laboratory Tests

Forty laboratory-reared wild house mice (*Mus musculus*) and 40 wild captured Norway rats (*Rattus norvegicus*) were randomly divided into two groups of 20 animals (sexes equal) to establish a treatment group and control group for each species. All animals were mature and in good physical condition. All of the rats were treated at time of capture in the wild with carbaryl (Sevin) to control ectoparasites before bringing them into the laboratory. The animals were weighed and individually housed in suspended cages on steel racks. The animals were selected randomly so age and weight differences occurred between groups.

The tests necessitated that the animals be maintained in two different facilities. The control (untreated or unexposed) groups were placed at the Institute of Ecology and the test groups at the Vertebrate Ecology Laboratory. The straight-line distance between the two buildings is 1,148 feet. This is well beyond the effective radius (650 ft) claimed for the device. Both buildings are air conditioned and have time-controlled lighting (12 hrs light - 12 hrs dark). All groups were acclimated to the laboratory at least 1 week prior to the start of the study.

The individually caged rats and mice were fed a diet of finely ground Purina Laboratory Chow. The rats received the food in cups clipped in place to prevent tipping and spillage and the mice were offered food in heavy glass bowls. Each cage was equipped with a tray to catch all food spillage. Food consumption was measured by weighing remaining food in containers and trays and subtracting this weight from the amount of food offered the previous day. Food was always offered in excess of maximum consumption. Food consumption was measured to the nearest 0.1 g.

Water was provided in graduated drinking bottles and equipped with curved drinking tubes. Water consumption was recorded to the nearest 1 ml per day. To establish an average daily consumption per animal, food and water consumption was recorded for four consecutive days during each test week.

Food and water consumption of the test groups was recorded for 1 week pre-test (pre-installation of device), for each week of the 4 weeks the device operated, and again for 1 week following the removal of the device. For the control groups the consumption data were collected for the identical time periods, although these animals were never under any possible influence of the device.

Simulated Field Test

Forty wild captured Norway rats were divided into two groups of 20 each (sexes equal). Each animal was weighed. They were eartagged on both ears for positive future indentification. The test animals were then released as a group into a relatively small rodentproof poultry house (16 x 16 ft) which is located directly behind the Vertebrate Ecology Laboratory (Fig. 1). The control animals were housed as a group in a comparable size enclosure (10 x 20 ft) at the Institute of Ecology. The rats in both locations were provided with a multiple compartmental nest box, and two pallets covered with a small sheet of plywood were positioned on the floor near the center of the room to offer additional cover.

The enclosures were not temperature or humidity controlled and varied with the weather which was recorded daily. Natural lighting existed in both enclosures.

Each group of rats received eight large food bowls and four one-quart chick watering fountains. All were spaced uniformly within the enclosures. As with the laboratory tests, both food (ground Purina Laboratory Chow) and water consumption were recorded to the nearest gram or ml for four consecutive days each week. In order to make needed corrections for any change in the moisture content of food and for evaporation of water, two food bowls and two waterers were placed outside each enclosure and protected from rodents. These were weighed each day and a correction factor arrived at for any water loss. The change in weights of the food was so minor that no corrections were made for any moisture uptake or loss from the ground chow.

The two groups of animals, which were designated to simulate rat infestations, were established one week prior to the start of the test, when the amounts of food and water consumed were recorded. This allowed sufficient time for the establishment of social hierarchies and group compatability of the rats prior to initiating the actual test.

The Nature-Shield rodent control device was placed on the ground eight feet from the poultry house and, in accordance with the instructions, the device was oriented to magnetic north. According to the manufacturer's claims the device will cover a radius of 650 ft, hence the active coverage of a single unit encompassed both the Vertebrate Ecology Laboratory, approximately 120 ft away, and the poultry house (Figure 1).

The flashing indicator light and compass orientation of the device were checked daily to be assured all were in functioning order.

General observations were made daily of the groups of rats to check for deaths and any possible abnormal behavior or other clues which might indicate in the test group that the device was having some influence on the rats. At the completion of the study all of the rats in the two enclosures were live-trapped, weighed, then caged individually and kept in the laboratory for an additional 3 weeks to determine whether any females had become pregnant.

RESULTS

Results of Laboratory Tests

The results of the laboratory tests are given in Table 1. The food consumption and water intake over the 6 weeks of measurements showed some fluctuations but in no instance did the intake of either food or water for the treated animal groups vary greatly from the control animal groups. There was no mortality in the test of control house mice or Norway rats. The test group of house mice gained an average 2.0 g in weight over the test period while the control group gained 1.0 g. The rats under test gained an average of 27 g, not much different from the control group which averaged a 15 g increase. The greater percentage increase (Table 2) in the test groups can probably be attributed to the fact that both test groups were slightly smaller (i.e., younger) at the start and thus would gain at a faster rate.

Brief observations of each rodent daily did not reveal any detectable abnormal behavior.

These results of the laboratory tests indicate that the Nature-Shield as tested was ineffective in producing mortality as a result of changes in feeding or drinking behavior or in any other behavioral trait.

Results of the Simulated Field Test

The results of the simulated field test are provided in Table 3. The food consumption and water intake over the 6 weeks of measurements fluctuated somewhat, but in no instance did the consumption of either the food or water in the treated group of rats vary greatly from the control group.

A male rat (number 3665-3666) died in the test group on July 19, two days following removal of the Nature-Shield. The rat did not show any signs of being emaciated or injured. The animal's weight at the start of test was 249 g and at death it weighed 302 g. Cause of death could not be determined from gross necropsy, but it is not unusual for an occasional wild laboratory rat to die for unexplainable reasons.

The simulated field tests were primarily established for measuring mortality and food and water consumption; however, some reproductive data were also obtained. One unidentified female dropped a litter of at least

9 young. She had been exposed to the device for 23 days so conceived after the device had been on for a few days. The litter was cannibalized, a relatively common occurrence in high-density rat populations. Following the removal of the females at the end of the study, 5 females from the control group and 2 from the test group had litters (Table 5), and they could all have conceived during the test period.

Rather substantial weight increases occurred in both groups of animals; however, a portion of these gains must be attributed to the heavier pregnant females.

The results of the simulated field test suggest that the Nature-Shield as tested was ineffective in controlling the Norway rats in the simulated field test.

ACKNOWLEDGMENTS

Our thanks to Staff Research Associate Dennis Stroud (M.S.) and Laboratory Assistant Deborah Grobman (B.S.) for their dedicated assistance in carrying out this study.

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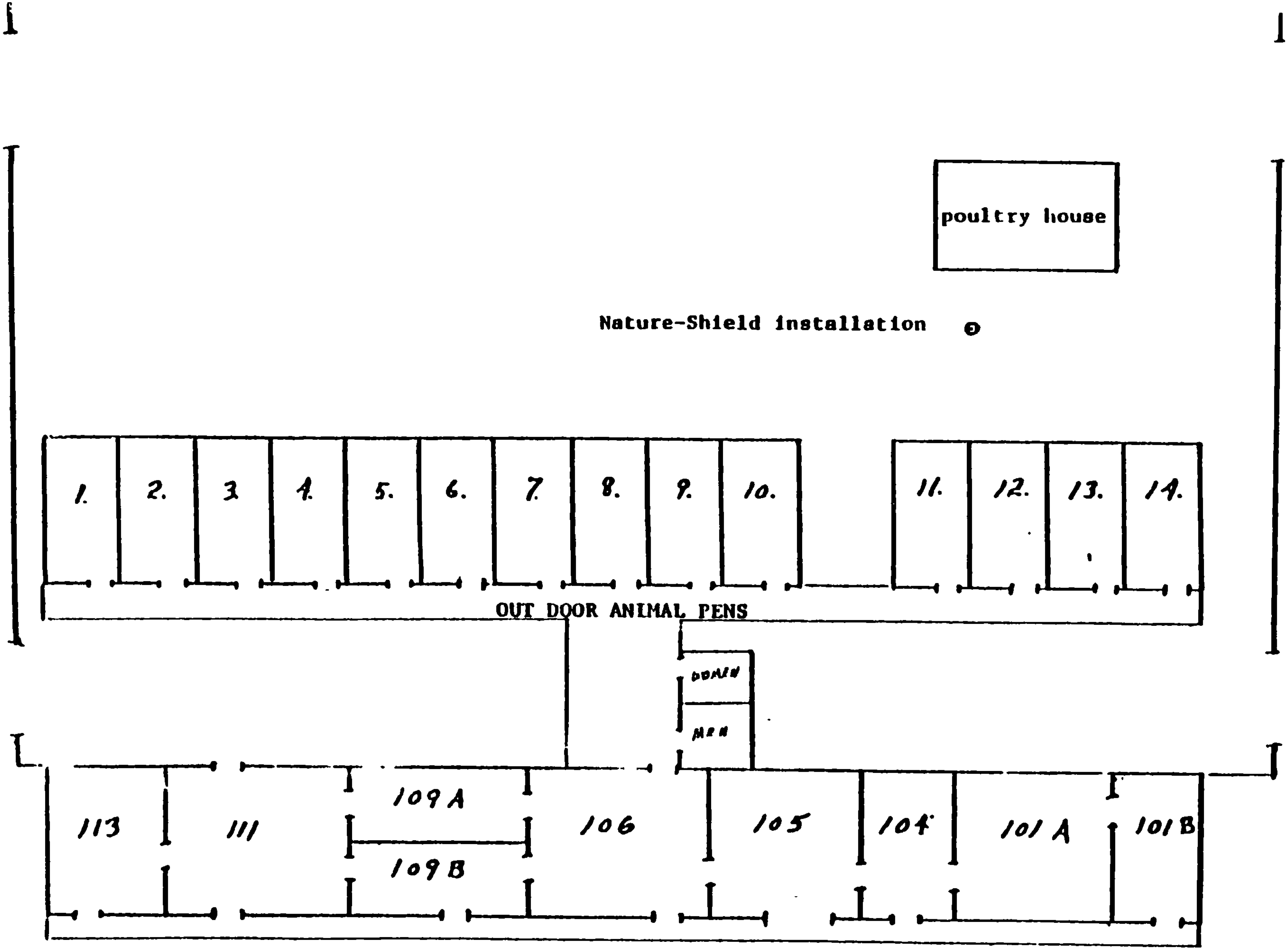
Jackson, W. B. 1967. Rats, bombs, and paradise - the story of Eniwetok. Proc. Third Vertebrate Pest Conference, March 7, 8 and 9, 1967. pp. 45-46.

Sprock, C. M., W. E. Howard and F. C. Jacob. 1967. Sound as a deterrent to rats and mice. J. Wildl. Mgmt. 31(4):729-741.



VERTEBRATE ECOLOGY LABORATORY (TB-1)

Figure 1. A diagram of the Vertebrate Ecology Laboratory showing location of installed Nature-Shield. The simulated field test was conducted in the poultry house and the laboratory tests in Room 111 (scale 1/2"=10').

Table 1. Food and water consumption measurements taken in the laboratory tests given in averages per animal per day when measured over a 4-day period of each week.

Animal group	One week pre-device		First week of test		Second week of test		Third week of test		Fourth week of test		One week post-device		Mortality
	Food*	Water**	Food	Water	Food	Water	Food	Water	Food	Water	Food	Water	
House mouse test group	3.83	3.98	5.15	5.48	5.08	5.60	5.1	5.90	5.03	5.48	5.27	5.54	0
House mouse control group	5.03	4.25	6.53	5.39	6.32	5.63	6.02	6.59	5.81	6.75	6.23	6.48	0
Norway rat test group	20.25	35.35	23.01	43.45	19.18	43.83	19.20	43.50	19.09	41.35	19.19	45.23	0
Norway rat control group	20.98	35.89	23.79	41.63	21.93	40.53	20.76	39.14	20.32	40.00	21.21	43.21	0

*Food values given in grams
**Water values given in mls.

Table 2. Average and range of weights at start and completion of laboratory tests.

Animal groups	Avg. weight at start (g)	Range of weight at start (g)	Avg. weight at end (g)	Range of weight at end (g)	Percent weigh change
House mouse test group	16.4	9.8-23.8	18.4	11.8-26.2	12.2% increas
House mouse control group	19.5	12.4-28.1	20.5	13.6-27.8	5.2% increas
Norway rat test group	252	151-338	279	187-372	10.6 increase
Norway rat control group	270	208-383	.285	229-376	5.5% increas

Table 3. Food and water consumption measurements taken in the simulated field test given in averages per animal per day when measured over a 4-day period of each week.

Animal group	One week pre-device		First week of test		Second week of test		Third week of test		Fourth week of test		One week post-device		Mortality
	Food*	Water**	Food	Water	Food	Water	Food	Water	Food	Water	Food	Water	
Norway rat test group	22.8	39.86	23.3	44.19	24.6	47.69	22.2	46.89	23.8	47.38	25.0	59.86	1†
Norway rat control group	19.5	37.24	20.8	38.06	21.5	38.48	21.8	41.20	24.6	43.78	24.2	47.06	0

*Food values given in grams.
**All water values corrected for evaporation and given in ml.
†One death (male #3665-6) occurred 7/19/78, two days following the removal of the device.

Table 4. Average and range of weights at start and completion of simulated field test.

Animal groups	Avg. weight at start (g)	Range of weight at start (g)	Avg. weight at end (g)	Range of weight at end (g)	Percent weigh change
Norway rat test group	215	131-395	284	215-497	33.0* increase
Norway rat control group	185	93-523	270	100-539	46.3% increase

*Calculated on the basis of the 19 surviving rats.

Table 5. Information on reproduction collected during and following the simulated field study. Calculating gestation at 21-22 days all females littering would have conceived during the period when the Nature-Shield was in operation (June 19 to July 17, 1978).

Female number	Date littered	Group	No. young
Number not determined	7/19	Test	9*
3618	7/31	Test	13
3629	8/3	Test	7
3639	7/25	Control	8
6052	8/1	Control	4
3647	7/28	Control	7
3635	7/31	Control	7
3649	7/28	Control	7

*Littered during the test.

q How does NATURE-SHIELD work?

a NATURE-SHIELD utilizes "Contro-clusive magnetism"T.M. developed by Solara Electronics, Inc. CCMT.M establishes a circular perimeter of protection. It weaves patterns above and below ground by stirring the existing magnetic field (it does not add any electric or similar force into the environment). These changes created in the environment provide a null effect in a pest's nervous system eliminating the ability for normal response systems to register a survival reaction to take place. Without the capacity for the survival responses, the creature "shuts down". It stops eating, drinking and reproducing.

q What creatures are affected?

a Rats, mice, ground squirrels, moles, voles, gophers (rodents in general), plus ants (certain species), roaches, termites.

q How long does it take for the creature to be controlled?

a The rate of effect is dependent on the creature. The NATURE-SHIELD is not a 'zap' machine . . . it is not instantaneous. It takes time for the creature to succumb. In effect, the creature starves to death. Rats and mice are effectively controlled in from ten to fourteen days. Gophers and moles in three to four weeks. The time for insects varies by the species.

q How do you know the creature is being affected?

a Confused behavior including the loss of a sense of direction is the primary observable effect. The survival responses are affected, and the creature no longer behaves with normal attack or defensive mannerisms. It becomes lethargic and "shuts down"

q Are people and domestic animals affected?

a No! Exposure to constant magnetic flux is part of our daily lives. The more highly evolved creatures that we consider part of our life style (i.e. – dogs, cats, livestock, etc.), have found it easier to adapt to change than those of a lower order (i.e. – rats, mice, and rodents in general). Observation has shown that bees, earthworms, ladybugs, etc. are not affected.

q Are the creatures driven from my area into my neighbors'?

a No. This unit utilizes magnetism, not ultrasonics, to establish control. The field of influence is uniform throughout the protected area; therefore, there is no means for the creature to detect the direction out of the area of influence. The flux factor is ever-changing which acts as a house-of-mirrors concept to increase disorientation.

q What area of protection does the NATURE-SHIELD offer?

a 30 acres (12 hectares) minimum. This is generally in a circular configuration . 650 ft. (200 meters) horizontal radius – above and below ground.

q Is there interference with devices (i.e. TV, Radio, etc.)?

a No. The NATURE-SHIELD unit is engineered in such a way that there is no interference, not even with pacemakers.

q Can a control be established in buildings?

a NATURE-SHIELD is effective over 30 acres minimum, with or without buildings, inside and out.

q Are there any installation problems?

a No. Being battery operated, it requires no electrical power connection or extensive installation.

q How does the weather or environment affect the operation of NATURE-SHIELD?

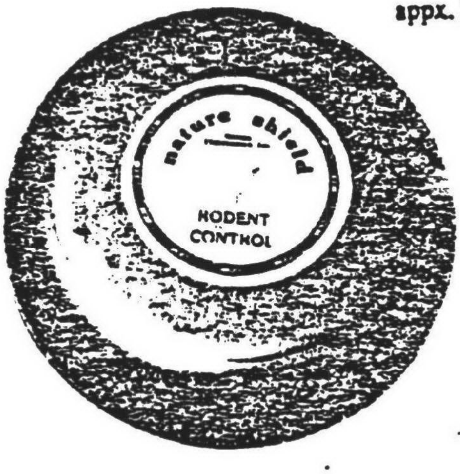
a In temperatures from -50° to 180° F, performance is satisfactory. Also, environmental conditions such as rain, snow or moisture amplifies the unit's effectiveness.

q Is the effect of contro-clusive magnetism permanent within the area?

a No. It works only while the NATURE-SHIELD unit is in operation. If the unit is removed, the magnetic effect dissipates within days, and the pests would have access to enter the area.

Patent Pend.

21 in. diam.
7 in. high
appx. 25 lbs.



"NATURE-SHIELD"™

IMPORTANT
NOTICE TO PURCHASER

Solara Electronics, Inc. will replace or repair at our option any units found to be defective in workmanship or materials within a year from date of purchase. Customer should contact nearest Solara dealer to receive authorization to return defective units. Proof of purchase date and return authorization is required.

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Products to benefit mankind

3621 West MacArthur Blvd., Suite 119
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Phone: (714) 751-3620

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WE'VE BUILT A BETTER MOUSE TRAP..

"NATURE-SHIELD"™

REPORT OF EFFICACY STUDIES OF THE MAGNA-PULSE RODENT CONTROL DEVICE

Principal Investigators

Rex E. Marsh and Walter E. Howard
Division of Wildlife and Fisheries Biology
University of California
Davis, California 95616

March 1, 1979

In cooperation with the Environmental Protection Agency and the California Department of Food and Agriculture (Contract No. 7061).

INTRODUCTION

The tests reported herein were conducted with the Magna-Pulse rodent control device. The objective was to determine whether the well-being of either wild Norway rats or wild house mice would be affected detrimentally when subjected to this device. The distributor claims that "Magna-Pulse controls ground inhabiting rodents and numerous insects," and that the evidence the creature is becoming affected is usually apparent due to its erratic behavior, and that "the pest will show a loss of sense of direction" (Appendix I). None of the many claims is supported by any logical scientific explanation nor by research data.

Since Magna-Pulse is promoted to "control dangerous pests," controlled laboratory tests and a simulated field study with adequate controls were established to evaluate the validity of this statement. Mortality rates and food and water consumption were the criteria used to monitor the well-being of the rodents that were exposed to the device. Both wild Norway rats (Rattus norvegicus) and wild house mice (Mus musculus) were used in the laboratory tests, but only Norway rats were monitored under simulated field conditions.

The manufacturer does not make any claims as to how long it takes to effectively control rats and mice with the Magna-Pulse device. In our tests the exposure time was arbitrarily established at 28 days, which seemed much longer than necessary to detect behavioral effects the device might cause, and it was more time than that suggested by other manufacturers of similar devices.

Any variation from the normal in consumption of food or water is a good indication of the animals' health and is a readily measurable value which can be quantified over a period of time. Weight gains or losses over time and abnormal mortality rates can be measured and used as a means of testing the validity of the maufacturer's claims about the device's efficacy.

PROCEDURES AND METHODS

Test Device

Two Magana-Pulse rodent control devices (Model MPC 1000) were used in this study. They were obtained from the distributor (Bell Products Corp., 696 Watson Way, Sparks, Nevada 89431) by Judy Cook of the Environmental Protection Agency, Region IX (215 Fremont Street, San Francisco) and were shipped to the investigators. The devices were marked Official Sample #131919.

The Magna-Pulse device is a rectangular plastic box approximately 17 3/4" x 10 3/4" x 6 1/2" with a contained battery power supply. There is no switch on the unit and it thus operates continuously as long as the power supply lasts. A small red indicator light comes on briefly every few seconds to indicate that the unit is operational.

The house mice and Norway rats were tested at different times in the laboratory. Both devices were unsealed and put into operation October 23, 1978 and removed on November 20, 1978; one of the units was put into operation again on January 15, 1979 and removed on February 12, 1979.

Laboratory Tests

Forty laboratory-reared wild house mice (*Mus musculus*) and 40 wild captured Norway rats (*Rattus norvegicus*) were randomly divided into two groups of 20 animals (sexes equal) to establish a treatment group and control group for each species. All animals were mature and in good physical condition. All of the rats were treated at time of capture in the wild with 5% carbaryl (Sevin) dust to control ectoparasites before bringing them into the laboratory. The animals were weighed and individually housed in suspended cages on metal racks. The animals were selected randomly, hence some age and weight differences occurred between the groups, although the total biomass was reasonably similar between test and control groups.

The test requirements necessitated that the animals be maintained in two different facilities. The control (untreated or unexposed) groups were placed at the Institute of Ecology and the test groups at the Vertebrate Ecology Laboratory, 15 to 25 feet from the test animals. Both buildings are air conditioned and have time-controlled lighting (12 hrs light - 12 hrs dark). All groups were acclimated to the laboratory at least one week prior to the start of the study.

The individually caged rats and mice were fed a diet of finely ground Purina laboratory chow. The rats received the food in cups clipped in place to prevent tipping and spillage and the mice were offered food in heavy glass bowls. Each cage was equipped with a tray to catch all food spillage. Food consumption was measured by weighing remaining food in containers and trays and subtracting this weight from the amount of food offered the previous day. Food was always offered in excess of maximum consumption. Food consumption was measured to the nearest 0.1 g.

Water was provided in graduated drinking bottles and equipped with curved drinking tubes. Water consumption was recorded to the nearest 1 ml per day. To establish an average daily consumption per animal, food and water consumption was recorded for four consecutive days during each test week.

Food and water consumption of the test groups was recorded for one week pre-test (pre-installation of device), for each week of the four weeks (28 days) the device operated, and again for one week following the removal of the device. For the control groups the consumption data were collected for the identical time period, although these animals were never under any possible influence of the device.

Simulated Field Test

Forty wild captured Norway rats were divided into two groups of 20 each (sexes equal). Each animal was weighed. They were eartagged on both ears for positive future indentification. The test aniamls were then released as a group into a relatively small rodentproof poultry house (16 x 16 ft) which is located directly behind the Vertebrate Ecology Laboratory (Fig. 1). The control animals were housed as a group in a comparable size enclosure (10 x 20 ft) at the Institute of Ecology. The rats in both locations were provided with a large nest box containing nest compartments. Also, in both situations two pallets on the floor near the center of the room were covered with a small sheet of plywood to offer additional cover.

Both the poultry house and the enclosure were not temperature or humidity controlled. These conditions depended on weather conditions, which were recorded daily. Natural lighting existed in both enclosures.

Each group of rats received eight large food bowls and four one-quart chick watering fountains. All were spaced uniformly within the enclosures. As with the laboratory tests, both food (ground Purina laboratory chow) and water consumption were recorded to the nearest gram or ml for four consecutive days each week. In order to make needed corrections for any change in the moisture content of food and for evaporation of water, two food bowls and two waterers were placed outside each enclosure and protected from rodents. These were weighed each day and a correction factor arrived at for any water loss. The change in weights of the food turned out to be so minor that no corrections were necessary for any moisture uptake or loss from the ground chow.

The two groups of animals, which were designated to simulate rat infestations, were established two weeks prior to the installation of the control device. This allowed sufficient time for the establishment of social hierarchies amongst the groups of rats prior to initiating the actual test. The amount of food and water consumed was also recorded for the week just prior to installing the device.

The two Magna-Pulse (Model MPC 1000) rodent control devices were installed in accordance with the manufacturer's instructions. The unit installed for the simulated field test was placed in a dug 3" recess in the ground at a distance of eight feet from the poultry house. The unit was oriented to magnetic north with the use of a compass. According to the claims the devices will cover a radius of 650 feet, hence the active coverage of a single unit should encompass both the Vertebrate Ecology Laboratory, approximately 120 feet away, and the poultry house (Fig. 1) where the test animals were housed. A second unit, however, was also installed in the Vertebrate Ecology Laboratory in accordance with the manufacturer's instructions. The indicator lights on the devices were checked daily to assure they were functioning.

General observations were made daily of the groups of rats to check for deaths and any possible abnormal behavior or other clues which might indicate in the test group that the device was having some influence on the rats. At the completion of the study all of the rats in the two enclosures were live-trapped, weighed, then caged individually and kept in the laboratory for an additional 3 weeks to determine whether any females had become pregnant.

RESULTS

Results of Laboratory Tests

The results of the laboratory tests are given in Table 1. The food consumption and water intake over the 6 weeks of measurements showed some fluctuations but in no instance did the intake of either food or water for the treated animal groups vary greatly from the control animal groups. There was no mortality in the test groups of house mice or Norway rats; however, one mouse and one rat of each control group died of undetermined cause. These presumably were natural deaths and not related to the study itself. The test group of house mice gained an average 0.6 g in weight over the test period while the control group lost 1.2 g on an average. The rats under test lost an average of 2 g, not a great difference from the control group which averaged a 7 g increase (Table 2).

Brief daily observations of each rodent did not reveal any detectable abnormal behavior.

These results of the laboratory tests indicate that the Magna-Pulse as tested is ineffective in producing mortality or in adversely altering feeding or other behavior.

Results of the Simulated Field Test

The results of the simulated field test are provided in Table 3. The food consumption and water intake over the 6 weeks of measurements fluctuated somewhat, but in no instance did the consumption of either the food or water in the treated group of rats vary greatly from the control group.

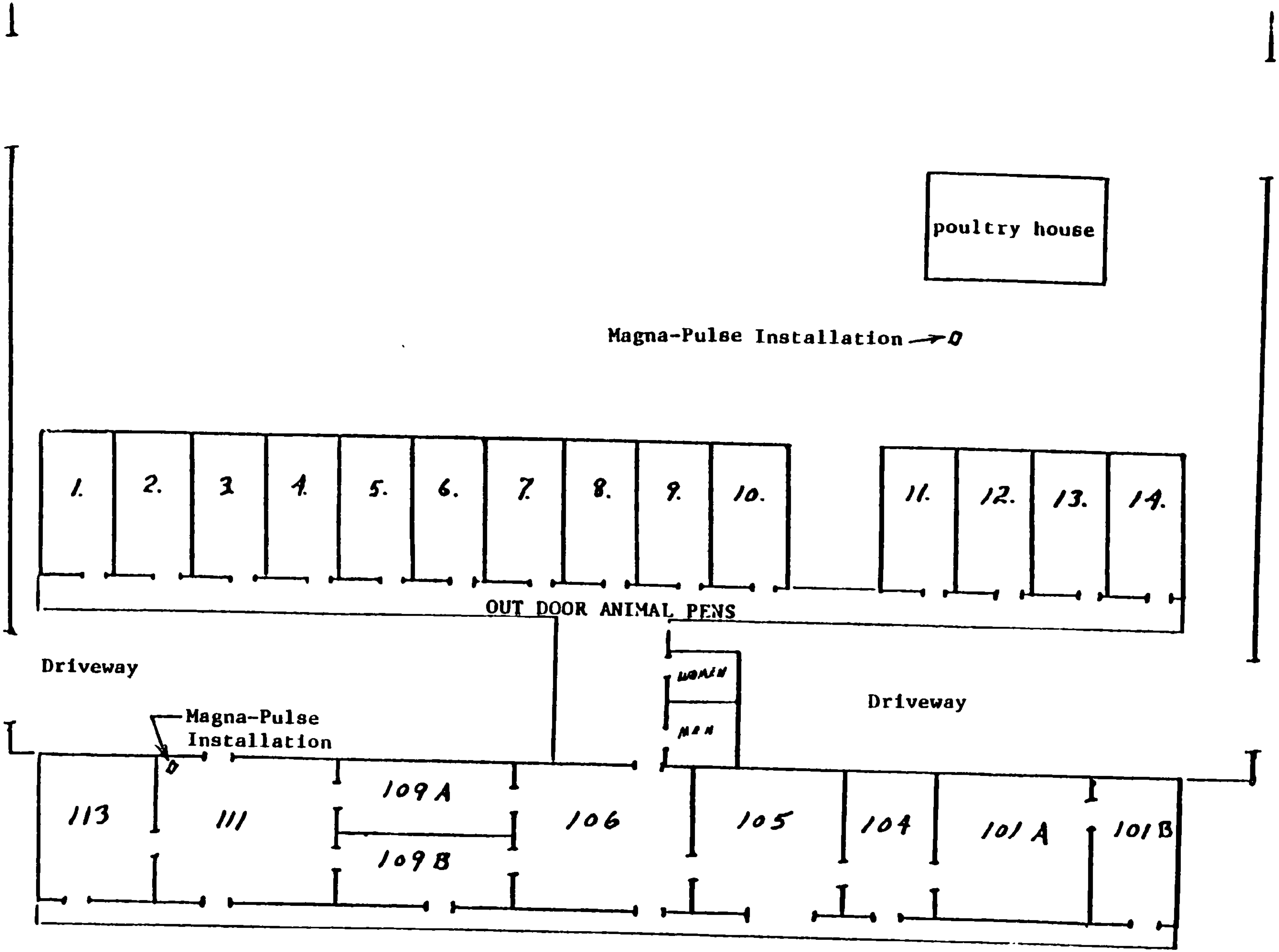
One male rat (#6851-52) was found dead on 10/23/78 in the control group. The carcass was decomposed indicating death had possibly occurred a week earlier. In the test group a total of 5 animals died. A male (#6834-35) died 10/13/78, the week prior to the installation of the device; and during the device exposure female #6821-22 died 11/1/78, and females #6849-50 and #6825-26 died on 11/8/78. All three carcasses had been heavily cannibalized with only the skin and a few bones remaining. The fourth day following the termination of the post-device period, 12/1/78, an additional female (#6837-38) was found dead and was also heavily cannibalized.

Deaths resulting from fighting are not uncommon when confined groups of breeding-age rats are established. With wild captured rats deaths may also result from physical conditions related to old age or from various diseases. The causes of death of the rats were not possible to determine; and whether or not the Magna-Pulse device was in any way responsible for deaths of the four animals which died during or after exposure to the device is unknown.

The simulated field tests were primarily established for measuring mortality and food and water consumption; however, some reproductive data were also obtained. While some litters may have been produced and immediately cannibalized in the group situation, two separate litters of 9 and 11 young were observed on 11/3/78 in the test group of rats. Since the Magna-Pulse device was in operation from October 23 to November 20, 1978, these females would have had to conceive prior to the installation of the device. Four days following completion of the post-test period (December 1), 5 young rats (1 female and 4 males) were retrieved from the building. On this same day all females from the simulated field study (test group and controls) were placed in individual holding cages for a 3-week observation to determine the number of gravid females. Female #6835-36 of the control group gave birth to 5 young on 12/10/78, and females #3691-92 and #3643-44 of the same group produced litters of 8 and 4 young, respectively, on 12/13/78. All 3 of these females from the control group conceived on or just following the date the devices were turned off for the test group.

The groups of wild rats were together for such a short duration, hardly time for the reproduction to get well under way before the test was terminated. The reproductive data can at best only serve as an indication of the general well-being of the group of rats.

The results of the simulated field test indicate that the Magna-Pulse as tested is ineffective in adversely altering feeding or drinking behavior. While 5 deaths occurred in the simulated field test group and only 1 in the control group, none occurred in the test groups of the laboratory studies. If all deaths in the simulated test group were attributed to the device, recruitment of young would appear to offset such mortality. The overall results suggest the device does not in any way live up to the distributor's claims.



VERTEBRATE ECOLOGY LABORATORY (TB-1)

Figure 1. A diagram of the Vertebrate Ecology Laboratory showing location of two installed Magna-Pulse devices. The simulated field test was conducted in the poultry house and the laboratory tests in Room 111 (scale 1/2"=10').

Table 1. Average amount of food and water consumed per animal per day in the laboratory tests when measured for 4 days (Tuesday-Friday) of each week.

Species	One week pre-device		First week of test		Second week of test		Third week of test		Fourth week of test		One week post-device		Mortality
	Food*	Water**	Food	Water	Food	Water	Food	Water	Food	Water	Food	Water	
20 test mice	4.96	5.21	5.13	5.41	5.55	5.84	5.48	5.74	5.92	5.95	5.81	6.13	0
20 control mice	6.04	6.18	5.81	6.46	5.29	5.93	5.43	5.89	5.20	6.50	5.34	6.79	1[†]
20 test Norway rats	22.42	47.29	22.72	48.84	24.37	46.20	24.07	52.81	22.99	51.69	22.92	47.35	0
20 control Norway rats	23.99	49.98	21.57	43.25	21.30	46.91	23.94	56.38	23.27	49.63	23.46	50.34	1[††]

*Food values given in grams

**Water values given in mls.

†Male (B-8) died of an undetermined cause 10 days following start of test.

††Male (I-9) died of an undetermined cause 11 days following start of test.

Table 2. Average and range of weights of the animals at start and completion of laboratory tests.

Species	Avg. weight (range) at start (g)	Avg. weight (range) at end (g)	Percent weight change
20 test house mice	19.3 (13.8-24.4)	19.9 (13.2-26.5)	3.6% increase
20 control house mice	19.9 (15.8-24.6)	21.1 (15.2-27.0)	7.0% increase*
20 test Norway rats	333 (233-520)	331 (247-525)	.5% decrease
20 control Norway rats	308 (217-455)	315 (224-489)	2% increase*

*Calculated on the basis of 19 surviving animals.

able 3. Average amount of food and water consumed per animal per day in the simulated field test when measured for 4 days (Tuesday-Friday) of each week.

nimal Group	One week pre-device		First week of test		Second week of test		Third week of test		Fourth week of test		One week post-device		Mortality
	Food[a]	Water[b]	Food	Water	Food	Water	Food	Water	Food	Water	Food	Water	
orway rat test group	25.05	48.76	26.58[c]	49.20[c]	27.58[d]	51.22[d]	25.00[e]	43.41[e]	26.78[e]	48.42[e]	28.11[e]	48.98[e]	5[f]
orway rat control group	26.29	49.41	26.76	55.08	30.83	59.91	29.94	58.39	31.33[c]	62.79[c]	36.36[c]	50.29[c]	1[g]

[a]Food values given in grams.

[b]All water values corrected for evaporation and given in ml.

[c]n = 19 rats.

[d]n = 16 rats.

[e]n = 18 rats.

[f]male (#6834-35) died 10/13/78, the week prior to the installation of the device. During the device exposure female (#6821-22) died 11/1/78, and females (#6849-50 and #6825-26) died on 11/8/78; all three carcasses been heavily cannibalized. Four days following the termination of the post-device period (12/1/78), one additional female (#6837-38) was found dead and was heavily cannibalized.

[g]Male (#6851-52) was found dead on 10/23/78 and was in a decomposed condition, indicating death had occurred possibly one week previously.

Table 4. Average and range of weights of the animals at start and completion of simulated field test.

Animal Groups	Avg. weight (range) at start (g)	Avg. weight (range) at end (g)	Percent weight change
Norway rat test group	284 (191-471)	315 (201-543)	9.7% increase*
Norway rat control group	290 (210-432)	344 (244-548)	20.2% increase**

*Calculated on the basis of the surviving rats only.
**Calculated on the basis of the 19 surviving rats.

NOTICE TO PURCHASER

MAGNA PULSE will replace or repair at our option, any unit found to be defective in workmanship or material within [illegible] years of date of purchase, excluding batteries, with proof of purchase date and return authorization. With exception of, misuse, abuse, and acts of God. Enclose $30.00 for postage and handling.

Neither seller nor manufacturer shall be liable for any injury, loss or damage, direct or consequential, arising out of the use of our products. User assumes all risks, liability whatsoever in use of our products. No representative or agent has the authority to waive or alter this notice.

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MAGNA PULSE

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Appendix I

"NATURES EQUALIZER"
CONTROLS
RODENTS & INSECTS

- Controls Dangerous Pests
- Safe, Electronic, Non-Polluting
- Wide Coverage
- Maintenance Free, Simple Installation
- Guaranteed

MAGNA-PULSE
NATURES EQUILIZER
CONTROLS RODENTS, & INSECTS

MAGNA-PULSE is absolutely safe, WILL NOT HARM ENVIRONMENT

The evidence the creature is becoming affected is ...lly apparent due basically to the erratic behavior. The ... will show a loss of sense of direction.

Magna-Pulse WILL NOT in any way affect our water ...ood supplies. There is no introduction of harmful toxins ...poisons to our environment. No chance of pollution or ...tamination. The reason remains simply in that we are ...introducing anything to the environment which is not ...ady there. We are merely stirring the existing magnetism ...in our world.

Magna-Pulse in no way will effect electronic equip... The unit is designed to work in a magnetic field and ...e is no effect on sensitive and delicate computers, tele...n, radios, C B 's, etc. Nor will it magnetize household ...iances or watches.

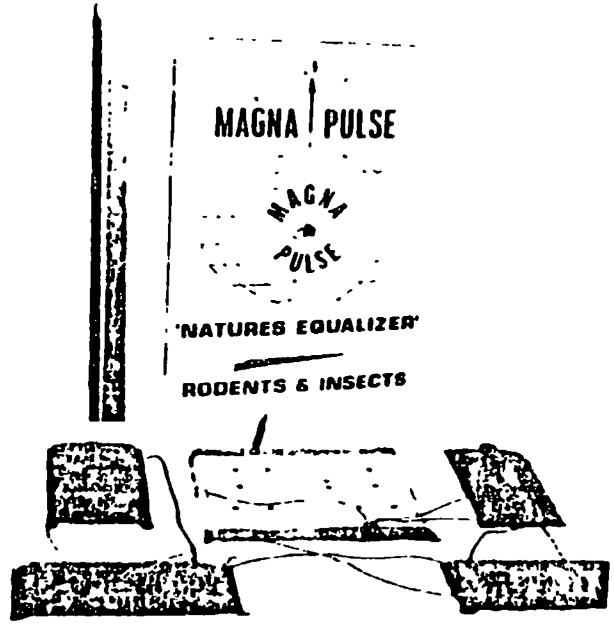
Because of the design of Magna-Pulse, and because the ...netic field is dissipated, removal of the unit means that ...s and rodents will have access to the area and they will ...ter after a short period of time.

Because control stimulants vary throughout the world, ...do not guarantee the percentage of control or the time ...ired to control. However, we have a record of 80% to ... control and do provide a 60 day performance warranty ...nst no results.

Magna-Pulse controls ground inhabiting rodents and ...erous insects. These dangerous pests carry many deadly ...ises and do billions of dollars in damage annually to ...s, buildings and people. Magna-Pulse employs the most ...nced electromagnetics technology for control of these ...

Magna-Pulse is a sophisticated, totally solid state, elect...agnetic device. It introduces no poisons, sprays, or other ...ns into the environment. Magna-Pulse generates a unique ...etic field which combines with Earth's natural mag... field. Humans and other higher animal forms, i.e., ...ehold pets, livestock, etc., adapt easily to changes in ... magnetic environment and are in no way affected ... Magna-Pulse's magnetic field. Once Magna-Pulse has ...lished its perimeter of protection, this electromag... field is sensed by pests which are then reluctant to ...r the area.

COMMERCIAL MODEL MPC 1000



8) Magna-Pulse provides a wide area of coverage around the unit.

a) The commercial model, with its 4 self contained 12V battery power supply, provides coverage of up to approximately a 650 foot radius. This unit is designed for outdoor use and is contained in a semi-weatherproof plastic housing.

b) The institutional or industrial model operates on 1 12 V battery and controls an area of up to approximately a 300 foot radius of the unit. It is designed for indoor use and is packaged in a durable "formica" case.

INDUSTRIAL MODEL MP 419

manufactured for
BELL PRODUCTS

Toll Free
1 800 648-1155

9) Magna-Pulse is a totally maintenance free electromagnetic device. It is fully warranted against defects in materials (excluding batteries) and workmanship for a period of 5 years. Magna-Pulse installation is very simple. (See unit for installation instructions). The battery powered commercial model may be buried in the ground for optimum operation in certain outdoor applications. A red LED located on the top of the Magna-Pulse lights briefly every few seconds to indicate that the unit is operational.

10) The applications for Magna-Pulse are as widespread as the pests it controls! Any operation involving food handling is a natural application for Magna-Pulse. It is a money saving device for such users as restaurants, food stores, produce packers, bakeries, school or company cafeterias, and private homes to name just a few. Other primary users include those seeking protection of plant life such as nurseries, farms, groves, orchards and gardens in general. In addition, storage of edible raw materials and finished products handlers are obvious beneficial users of Magna-Pulse. Examples include grain elevators, food distribution warehouses, cereal packagers, and organic fiber operations.

SPECIFICATIONS (approximate)

	Commercial	Institutional (Industrial)
Model Number	MPC 1000	MP 419
Dimensions (H x W x L)	6 x 11 x 18	[illegible] x 10 x 16
Weight	19 lbs	10 [illegible]
Operating Voltage	4 12 VDC (Batt.)	1 12 VDC Batt.
Power Consumption	[illegible]	[illegible]

FOR INFORMATION CONTACT YOUR LOCAL DISTRIBUTOR

REPORT OF EFFICACY STUDIES OF THE AMIGO (Phase 2) RODENT CONTROL DEVICE

Principal Investigators

Rex E. Marsh and Walter E. Howard
Division of Wildlife and Fisheries Biology
University of California
Davis, California 95616

December 1, 1978

In Cooperation with the Environmental Protection Agency and the California Department of Food and Agriculture (Contract No. 7061).

INTRODUCTION

The tests reported herein were conducted with Amigo (Phase 2) rodent control device to determine if either wild Norway rats or wild house mice would respond in a manner detrimental to their well-being when subjected to a device which the manufacturer claims "sends out a protective frequency sound" (Appendix I). In another Amigo (Phase 2) advertisement it states that the "Amigo generates an electromagnetic energy made up of high and low magnetic frequencies, harmonic and sonics" (Appendix II). The manufacturer's claim that "all creatures that are controlled by Amigo will stop eating and breeding right away" is not supported by any logical scientific explanation nor by any research data.

Since Amigo (Phase 2) advertisements claim that the rodents stop eating, tests were established to evaluate the validity of this statement in a controlled experiment.

Laboratory tests and a simulated field study were established, with adequate controls, to measure the food and water consumption and mortality of two important rodent pests when exposed to the device. Both wild Norway rats (Rattus norvegicus) and wild house mice (Mus musculus) were used in the laboratory tests, but only Norway rats were monitored under simulated field conditions.

Since the manufacturer claims that rats and mice are effectively controlled in from 1 to 10 days, to avoid any doubt the duration of exposure to the device in our tests was arbitrarily established at 25 days, or 2-1/2 times that period.

The food and water intake of rodents may fluctuate somewhat from day to day and week to week depending on several factors such as age of rodent, temperature, humidity, changes in nutrient value of food, etc. However, for rodents to be controlled by some self-regulated starvation in 1 to 10 days would require a rather drastic decrease in food intake over a short period of time (i.e., a few days). Commensal rats and house mice, unlike some other rodent species, such as ground squirrels, do not naturally go into hibernation and hence cannot live for extended periods on accumulated fat.

Decreases or increases in food or water consumption is a readily measurable value which can be quantified over a period of time. Weight gain or loss over time and mortality can also be measured to test the validity of the claim for the device's efficacy.

PROCEDURES AND METHODS

Test Device

The Amigo (Phase 2) rodent control device used in this study was obtained from the manufacturer (Mira Manufacturing Corp.) by Judy Swenson of the Environmental Protection Agency, Region IX (215 Fremont Street, San Francisco) and, following other studies, was shipped to the investigators by Charles Gordon, National Bureau of Standards, Rt. 270 and Quince Orchard Road, Gaithersburg, MD 20760. The device was marked Official Sample #131903. The device was unsealed and put into operation August 21, 1978 and removed on September 15, 1978

The Amigo (Phase 2) appears to be marketed in at least three different external cases. The unit used in this study was a rectangular box approximately 7-1/4" x 4-1/2" x 2-1/4" with the electric cord extending from the end of the unit, and also at the same end alongside the cord is an externally replaceable fuse component. This particular unit did not have a metal bar or bolt extending from it, as do the other Phase 2 cases, nor did it have any special points for attachment to any object or surface (i.e., brackets, ears, holes, etc.). The unit is manufactured by Mira Manufacturing Corp., Pine Valley, California 92062.

Laboratory Tests

Forty laboratory-reared wild house mice (*Mus musculus*) and 40 wild captured Norway rats (*Rattus norvegicus*) were randomly divided into two groups of 20 animals (sexes equal) to establish a treatment group and control group for each species. All animals were mature and in good physical condition. All of the rats were treated at time of capture in the wild with carbaryl (Sevin) to control ectoparasites before bringing them into the laboratory. The animals were weighed and individually housed in suspended cages on metal racks. The animals were selected randomly, hence some age and weight differences occurred between the groups, although the total biomass was reasonably similar between test and control groups.

The test requirements necessitated that the animals be maintained in two different facilities. The control (untreated or unexposed) groups were placed at the Institute of Ecology and the test groups at the Vertebrate Ecology Laboratory. The straight-line distance between the two buildings is 1,148 feet. This is well beyond the effective radius (263 ft, equivalent to 5 acres) claimed for the device. Both buildings are air conditioned and have time controlled lighting (12 hrs light - 12 hrs dark). All groups were acclimated to the laboratory at least 1 week prior to the state of the study.

The individually caged rats and mice were fed a diet of finely ground Purina Laboratory Chow. The rats received the food in cups clipped in place to prevent tipping and spillage and the mice were offered food spillage. Food consumption was measured by weighing remaining food in containers and trays and subtracting this weight from the amount of food offered the previous day. Food was always offered in excess of maximum consumption. Food consumption was measured to the nearest 0.1 g.

Water was provided in graduated drinking bottles and equipped with curved drinking tubes. Water consumption was recorded to the nearest 1 ml per day. To establish an average daily consumption per animal, food and water consumption was recorded for four consecutive days during each test week.

Food and water consumption of the test groups was recorded for 1 week pre-test (pre-installation of device), for each week of the approximately 4 weeks (25 days) the device operated, and again for 1 week following the removal of the device. For the control groups the consumption data were collected for the identical time period, although these animals were never under any possible influence of the device.

Simulated Field Test

Forty wild captured Norway rats were divided into two groups of 20 each (sexes equal). Each animal was weighed. They were eartagged on both ears for positive future identification. The test animals were then released as a group into a relatively small rodentproof poultry house (16 x 16 ft) which is located directly behind the Vertebrate Ecology Laboratory (Fig. 1). The control animals were housed as a group in a comparable size enclosure (10 x 20 ft) at the Institute of Ecology. The rats in both locations were provided with a large nest box containing nest compartments. Also, in both situations two pallets on the floor near the center of the room were covered with a small sheet of plywood to offer additional cover.

Both the poultry house and the enclosure were not temperature or humidity controlled. These conditions depended on weather conditions, which were recorded daily. Natural lighting existed in both enclosures.

Each group of rats received eight large food bowls and four one-quart chick watering fountains. All were spaced uniformly within the enclosures. As with the laboratory tests, both food (ground Purina Laboratory Chow) and water consumption were recorded to the nearest gram or ml for four consecutive days each week. In order to make needed corrections for any change in the moisture content of food and for evaporation of water, two food bowls and two waterers were placed outside each enclosure and protected from rodents. These were weighed each day and a correction factor arrived at for any water loss. The change in weights of the food turned out to be so minor that no corrections were necessary for any moisture uptake or loss from the ground chow.

The two groups of animals, which were designated to simulate rat infestations, were established two weeks prior to the installation of the Amigo device. This allowed sufficient time for the establishment of social hierarchies amongst the groups of rats prior to initiating the actual test. The amounts of food and water consumed were also recorded for the week just prior to installing the device.

The Amigo (Phase 2) rodent control device was placed on the ground eight feet from the poultry house and plugged into a 110-volt power supply. No specific instructions for installation were provided with the unit. According to the manufacturer's claims the Amigo devices will cover 5 acres (a radius of 263 ft), hence the active coverage of a single unit should encompass both the Vertebrate Ecology Laboratory, approximately 120 ft away, and the poultry house (Figure 1) where the test animals were housed.

The device was checked daily to assure it was functioning. The device vibrates slightly when operating and is warm or hot to the touch.

General observations were made daily of the groups of rats to check for deaths and any possible abnormal behavior or other clues which might indicate in the test group that the device was having some influence on the rats. At the completion of the study all of the rats in the two enclosures were live-trapped, weighed, then caged individually and kept in the laboratory for an additional 3 weeks to determine whether any females had become pregnant.

RESULTS

Results of Laboratory Tests

The results of the laboratory tests are given in Table 1. The food consumption and water intake over the 6 weeks of measurements showed some fluctuations but in no instance did the intake of either food or water for the treated animal groups vary greatly from the control animal groups. There was no mortality in the test or control house mice or Norway rats. The test group of house mice gained an average 0.6 g in weight over the test period while the control group lost 0.5 g on an average. No specific explanation can be given for the slight loss in weight in the control group. The rats under test gained an average of 36 g, not a great difference from the control group which averaged a 13 g increase. The greater percentage increase (Table 2) in the test group of rats can probably be attributed to the fact that the rats in the test group were slightly smaller (i.e., younger) at the start and thus could gain at a faster rate.

Brief daily observations of each rodent did not reveal any detectable abnormal behavior.

These results of the laboratory tests indicate that the Amigo (Phase 2) as tested was ineffective in producing mortality or in adversely altering feeding or drinking behavior.

Results of the Simulated Field Test

The results of the simulated field test are provided in Table 3. The food consumption and water intake over the 6 weeks of measurements fluctuated somewhat, as is normal in changing weather, but in no instance did the consumption of either the food or water in the treated group of rats vary greatly from the control group.

A male rat (number 832-833) was found dead on September 7, 1978 in the control group and was in a mummified condition, indicating death had occurred possibly two weeks or more previously. Deaths resulting from fighting are not uncommon when rat groups are established. With wild captured rats deaths may also result from old age or various diseases. The condition of the rat when found made it impossible to determine possible cause of death.

The simulated field tests were primarily established for measuring mortality and food and water consumption; however, some reproductive data were also obtained. While some litters may have been produced and cannibalized in the group situation, no young were seen when recording food and water consumption. Upon the completion of the week post-device consumption measurements, all of the rats were removed from both the test and control group situations and caged individually. The females were held for at least 3 weeks to determine if any of them were gravid. The number of littering females and their litter size were recorded (Table 5).

The groups of wild rats were together for such a short duration, hardly time for the reproduction to get well underway before the test was terminated, that the reproductive data can best serve as an indication of the general well-being of the group of rats.

The results of the simulated field test indicate that the Amigo (Phase 2) as tested was ineffective in producing mortality or adversely altering feeding or drinking behavior. The results, although limited, suggest that reproduction will occur whether or not the rats are exposed to the Amigo (Phase 2) device.

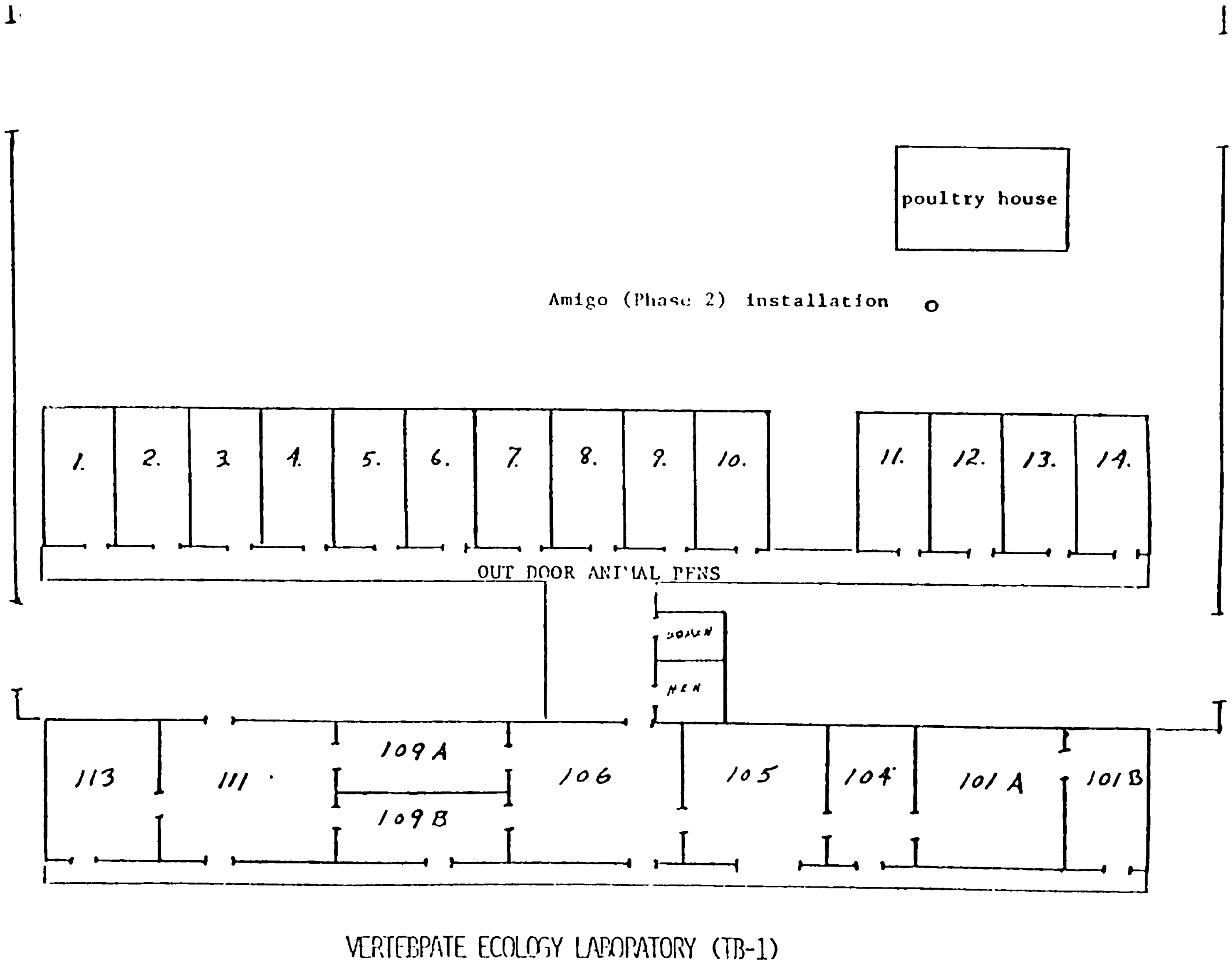


Figure 1. A diagram of the Vertebrate Ecology Laboratory showing location of installed Amigo (Phase 2) The simulated field test was conducted in the poultry house and the laboratory tests in Room 111 (scale 1/2"=10').

Table 1. Food and water consumption measurements taken in the laboratory tests given in averages per animal per day when measured over a 4-day period of each week.

Animal group	One week pre-device		First week of test		Second week of test		Third week of test		Fourth week of test		One week post-device		Mortality
	Food*	Water**	Food	Water	Food	Water	Food	Water	Food	Water	Food	Water	
House mouse test group	5.92	5.74	5.72	6.51	5.89	6.79	5.52	6.49	5.62	5.99	5.50	5.91	0
House mouse control group	4.51	3.93	5.48	5.06	5.18	4.55	5.58	5.26	5.30	5.[illegible]4	5.46	5.76	0
Norway rat test group	19.98	40.51	19.53	41.99	19.45	42.98	20.44	44.81	20.87	43.94	20.55	45.06	0
Norway rat control group	17.94	32.71	19.97	38.13	19.65	39.34	19.09	39.98	20.87	44.75	20.72	45.25	0

*Food values given in grams

**Water values given in mls.

Table 2. Average and range of weights at start and completion of laboratory tests.

Animal groups	Avg. weight at start (g)	Range of weight at start (g)	Avg. weight at end (g)	Range of weight at end (g)	Percent weight change
House mouse test group	21.8	14.8-30.1	22.4	15.7-30.6	2.8% increase
House mouse control group	19.1	15.1-24.4	18.6	13.9-25.4	2.6% decrease
Norway rat test group	229	98-357	265	146-390	15.7% increase
rway rat control group	251	101-375	264	150-388	5.17% increas

Table 3. Food and water consumption measurements taken in the simulated field test given in averages per animal per day when measured over a 4-day period of each week.

Animal group	One week pre-device		First week of test		Second week of test		Third week of test		Fourth week of test		One week post-device		Mortality
	Food*	Water**	Food	Water	Food	Water	Food	Water	Food	Water	Food	Water	
Norway rat test group	24.14	49.64	23.94	49.91	24.80	50.39	24.88	48.39	23.95	50.03	27.40	58.93	0
Norway rat control group	23.65	44.08	24.83	47.84	23.14	45.85	23.07[†]	45.72[†]	25.87[†]	53.21[†]	22.82[†]	53.18[†]	1[‡]

*Food values given in grams.

**All water values corrected for evaporation and given in ml.

†n = 19 rats

‡Male (#832-833) was found dead on 9/7/78 and was in a mummified condition, indicating death had occurred possibly two weeks previously.

Table 4. Average and range of weights at start and completion of simulated field test.

Animal groups	Avg. weight at start (g)	Range of weight at start (g)	Avg. weight at end (g)	Range of weight at end (g)	Percent weight change
Norway rat test group	225	160-366	282	203-400	25.3% increase
Norway rat control group	238	127-464	293	188-528	23.1%* increase

*Calculated on the basis of the 19 surviving rats.

Table 5. Reproductive information on the females removed (September 22, 1978) from the test and control groups, following the simulated field study and placed in individual holding cages for observation. Calculating gestation at 21-22 days, all females littering, except one, would have conceived during the period when the Amigo (Phase 2) was in operation (August 21-September 15, 1978).

Female number	Date littered	Group	No. young
6052-53	10/1/78	Test	3
6090-91	10/2/78	Test	10
3649-50	10/4/78	Test	10
6071-72	10/10/78	Test	4*
3693-94	9/26/78	Control	10
3639-40	9/27/78	Control	10
3633-34	9/28/78	Control	9
3645-46	9/28/78	Control	10
3637-38	10/1/78	Control	10
3643-44	10/1/78	Control	5
3691-92	10/6/78	Control	8

*Conceived the week after the Amigo device was turned off and before the groups were separated.

Los Alamitos, CA 90720

MIRACO, INC.

BIO-ELECTRONIC DEVICES

BIO-MEDICAL NUTRIENTS

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The VRP Corporation

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LOS ALAMITOS, CA 90720

FRANK H. PARKER
VICE PRESIDENT

Appendix I

THE FOLLOWING ARE PROTECTED BY AMIGO

BUILDINGS	FARMS & RANCHES	OPEN SPACES
Houses	Orchards	Docks
Condominiums	Gardens	Wharf Areas
Townhouses	Crops	Parks
Resort Cabins	Nurseries	Playgrounds
Warehouses	Pastures	Golf Courses
Fairs	Truck Farms	Race Tracks
Schools	Tree Farms	Meadows
Hospitals	Egg Ranches	Breakwaters
Tenements	Poultry Ranches	Freeway Landscapin
Boats & Ships	Barns	Water System Levee
Processing Plants	Dairies	Garbage Dumps
Cafeterias	Stables	Sewers
Commissaries	Silos	Hillsides
Stores	Feeding Areas	Storage Areas

Please contact Miraco, Inc. or your local distributor of AMIGO products regarding consultation on special situations. A sketch and brief description is usually sufficient in order to make installation recommendations.

Please advise Miraco, Inc. of any research on special animals, insects, etc. which you feel is of concern to you.

AMIGO is warranted to function properly for a period of 3 years. If not, it will be replaced with a new unit, free of charge, for the unexpired warranty period.

AMIGO R

AMIGO is the new, natural, safe, and harmless way to again create a balanced pest-rodent environment compatable with the laws of Nature. Various kinds of ants: fire-ants, army, termites, wood-ants, and their related insects such as thrips, red and black scale, and aphids. These do not belong in man's habitats. Various kinds of rats: from field mice to pack-rats, kangaroo-rats, roof-rats, Norwegian rats, wharf and warehouse rodents. These also do not belong in man's habita Other rodents such as gophers and moles are considered undesirable in man's habitats. AMIGO informs these pests and rodents that man's habitats are not for them !!

AMIGO is the only effective electronic repeller which sends out a warning system for pests and rodents to KEEP OUT! It is an electronic repeller which sends out a protective frequency sound to create a natural, front-line shield to keep ANTS-MICE-GOPHERS from entering any protected area. Effective prevention is established immediately. Unwanted pests and rodents can hear and feel that the protected environment is uninhabitable for them. They have no desire to enter. AMIGO' range of frequency protection is any one building or warehouse; any house or small garden; any farmland or open field spaces up to five acres. The range of protection is dependent upon the type of installation made.

For control of existing problems in the protected area, AMIGO immediat enters existing below-ground burrows and nests. Unwanted ANTS-MICE-GOPHERS will feel and hear the repelling frequency. Wherever they start to turn, the electronic repeller has already made their environment uninhabitable. Finding no escape, they will stay where they are. They will not breed new generations. Unable to tolerate the repelling frequency they will go dormant, never to leave the area. Effective control of identified kinds of ants is 1-5 days; effective control of identified kinds of mice and rats is 1-10 days; and effective control of gophers and moles is about 20 days.

AMIGO is truly a friend! AMIGO will affect only the habitats of those pests and rodents identified and indicated. Any domestic fowl, birds, pets such as dogs and cats, cattle, horses, sheep, goats, pigs,ducks, pheasant, quail, deer, and plant or vegetable life is unaffected. AMIGO sends out a frequency repelling shield for unwanted ANTS-MICE-GOPHERS.

The technology of solid-state circuitry makes AMIGO able to operate less than a penny per day. It is designed for dependable long life. All that needs to be done is to plug it into any electrical outlet. AMIGO will do the rest.

INSTALLATION (continued)

1. Drive a 2-3 foot 3/4 inch (inside diameter) galvanized pipe into the ground next to or adjacent to plumbing pipe. Clamp firmly to plumbing pipe. Allow no more than 2 inches of ground pipe to extend above ground surface.

2. Insert AMIGO electronic repeller bar into top of 3/4 inch ground pipe. AMIGO should fit snugly.

3. Plug electrical cord into any electrical outlet. If extension cord is used for power, be sure it is a 12 guage heavy duty waterproof cord and use only enough wire to reach the AMIGO.

HOW TO INSTALL AMIGO:

B. FOR FARMS AND RANCHES:

Basic Installation: Minimum guaranteed range is 5 acres.

Things of importance are:

* Look for existing underground water line.
* Look for existing outside electrical outlet.
* Look for sides of paths or roads.
* Avoid securing to any kind of PVC pipes.
* Avoid running extension cord power across furrows.
* Installation will require 3/4 inch (inside diameter) galvanized water pipe only.

1. If existing underground water line is also metal piping, drive a five foot length of galvanized pipe 4 feet into the ground and clamp or secure to underground water line; insert AMIGO electronic repeller bar into five foot pipe and plug electrical cord into electrical outlet.

2. If existing water line piping does not exist or is not metal piping, drive a ten foot length of metal or steel pipe at least nine feet into ground; insert AMIGO electronic repeller bar into metal pipe and plug electrical cord into electric outlet.

Grounding:

AMIGO units are equipped with approved 3 conductor power cord and 3 blade grounding type attachment plug to be used with the proper grounding type receptacle, in accordance with the National Electrical Code, Canadian Electrical Code, and Underwriters' Laboratories specifications. The green colored conductor in the cable is the grounding wire. If plug replacement becomes necessary never connect the green wire to "live" terminal. All necessary electrical components used have been UL approved. Grounding must be continuous from the tool plug to a grounded receptacle.

REMEMBER:

AMIGO must not be turned off after placed in service. It is a preventive unit and cannot be temporarily installed. Once it is connected, leave it plugged in for most effective results.

HOW TO INSTALL AMIGO:

C. FOR OPEN SPACES:

Basic Installation: Minimum guaranteed range is 5 acres.

Things of importance are:

* Look for existing underground or above ground metal water pipes.
* Look for existing outside electrical outlet boxes.
* Installation will require 3/4 inch (inside diameter) galvanized water pipe only, 5 feet or 10 feet in length.

1. If water pipes are sprinkler systems and are made of metal or steel, drive a five foot length of galvanized pipe into the ground and clamp or secure to water pipe; insert AMIGO electronic repeller bar into five foot pipe and plug electrical cord into electrical outlet.

2. If there are no existing water pipes, but perimeter or linear metal fencing is available or metal fence stakes are present, drive a ten foot length of galvanized pipe at least 9 feet into the ground; clamp or secure to adjacent metal stake or fence; insert AMIGO electronic repeller bar into ten foot pipe and plug electrical cord into electrical outlet.

Grounding:

AMIGO units are equipped with approved 3 conductor power cor and 3 blade grounding type attachment plug to be used with the proper grounding type receptacle, in accordance with the National Electrical Code, Canadian Electrical Code, and Underwriters' Laboratories specifications. The green colored conductor in the cable is the grounding wire. If plug replacement becomes necessary, never connect the green wire to "live" terminal. All necessary electrical components used have been UL approved. Grounding must be continuous from the tool plug to a grounded receptacle.

REMEMBER:

AMIGO must not be turned off after placed in service. It is a preventive unit and cannot be temporarily installed. Once it is connected, lea it plugged in for most effective results.

EPA Approved
EPA Registrant No.
39958 - CA - 01
Components U.L. Listed

WHAT'S AN AMIGO?

It's an electro-magnetic device designed to control pests and rodents.

HOW DOES IT WORK?

Amigo generates an electro-magnetic energy made up of high and low magnetic frequencies, harmonics and sonics. This energy is transferred to and through a building or the ground. A confusing and uncomfortable pattern is presented to pests causing disorientation and lack of direction and purpose. This, in turn, causes reduction in activity, feeding, breeding and in some cases expiration through forced hibernation.

ACCIDENTAL INVENTION

Guitarist's High Note a Low Blow to Vermin

HIPASS, Calif. (AP)—A sound so shrill it drives rodents wild, kills cockroaches and sends fleas flying is whistling up a fortune for Bob Brown, a polio-crippled guitar player who retired in 1965 on a $235 monthly Social Security check.

In his garage one day six years ago, Brown was putting together an electric guitar when he tangled some wires. He recalled Tuesday that he saw rats scattering. He crossed the wires and the rodents ran again.

Brown, 51, built what he called a rat repellent box and since then 18,000 have been produced in Los Angeles and Tijuana.

A chicken farmer north of San Diego, about 50 miles west of Hipass, bought the first one when "about 10,000 mice were bothering the chickens every night. It cleared his place in four or five days," Brown said.

The government of Venezuela recently ordered 300 to kill cockroaches in food stores in Caracas, and 1,000 were sent to granaries in Barcelona, Spain. Brown plans to fly to Brooklyn, N.Y., next Tuesday to talk to U.S. Housing and Urban Development Department officials about placing 9,000 units in low-rental apartments.

"We flew to Hawaii and discovered the antennae on roaches just fold up when they hear it—they're on their backs, out of touch, without any balance," said Brown.

Brown, a native of Fairmont, Minn., said the frequency is "over a million cycles a second." The human ear can hear up to about 20,000 cycles. Said Brown, who played with bands in Las Vegas: "Musicians know of the overtones, the harmonics, which is what excite rock musicians—the frequencies that go through your head and you don't even know what's doing it to you.

"We're jamming the sensory systems of rats, cockroaches and even ants. We've got a vibration high enough to jam 'em like a foreign broadcaster jams our radio."

Brown said the net profits of his Amigo Ecology Corp. were about $800,000 last year and the gross "about a million and a half."

"A millionaire? I guess I am," Brown said.

"Just like in the movie," he says, referring to "Willard," a film in which thousands of rats scuttled about communicating on their own sound system. But, he adds, domestic or pet rodents aren't susceptible because they do not possess the sensitivity that the wild populations do.

What happens to a rodent in range?

"First, they start washing up and cleaning themselves like all rats and mice do before they go to sleep," says Brown. "Then they become dormant and move in slow motion. They quit nesting and there is no reproduction, so sooner or later the population is destroyed."

Brown says it was initially the poultry industry that became interested in his device after he received a patent and began marketing it in 1975. Now it is being used to control rodent infestations in supermarkets, peanut butter factories, bakeries and restaurants.

Many Favorable Reports

In an interview several weeks ago, Brown told of a stream of positive reports from Georgia to the Fiji Islands.

Brown first described his invention as an "erratic-wound coil," a description that gives a clue as to how the AMIGO works. The theory, Brown said, is this: Rodents and other pests use the earth's electromagnetic field to orient themselves. The coil amplifies this field. The coil also, as it is heated by the passage of electricity through it, switches its magnetic polarity several times as it passes through various heat ranges. Thus the magnetic field for as much as a mile around the device is affected, and the rodents in that area are completely disoriented.

Already the device, retailing for $250 to $1,000, has made Brown a millionaire. But he continues to refine the mechanism to zap other pests.

On March 11 the inventor of this amazing Amigo pest control system, Bob Brown, will be at our booth at the California Midwinter Fair. Come out to the fair to learn more about this invention and meet its inventor.

AMIGO II

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FIELD TESTS OF ELECTROMAGNETIC DEVICES TO CONTROL POCKET GOPHERS

John O'Brien
Nevada State Department of Agriculture Center

EXPERIMENTAL PROCEDURE

Study Area

Field tests were conducted on two circular 130-acre (about 50 hectares) alfalfa fields approximately 10 miles (16 kilometers) northwest of Battle Mountain, Nevada. The alfalfa was sprinkler irrigated.

Plant species present on surrounding uncultivated lands included: big sage (Artemisia tridentata); rabbitbrush (Chrysothamnus sp.); cheatgrass (Bromus tectorum); wheatgrass (Agropyron sp.); Great Basin wildrye (Elymus cinereus); and inconspicuous forbs.

Wildlife species observed in the test area included: coyote (Canis latrans); deermice (Peromyscus maniculatus); prairie falcon (Falco nevadensis); sparrow hawk (F. sparverius); golden eagle (Aquila chrysaetos); red-tailed hawk (Buteo jamaicensis); marsh hawk (Circus cyaneus): raven (Corvus corox); black billed magpie (Pica pica); and long billed curlew (Numenius americanus). The townsend pocket gropher (Thomomys townsendi) was the gopher species present in the study area.

Insects collected on the test area were: ground beetle (Calosoma obsolitum); two lygus bug species (Lygus spp.); one species of muscoid fly (Muscidae); leaf beetle (Chrysochus cobaltinus); thread waisted wasp (Podalonia sp.); two species of parasitic wasps (Ichneumonidae); giant water beetle (Hydrophilus triangularis); and carrion beetle (Nicrophorus marginatus).

Census Methods

In adjacent areas two methods were used to measure pre- and post-treatment activity.

1. Each day for five days twenty burrows were opened and checked 24 hours later to determine if they had been closed; closed burrows were then reopened. Opened burrows were at least 25 feet (7.6 meters) apart to reduce the likelihood of opening more than one burrow belonging to the same gopher. Numbered stakes were used to mark each opened burrow. Generally speaking, the higher the stake number the further the opened burrow was from the device in test plots (See maps). A burrow, which remained opened for a whole five day treatment period, was considered unoccupied. A burrow, which was plugged at any time during the treatment period, was considered occupied. If a plugged burrow could not be reopened due to the length or compactness of the plug, another opening was made close to the original opening.

2. The number of new mounds and plugs appearing in a 9,000 square foot area in 24 hours was counted each day for five days. After counting, the mounds and plugs were smoothed down so they would not be recounted the following day. Mound and plug formation has been shown to be positively correlated to pocket gopher populations (Reid, et al., 1966). Mounds are piles of soil pushed to the surface of the ground which are closed by the

gopher. Plot dimensions were 15 x 600 feet for Nature Shield and Magna Pulse areas and 60 x 150 feet for Sigma areas. Plots were divided into ten 15 x 60 foot subplots to facilitate counting.

The regression equation of Reid, et al., 1966, was used to estimate gopher populations from mean number of mounds and plugs appearing on test and control plots (Table 1). To enable their use in the regression equation, means were adjusted from one day - 9,000 square foot values to two day - one acre values by multiplying them by 9.68. Though not precise, these population figures provide a rough approximation of what gopher populations were on the plots.

These methods were used to determine whether claims made by electromagnetic device manufacturers have a basis in fact. If gophers do "go dormant, stop eating and reproducing, become inactive, etcetera" as claimed, there should be a sharp drop in mound and plug formation on the test plots. Similiarly, there should be a sharp increase in the number of burrows remaining open.

Weather Parameters

Minimum and maximum temperature (F°) and wind speed (knots) during census periods were obtained from the Battle Mountain weather station located approximately 12 miles (19 kilometers) from the test area (field sheets). Weather parameters on the test site probably did not coincide with those at the recording station; however, changes in parameters would be similar. Because pocket gophers spend most of their time underground, day to day changes in above ground weather parameters (excluding precipitation) probably have little influence on burrowing activity. There was no precipitation at the test site during census periods. Changes in soil moisture were influenced by the sprinkler irrigation of the alfalfa. The sprinkler passes over the test and control plots once every five days.

Device Installation and Functioning

Devices were checked daily to determine if they were working. A glowing or blinking light present on each device indicated it was working. Devices were installed according to accompanying manufacturers' instructions.

A 1,000 VA-440/110 transformer and "Raintite" bell boxes were installed in the sprinkler pump panel in the Sigma devices. Twelve-two weather resistant Romex cable supplied power to the Sigma devices. Unlike the Sigma devices, which operated on AC current, the Nature Shield and Magna Pulse units were powered by internal batteries.

Devices were received with their official sample seals intact. Seals were broken when the devices were installed. At the end of the tests the devices were resealed and placed in a locked storage area.

Devices were installed on June 16, 1978. The Nature Shield continued to operate until sometime between 1:30 P.M. August 13 and 3:05 P.M. August 14,

1978. Magna Pulse continued to operate until sometime between 12:15 P.M. August 1 and 12:00 Noon August 2, 1978. On August 2 condensation was observed on the inside of the red indicator light. In both of these instances the devices were considered to be non-operational because the red indicator lights no longer flashed. Power to the Sigma I and II devices was inadvertently cut off on two occasions: between 12:45 P.M. July 2 and 12:59 P.M. July 3, 1978 and also between 1:00 P.M. July 18 and 12:30 P.M. July 19, 1978. Devices were restarted at the latter time in each case. Except for these two occasions the Sigma I and II devices functioned throughout the test.

The devices were in operation, as follows, prior to post-treatment censusing:

Nature Shield - 58 days (8 weeks 2 days)

Magna Pulse - 47 days (6 weeks 5 days)

Sigma I & II - 16 days (then off for 24 hours max.),

15 days (then off for 24 hours max.), and

34 days (4 weeks 6 days uninterrupted,

9 weeks 2 days total)

Magna Pulse and Nature Shield were in operation longer than the three to four week time period the manufacturers indicated was necessary to control gophers. No time period was indicated for the Sigma units.

RESULTS AND CONCLUSIONS

Device Efficacy

Nature Shield

Both Nature Shield test and control areas showed a decrease in mound and plug formation from pre-treatment census to post-treatment census (Table 1). The control area reduction approached the P .05 level of statistical significance (T = 2.26, 8 df) while the test area reduction was not significant ($P < .2$, T = 1.85, 8 df). Practically speaking, these reductions do not indicate a significant degree of control either. In terms of approximate numbers of gophers per acre the changes in mound plug formation indicated reductions from 87 to 75 gophers per acre on the test area and 63 to 51 gophers per acre on the control area. These population density estimates were derived utilizing the formula of Reid, et al., 1966. There was no change in burrow plugging behavior between pre- and post-treatment censuses. In both test and control areas all twenty opened burrows were closed within the five day census period for both pre- and post-treatment censuses (Table 2).

Magna Pulse

There were increases in mound and plug activity from the pre-treatment census to the post-treatment census in both test and control areas (Table 1). The Magna Pulse test area showed a statistically significant increase in mound and plug formation ($P < .01$, $T = -4.74$, 8 df). The control area increase was not statistically significant ($P < .3$, $T = 1.20$, 8 df). These changes in mound and plug formation would be comparable to population increases from 20 to 29 gophers per acre on the test area and 24 to 30 gophers per acre on the control area (Reid, et al., 1966). These increases illustrate the fact that animal populations undergo natural fluctuations (Vaughn, 1972). The Magna Pulse test and control areas, which had the lowest levels of mound and plug production among the test and control plots, experienced increases.

There was no reduction in burrow plugging activity in the test and control areas. All twenty opened burrows were closed in both pre- and post-treatment censusing in the Magna Pulse test area. In the control area 19 were closed in the pre-treatment census while 20 were closed in the post-treatment census.

Sigma I and II

There were decreases in mound and plug formations in Sigma I, Sigma II and Sigma control areas from the pre-treatment census to the post-treatment census (Table 1). Sigma I and Sigma II reductions were small and not significant practically or statistically (Sigma I: $P < .5$, $T = .26$, 7 df; Sigma II; $P < .5$, $T = .76$, 7 df). In terms of approximate numbers of gophers per acre (Reid, et al., 1966) the Sigma I area dropped from 59 to 58, Sigma II area from 60 to 58, essentially no change. Sigma control area reduction was statistically significant ($P < .05$, $T = 2.48$, 7 df). The approximate number of gophers per acre dropped from 72 to 54.

Burrow plugging activity remained high in all cases. Sigma II and control areas had all 20 opened burrows plugged in both pre-treatment and post-treatment censuses. Sigma I had 19 of 20 plugged in the pre-treatment census and 20 of 20 in the post-treatment census (Table 2).

Summary

There were no indications of device efficacy with either activity index method. Burrow plugging behavior remained high (which is normal) in all areas in both pre- and post-treatment censuses.

Mound and plug formation changed, as follows, from pre-treatment to post-treatment censusing: test and control areas with high levels of activity experienced decreases; low activity areas experienced increases; and medium activity areas remained essentially unchanged. Reductions in all cases were not of a practical nature; economically damaging populations of gophers existed in all areas during both censuses.

Miscellaneous Observations

Two pocket gophers were observed above ground during the test. One, observed July 15 in the Sigma II test plot appeared sick and moved sluggishly; the second, observed July 22 in the Magna Pulse test area appeared normal (i.e., aggressive, not sluggish).

Canine prints (probably coyote) were observed in test and control areas throughout the test. Similarly, coyotes were observed periodically and a young coyote was killed by the farmer's dog on July 1.

Prairie falcons were the most frequently observed raptor in the area. It was not uncommon to see a dozen or so birds perched on telephone poles and fence posts.

Similarly, ravens were always observed in the area. They usually followed the sprinklers and preyed on gophers flooded out of their burrow systems. The number of ravens ranged from perhaps fifty to three or four hundred. It was not uncommon to see a raven carrying off a gopher.

Generally speaking, predator populations were extremely high indicating the density of prey species in the area. It is apparent that predators (like the devices) were not able to effectively reduce gopher populations.

TABLE 1. NUMBER OF POCKET GOPHER MOUNDS AND PLUGS PRODUCED IN 24 HOURS IN 9,000 SQ. FT. PLOTS

	Pretreatment						Posttreatment					
	Day 1	Day 2	Day 3	Day 4	Day 5	Mean ± S.E.	Day 1	Day 2	Day 3	Day 4	Day 5	Mean ± S.E.
Nature Shield Test	182	186	138	157	216	175.8 ± 13.3	151	154	153	74	155	137.4 ± 15.
Nature Shield Control	94	116	91	102	131	106.8 ± 7.4	114	43	72	70	81	76.0 ± 11.
Magna Pulse Test	22	14	22	21	13	18.4 ± 2.0	26	38	34	35	29	32.4 ± 2.
Magna Pulse Control	30	16	23	30	26	25.0 ± 2.6	49	30	14	51	26	34.0 ± 7.
Sigma I	*	99	78	101	101	94.8 ± 5.6	76	86	107	104	90	92.6 ± 5.
Sigma II	*	94	83	107	103	96.8 ± 5.3	83	84	106	99	85	91.4 ± 4.
Sigma Control	*	99	150	137	130	129.0 ± 10.8	60	45	106	77	123	82.2 ± 14.

*Sprinkler passed over census area invalidating counts.

TABLE 2. NUMBER OF POCKET GOPHER BURROWS CLOSED IN FIVE DAYS (20 OPENED).

	Nature Shield Test	Nature Shield Control	Magna Pulse Test	Magna Pulse Control	Sigma I	Sigma II	Sigma Control
Pretreatment	20	20	20	20	19	20	20
Posttreatment	20	20	20	19	20	20	20

Literature Cited

Reid, W. H., R. M. Hanson and A. L. Ward, 1966. Counting mounds and earth plugs to census pocket gophers. J. Wildl. Mgmt. 30:327-334.

Vaughn, T. A., 1972. Mammalogy. W. B. Saunders Co., Philadelphia. 463 pp.

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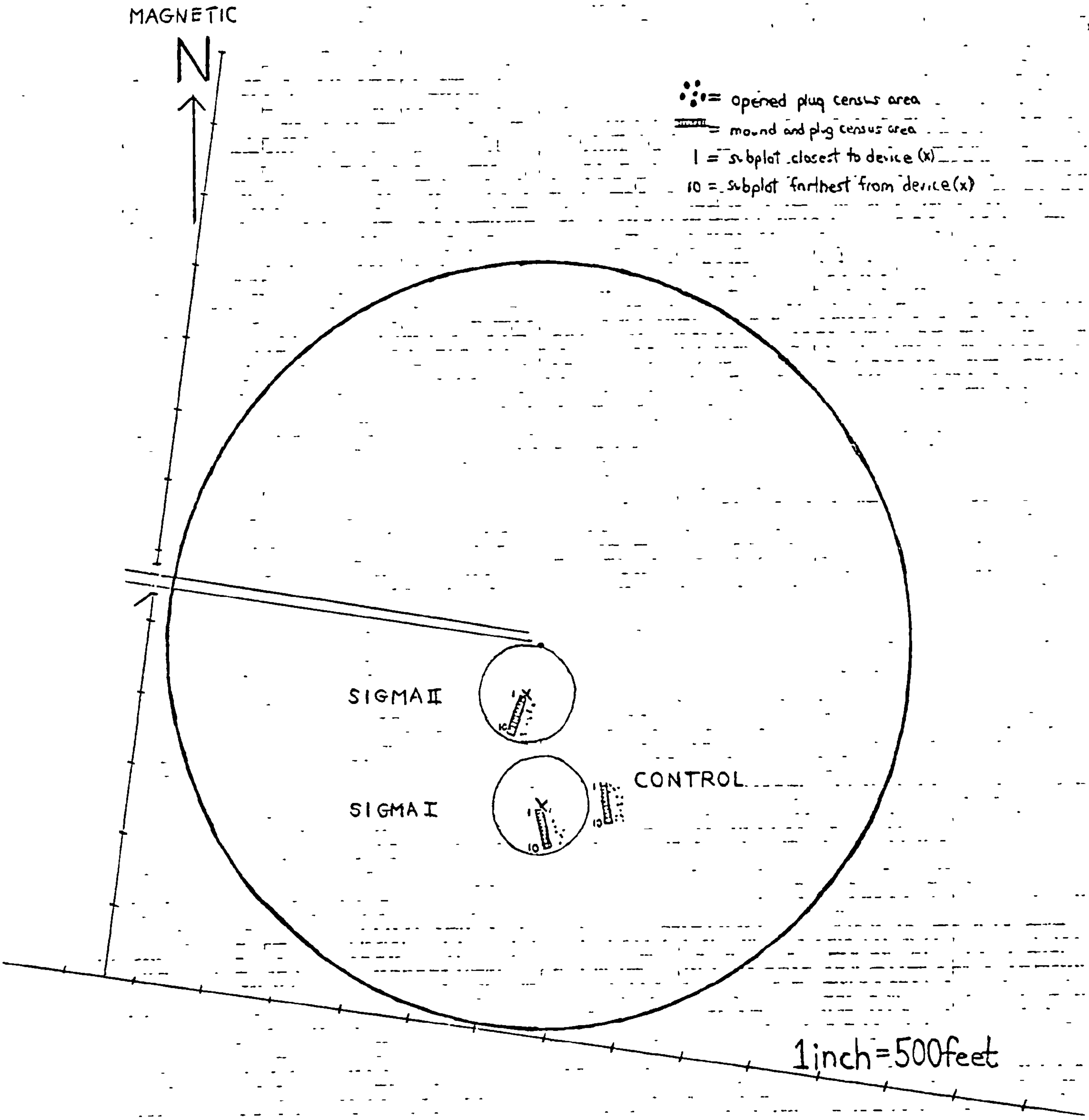
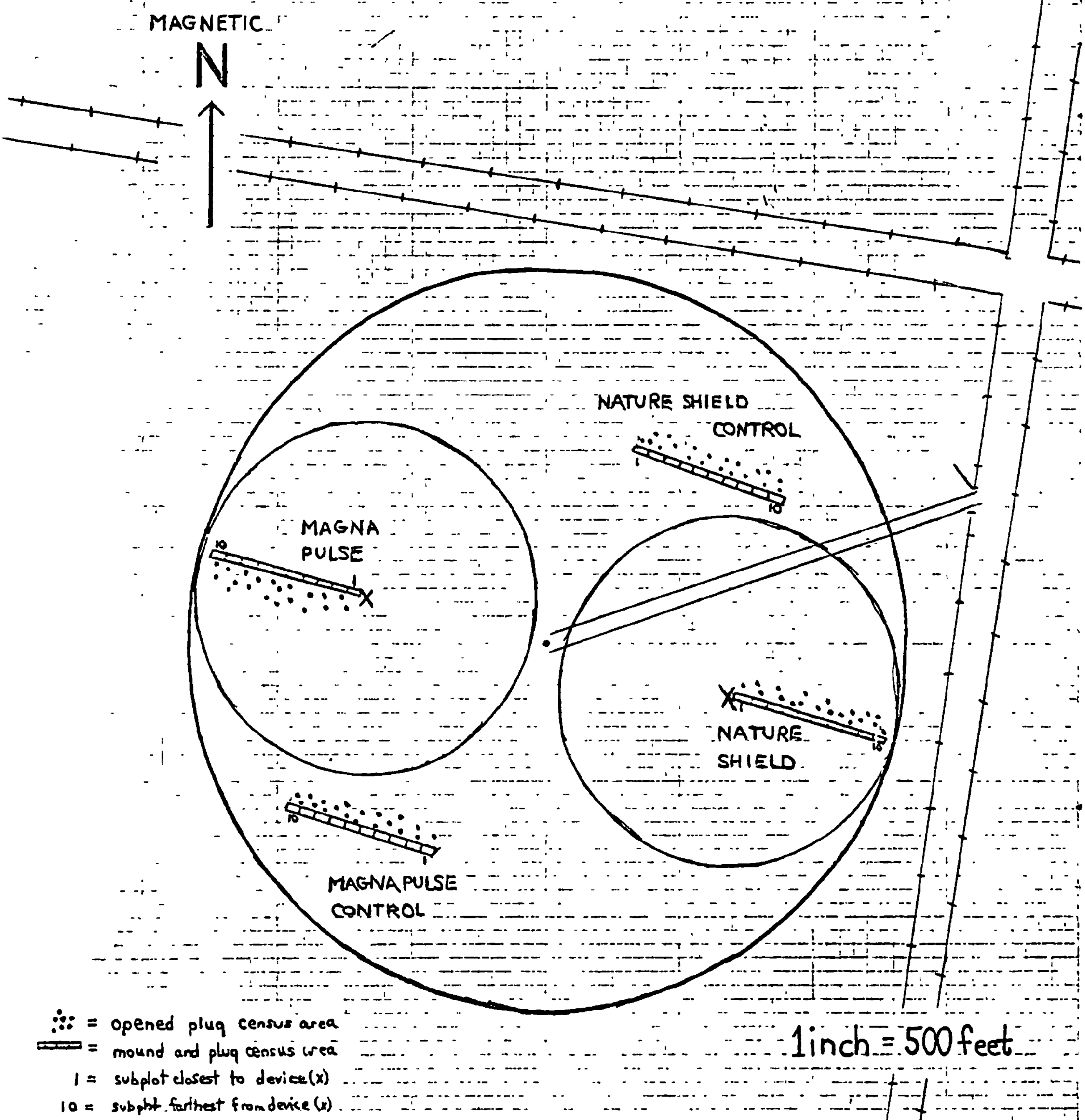
SIGMA I SIGMA II and CONTROL



MAGNA PULSE and NATURE SHIELD



AMIGO ELECTRONIC REPELLER

EFFICACY TEST

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AMIGO ELECTRONIC REPELLER EFFICACY TEST

Animal Biology Laboratory

The Animal Biology Laboratory has conducted efficacy tests on the Amigo Electronic Repeller at the request of Enforcement personnel in Region IX and in the main office in Waterside Mall. The efficacy tests were composed of feeding and breeding experiments. The brochure that accompanied the sample jacket (sample number 131211) claimed that rats will cease to eat, drink, or reproduce when within the 5-acre coverage of the device.

Test and Control Sites

In accordance with good scientific procedure and reading the claims made by Miraco Inc. for the Amigo Electronic Repeller, both test and control sites were set up. The manufacturer claims a 5-acre field of influence but infers it could be up to 12 acres. Therefore, it was considered necessary to separate the two sites by at least one mile. After considerable searching, an adequate location was found for the test site in Building 412-A about 2 miles from the control site at the Animal Biology Laboratory (Building 289).

The test site consisted of a one room 12 by 16-foot building with an average temperature of 60°F. The rats were individually caged in 9 by 11 by 8-inch metal cages. The Amigo device was installed one foot outside the building. A 10-foot, 3/4-inch inside diameter water pipe (galvanized steel) was driven into the ground 9 feet 6 inches. A 2-inch hacksaw cut was made in the top of the pipe in 4 places and the repeller bolt was set inside the pipe. The top of the pipe was tightened with an auto hose clamp and the device was plugged into a 115 volt AC outlet. No extension cord was necessary.

The control site consisted of a 24 by 24-foot room in a 24 by 60-foot building. The average temperature in the building was about 60°F. Cage sizes were identical with the units used with the test rats.

Feeding Test Procedure and Results

Two separate feeding trials were conducted with laboratory rats. The first test consisted of an 11-day feeding trial at both sites on ten rats each. The device was plugged in on the first day of this test. Daily all rats were offered 50 grams of Waynes Laboratory Chow (meal form) in a metal cup. The gross weight of each container and its contained food were determined daily and returned to starting weight by addition of the laboratory chow. If the food was fouled by urine or feces it was replaced. The quantity of food consumed by each rat was recorded each day.

When it became obvious that an 11-day test (no pre-test data) would not effectively reveal the efficacious nature of the repellent device, a second series of tests were commenced. The tests were similar to those above with the following exceptions: there were 25 rats used at both test and control sites, the rats were given a 2-week pre-test feeding trial at a third location before being transported to test and control sites, and the test period was for 5 weeks followed by a 2-week post-test feeding trial.

Results of Feeding Trials

Trial 1

Rats offered laboratory chow at the test site consumed 19.3 grams per day per rat. Consumption the first day was 16.5 grams per rat and on day 11 it was 22.0 grams per rat. Rats at the control site consumed 25.6 grams per day per rat. One rat died at the test site on the last day of the 11-day test. The average weight of test rats was 207 grams and control rats 233 grams.

In short, test rats did not stop eating when tested at almost "ground zero" of the Amigo's claimed effective range, but the control rats ate slightly more per day. This difference is not statistically or practically significant.

Trial 2

Test rats consumed an average of 25.1 grams per day during the pre-test period and 31.7 grams during the test period (Table 1). Control rats consumed 23.8 grams per day during the pre-test period and 31.7 grams during the testing period. Again, the test rats did not stop eating when exposed to the repeller device. Control rats consumed laboratory chow at the same rate as the test rats (Table 1).

No test or control rats died during this second feeding trial.

Reproduction Test Procedure and Results

Ten cages (26 by 10 by 7) were set up at both test and control sites with 1 male and 1 female rat per cage for 98 days. All breeding pairs received water and laboratory chow *ad libitum*. A nest box was provided in each cage. The rats were monitored daily for possible deaths and breeding success. All rat pups were wieghed at 7 days and sacrificed.

Results of Breeding Tests

Breeding success was relatively poor for both test and control rats. The most probable reason is the lack of artificially controlled lighting. Day length was only about 8 to 9 hours while 18 hours is the optimal for reproductive success. However, the 10 pairs of breeding rats at the test site managed to produce 20 litters for a total of 236 pups (Table 2). Control rats begat 23 litters with a total of 206 pups. This is very little difference in success and is not statistically ($p < 0.05$) or practically significant.

While more control rat pups survived the 7-day period from birth until sacrificed at 1 week of age than the test rats (144 controls, 110 test) the test rats were bigger (16.3 grams compared to 159 for control). There was no difference in reproductive success in both test and control animals.

Conclusion and Discussion

It can be concluded from the results of this test that rats do not fail to eat or reproduce when within the claimed zone of influence. The rat, either wild Norway or laboratory bred, would respond in the same manner to the device. There is no mammal, including dogs or cats, that lives in closer association with man than the rat. Therefore, domesticated rats were used instead of wild Norway rats.

In conclusion, the claims made by the manufacturer for the electronic repeller are unfounded and are extremely exaggerated.

TABLE 1

Amigo Electronic Repeller Feeding Trials

Values shown are mean daily consumption (in grams) per rat, per day of a commercial laboratory chow. Test rats (13 males, 12 females) were within 10 feet of the repeller device. Control rats (13 males, 12 females) were located 2 miles from the test site.

Pre-test Period Amigo Switched Off	Control Rats	Test Rats
Week 1	22.3	23.6
Week 2	25.0	26.4
Pre-test mean	23.8	25.1
Test Period Amigo Exposed to Test Rats		
Week 1	29.6	31.4
Week 2	29.9	31.0
Week 3	31.8	32.1
Week 4	33.0	31.2
Week 5	34.0	32.9
Mean for Test Period	31.7	31.7
Post-test Period Amigo Switched Off		
Week 1	34.5	31.5
Week 2	31.9	30.0
Mean for Post-test Period	33.2	30.7

TABLE 2

Amigo Electronic Repeller Breeding Trials

Number of litters born and sacrificed (7 days old) at Amigo test site (TS) and control site (CS). Test rats were stationed within 10 feet of the Amigo Electronic Repeller.

Week #	Number of litters born TS	CS	Total number of pups TS	CS	Number of litters sacrificed TS	CS	Total number of pups TS	CS	Mean pup weight in grams TS	CS
1	0	0	0	0	0	0	-	-	-	-
2	0	0	0	0	0	0	-	-	-	-
3	0	0	0	0	0	0	-	-	-	-
4	0	0	0	0	0	0	-	-	-	-
5	3	2	17	14	0	0	-	-	-	-
6	3	3	24	28	0	3	-	17	-	21.4
7	1	2	14	22	3	0	32	-	17.0	-
8	2	0	18	0	1	2	4	21	9.7	15.4
9	1	6	3	42	1	0	6	-	19.6	-
10	4	2	54	26	0	5	-	43	-	15.3
11	2	1	23	4	3	2	28	18	17.0	14.8
12	2	2	25	26	1	1	7	3	17.61	22.6
13	1	1	14	33	2	2	20	23	17.3	17.1
14	4	2	44	11	1	2	13	19	15.5	14.2
Sum	20	23	236	206	12	17	110	144	16.3	15.9
Post-test Amigo Off										
1	3	1	38	7	3	2	36	16	15.0	16.6
2	2	2	22	16	1	1	8	8	10.8	16.8
Sum	5	3	60	23	4	3	44	24	14.2	16.7

AMIGO PHASE II ELECTRONIC REPELLER

EFFICACY REPORT

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October 26, 1977

AMIGO PHASE II ELECTRONIC REPELLER EFFICACY REPORT (SAMPLE NUMBER 148834)

The purpose of this report is to document the results of testing the Amigo Phase II Electronic Repeller for efficacy. This device has claims for both above and below ground pest animals control. A brochure accompanying the device claims pest species will stop eating, breeding, and drinking when within the zone of influence. The size of the zone of influence is not clearly stated but ranges from 5 to 30 acres and up.

Equipment and Procedure

Testing was conducted at two locations. One site was designated the test site and consisted of a one room 12 by 16-foot building. The Amigo Phase II device was installed about 1 foot outside the building. A 10-foot, 3/4-inch inside diameter water pipe (galvanized steel) was driven into the gound 9 1/2 feet. A 2-inch hacksaw cut was made in the top of the pipe in four places and the repeller bolt was set inside the pipe. The top of the pipe was tightened with an auto hose clamp.

A control site was also set up in a 24 by 24-foot room in a 24 by 60-foot building. The control site was located 2 miles from the test site.

All feeding tests were conducted in 9 by 11 by 8-inch wire mesh metal cages. All rats were individually caged and laboratory chow consumption was recorded daily. There were 30 rats each at the test and control sites. The rats received 50 grams of food per day.

All drinking tests were conducted in 3 by 6-foot stock watering tanks. The bottom of each tank was covered to a depth of approximately 1 inch with clean wood shavings. The wood shavings were changed weekly. Each tank also contained two 14 by 14 by 4-inch metal nest boxes. There were 20 rats (10 males, 10 females) used at both the test and control areas. There were twelve 100 milliliter graduated no-drip waterers used per tank. All waterers were filled with fresh tap water after daily intake was recorded.

Breeding

The tests were conducted in 20 by 20 by 9-inch metal cages. There were 12 pairs (1 male, 1 female) each at both test and control sites. All pairs were inspected for birth daily. All rat pups were counted, weighed to the nearest tenth of a gram and sacrificed at 7 days.

Before the device was plugged in, all rats (eating, drinking and breeding) were monitored for 3 weeks (pre-test period). After 14 weeks, the repeller device was unplugged. All rats were monitored for 3 weeks (post test period).

Results

Feeding Trials

Test rats consumed 24.5 grams of laboratory chow daily during the test and control rats 25.4 (Table 1, Figure 1). There is no statistical difference ($P > .05$). Consumption fell off steadily during the 14 week test period for rats at both sites. Computing the 14 week trend by the method of least squares indicates a slight but steady decline, using the formula $Y=A+Bx$, $B=-0.6900$, and $A=25.4079$ for the controls and $B= - 0.4793$ and $A=24.4657$ for the test rats. See the calculated trends in Figure 1a.

Drinking Trials

Test rats consumed water at twice the rate of control rats during the 3 week pre-test period (40.18 to 23.13 ml respectively). The explanation for this low water consumption in the controls is not available. The test rats' water intake was at levels published in the literature. However, by the first week of the test period, control rat water intake had increased ten milliliters. (Table 2, Figure 2). Test rat water consumption remained fairly constant during the 14 week trial (Figure 2a) using the method of least squaress $B= - 0.6820$ and $A=42.3736$. Controls rats drank an average of 37.36 milliliters during the 14 week period as compared to the test rats (42.37 ml) but the trend was slightly upward (Figure 2a). The least square solutions are $B= +0.2879$ and $A= +37.3579$.

Breeding Trials

Test rats begat 23 litters of pups and control rats 32 during the 14 week test period (Table 3). There were two pairs in the test rats that never produced a litter during the entire 20 week period they were monitored. However, test rats averaged 12.65 pups per litter and controls 10.94. Eighty-five percent of the control rats survived this same period. The difference is not statistically significant ($P > 0.05$).

Test rat pups averaged 15.0 grams at 7 days and control pups 16.1 grams. Again, the difference is not significant.

Conclusion:

Rats stationed within the claimed zone of influence of the Amigo Phase II repeller consumed food, drank water and bred with vigor over the entire 14 week test period. The literature indicates some effects of electromagnetism upon animals but only at a much higher output than is radiating from the Amigo Phase II. There is also some controversy as to whether the 760 kilovolt transmission lines affect people adversely. The Amigo Phase II operates on 110 volts. The test data shows the device did not stop the rats from drinking, eating, or breeding.

TABLE 1

Amigo Phase II feeding test. Sample no. 148834. Values shown are mean daily consumption (in grams) per rat, per day of a commercial laboratory chow. Test rats (15 males, 15 females) were located within 10 feet of the electromagnetic repeller device. Control rats (15 males, 15 females) were located 2 miles from the test site.

	Control rats	Test rats
Pre-test Period		
Week 1	23.63	25.07
Week 2	25.93	27.13
Week 3	28.87	27.08
Pre-test mean	26.14	26.43
Test Period (device turned on)		
Week 1	30.00	28.18
Week 2	28.11	26.53
Week 3	27.84	25.86
Week 4	28.90	26.88
Week 5	28.12	25.70
Week 6	26.57	24.10
Week 7	24.00	22.54
Week 8	25.67	24.05
Week 9	24.76	25.77
Week 10	24.76	26.09
Week 11	23.21	23.56
Week 12	22.77	23.48
Week 13	20.87	20.43
Week 14	20.13	19.35
Test mean	25.41	24.47
Post-test Period		
Week 1	18.28	19.09
Week 2	18.97	18.26
Week 3	20.46	22.59
Post-test mean	19.23	19.98

TABLE 2

Amigo Phase II drinking test. Sample no. 148834. Values shown are mean daily water consumption (in milliliters per rat, per day). Test rats (10 males, 10 females) were located within 10 feet of the repeller device. Control rats (10 males, 10 females) were located two miles from the test site.

	Control rats	Test rat
Pre-test Period		
Week 1	20.91	34.92
Week 2	24.63	37.11
Week 3	25.65	48.51
Pre-test mean	23.73	40.18
Test Period (device turned on)		
Week 1	33.52	40.81
Week 2	38.54	39.49
Week 3	38.79	42.14
Week 4	34.51	45.41
Week 5	33.78	45.77
Week 6	39.39	41.96
Week 7	37.00	47.20
Week 8	37.40	41.59
Week 9	38.44	40.23
Week 10	35.74	43.09
Week 11	36.82	43.26
Week 12	38.86	40.28
Week 13	38.07	38.06
Week 14	42.14	43.94
Test mean	37.36	42.37
Post-test Period		
Week 1	42.74	41.07
Week 2	42.94	41.75
Week 3	38.10	46.03
Post-test mean	41.26	42.95

TABLE 3

Number of litters born and sacrificed (7 days old) at Amigo test site (TS) and control site (CS). Test rats were stationed within 10 feet of the Amigo Phase II Electronic Repeller (Sample no. 148834).

	Number of litters born		Total number of pups		Number of litters sacrificed		Total number of pups at sacrifice		Mean pup weight in grams	
Pre-test	TS	CS	TS	CS	TS	CS	TS	CS	TS	CS
Week 1	0	0	0	0	0	0	0	0	0	0
Week 2	2	1	30	15	2	1	30	11	14.2	11.8
Week 3	5	5	55	42	5	3	52	28	17.1	15.0
Sum	7	6	85	57	7	4	82	39	16.0	14.1
Test										
Week 1	0	0	0	0	0	0	0	0	0	-
Week 2	2	3	36	27	2	3	31	23	12.2	14.9
Week 3	1	2	8	20	1	2	7	15	19.3	15.6
Week 4	3	4	36	45	3	4	32	41	14.9	17.6
Week 5	1	3	14	32	0	3	0	29	-	17.2
Week 6	2	2	22	20	2	2	17	20	12.3	15.1
Week 7	2	2	24	13	2	2	23	11	16.0	18.6
Week 8	3	1	43	9	3	1	40	9	16.4	18.8
Week 9	2	3	22	30	2	3	20	30	14.8	15.0
Week 10	0	3	0	42	0	3	0	39	-	16.0
Week 11	3	2	35	28	3	2	30	28	16.0	13.6
Week 12	2	1	24	9	2	1	21	9	17.1	21.6
Week 13	1	3	14	40	1	3	14	31	12.5	17.5
Week 14	1	3	13	35	1	3	13	31	13.8	14.9
Sum	23	32	291	350	22	32	248	316	15.0	16.1
Post-test Amigo off										
Week 1	1	1	16	10	1	1	13	10	13.8	16.0
Week 2	2	2	16	22	2	2	16	21	16.6	14.1
Week 3	0	2	0	25	0	2	0	24	-	10.7
Sum	3	5	32	57	3	5	29	55	15.3	13.0

BEE 20x20 TO INCH

FIGURE 1 AMIGO FEEDING TRIALS

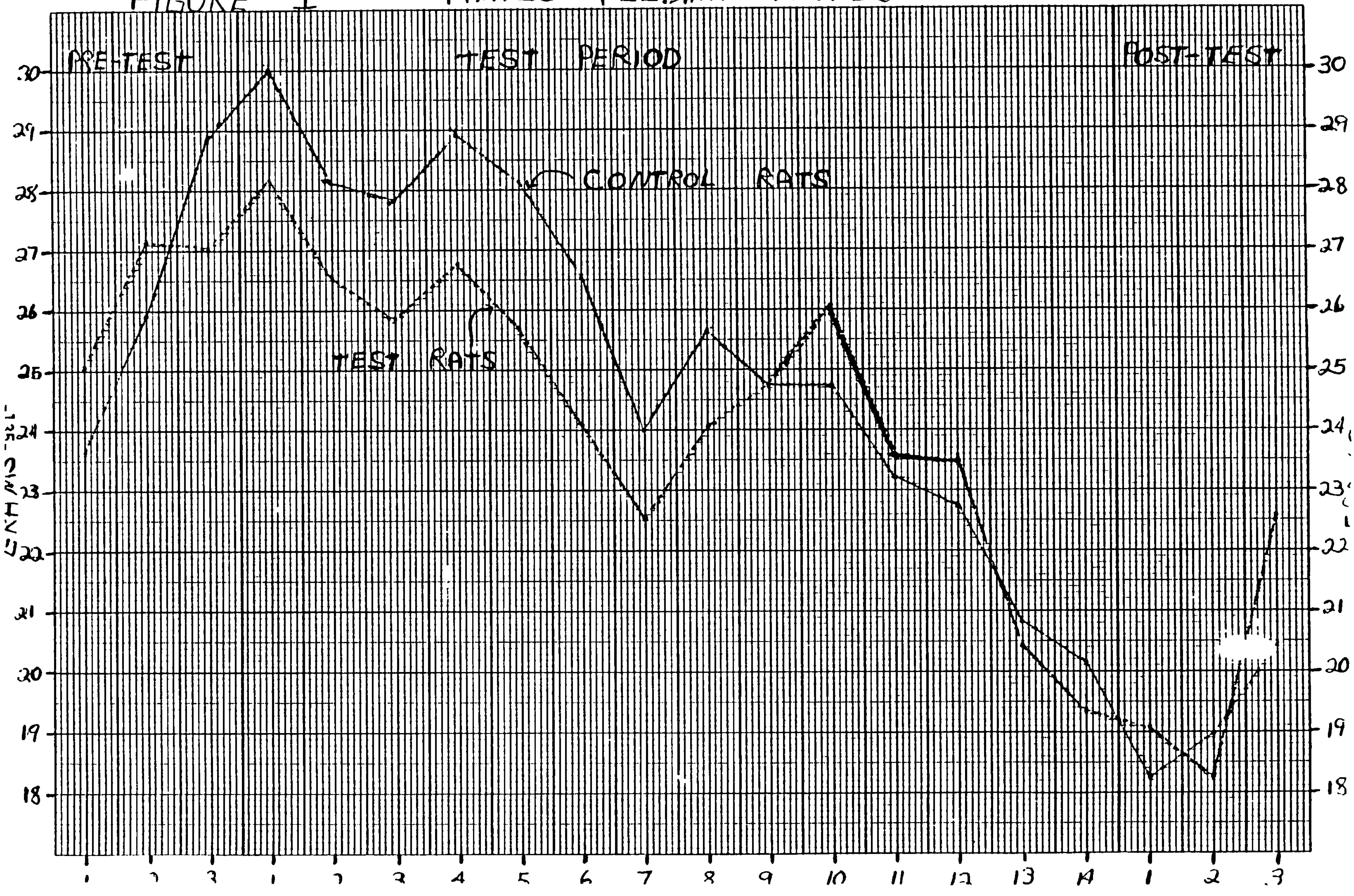
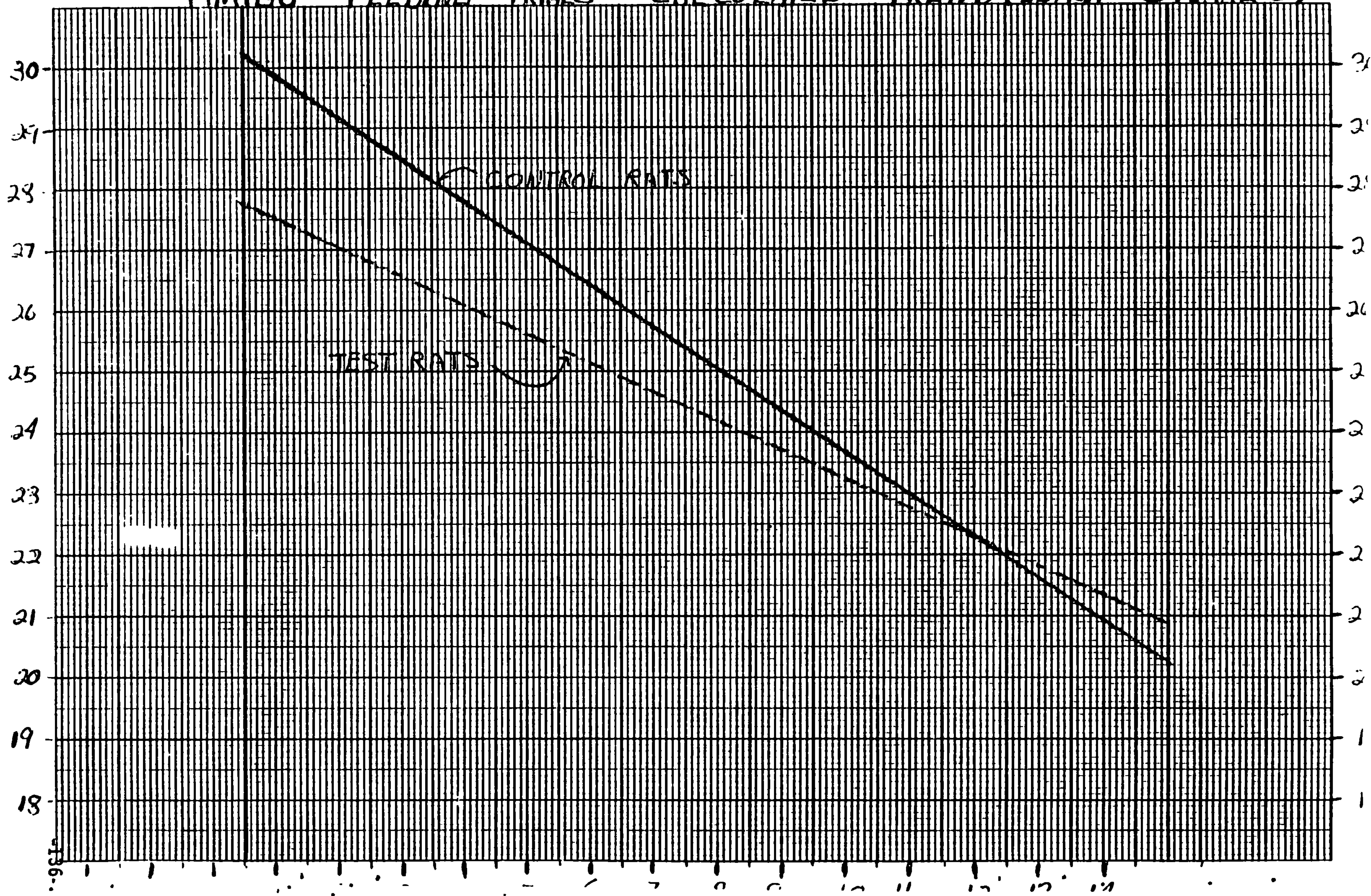


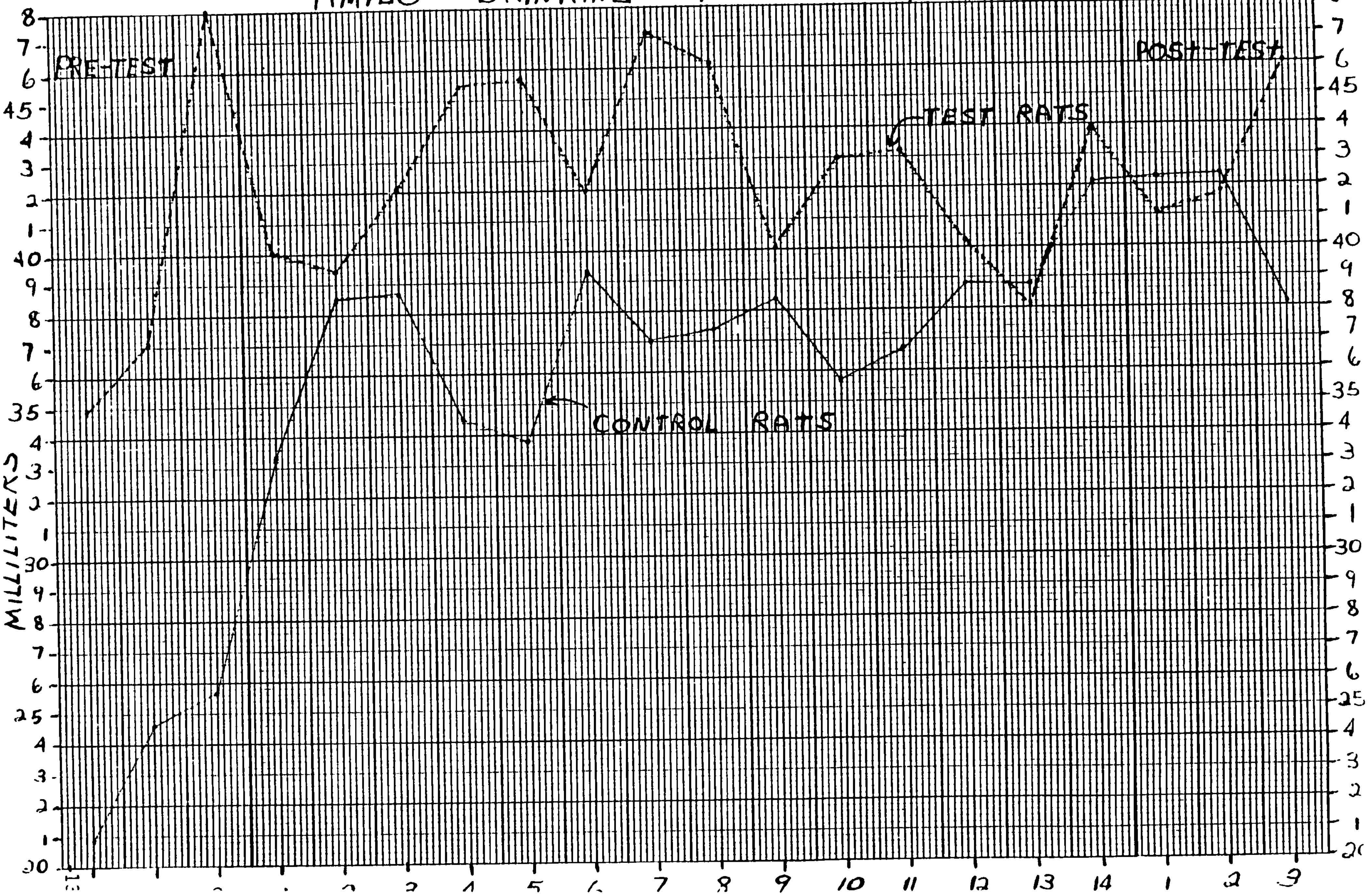
FIGURE 1A

AMIGO FEEDING TRIALS ' CALCULATED TREND (LEAST SQUARES)



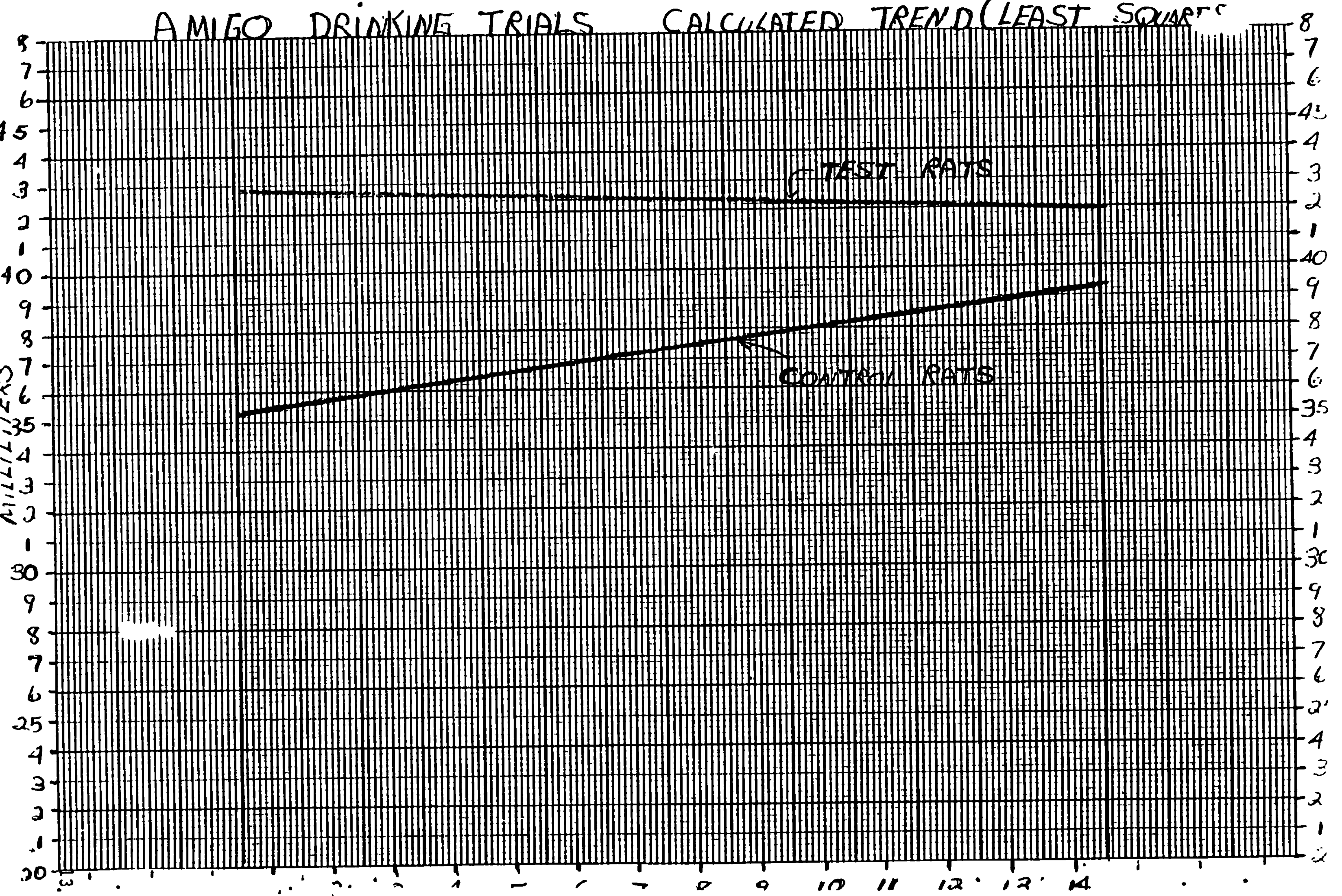
BEE 20x20 TO INCH

AMIGO DRINKING TRIALS FIGURE 2



BEE 20x20 TO INCH

FIGURE 2A



NATURE SHIELD ELECTROMAGNETIC REPELLER

EFFICACY TEST

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Nature Shield Electromagnetic Repeller Efficacy Test--Sample Number 131904

Animal Biology Laboratory

The Animal Biology Laboratory has conducted efficacy tests on the "Nature Shield" electromagnetic repeller at the request of A. E. Conroy II, Director PTSED.

Testing of the Nature Shield and earlier electromagnetic devices (Amigo) has resulted in considerable publicity by the media. For example, NBC film crews filmed the Animal Biology Laboratory testing facilities and interviewed Barbara Blum, EPA's Deputy Administrator. Many magazine and newspaper articles appeared, some of which were inaccurate. Also, laboratory personnel have received an enormous number of phone calls concerning electromagnetic devices requiring a large expense of time.

In order to design a laboratory efficacy test that will simulate an actual use situation as much as possible, laboratory personnel studied the written claims made by Solara Electronics for the Nature Shield device. Also, Steve Palmateer visited several sites in Sacramento and San Francisco, California (March 11, 1978) where Nature Shield devices had been installed by Solara's Herb Wilson. The inspection tour was given personally by Solara Electronic's Michael H. Elley and Herb Wilson. Mr. Elley had many ideas on how to test his company's device and these were carefully recorded. Mr. Elley has also visited the Animal Biology Laboratory twice.

Solara Electronics Inc., claims a 650-foot radius field of influence for Nature Shield. Their brochures claim the device will eliminate termites, gophers, ants, moles, roaches, mice, aphids, squirrels, voles and rats. In fact, one brochure makes a claim on "rodents in general."

The manufacturer claims the Nature Shield utilizes "contro-clusive magnetism" (a trademark) to stir the existing magnetic field. These changes in the environment will ultimately provide a null effect in a pest species' nervous system and eliminate its normal survival reactions. "It stops eating, drinking and reproducing."

Equipment and Procedure

Efficacy testing was conducted at two locations in Beltsville, Maryland. Building 412-A was designated the test site. It is a single room 12 by 16-foot wood frame building. The Nature Shield was installed about 10 feet outside the building. The device was mounted in the soil according to Solara instruction (i.e., half in soil and half in air). Also, the "N" on decal of unit was pointed toward magnetic north. The light at the top of the device was difficult to see in full daylight; therefore, a 6-inch piece of 1/2-inch inside diamter PVC pipe was used to determine if the unit was functioning. The observer would place one end of the pipe on the light and look through the other end to see the light flash (about every 7 seconds). The light continued to flash during the entire test period of 14 weeks.

A control site was set up in Building 288, about 2 miles from the check site.

Feeding tests

All feeding tests were conducted in 9 by 11 by 8-inch wire mesh galvanized metal cages. All rats were individually caged and Wayne 4% protein laboratory rodent food consumption was recorded to at least the nearest gram. There were 30 rats each used at both the test and control site. Ten of the 30 rats at both sites were wild Norway rats and the remaining 20 were Wistar Norway rats. Rats received laboratory rodent food in excess of the daily food requirement.

Drinking tests

All drinking tests were conducted in 3 by 6-foot stock watering tanks. The bottom of each tank was covered to a depth of approximately 1 inch with clean wood shavings. The wood shavings were changed weekly. Each tank contained two 14 by 14 by 4-inch metal nest boxes. There were 20 rats (10 males, 10 females) used at both the test and control areas. Two water founts attached to 2,000 milliliter graduate water bottles were used at both test and control areas. Siper tubes were not used in the drinking tests.

Breeding tests

The breeding tests employed the use of Swiss-Webster house mice and Wistar Norway rats.

The rat breeding tests were conducted in 20 by 20 by 9-inch metal cages. There were 12 pairs (1 male, 1 female) each at both test and control sites. All pairs of breeding rats were inspected for births daily. All rat pups were counted, weighed to the nearest tenth of a gram and sacrificed at 7 days.

The house mouse breeding tests were conducted in 9 by 18 by 5-inch plastic cages. All cages had a wire mesh top. There were 3 mice (1 male, 2 females) used in each breeding cage. Ten breeding cages each were used at the test and control sites. All mice breeding cages were inspected daily, new litters weighed and recorded and all pups sacrificed.

Before the Nature Shield device was installed at Building 412-A, all rodents were monitored for a 3-week pre-test period. After 14 weeks exposure to the device, the device was removed from Building 412-A, the test site. All rodents were monitored for an additional 3 weeks (post-test period).

During the test and post-test periods food consumption of unconfined wild rodents at the test site was monitored at several locations within the 650-foot zone of influence. At the end of the test period 48 snap trays were set to give an indication of the types of rodents consuming the food at the census bait locations.

Results

Feeding tests

Test site rats consumed an average of 23.9 grams of laboratory chow per day and control rats 21.6 grams (Table 1A and Figure 1). Control wild Norway rats consumed less laboratory chow than test wild Norway rats (20.4 versus 21.30 grams). Test Wistar Norway rats consumed an average of 25.1 grams of laboratory chow per day and controls 23.2 grams.

Food consumption was steady over the entire 14-week test period (Tables 1A and 1B). There is a very slight downward trend in food consumption for both test site and control site Norway rats. However, there is a small insignificant upward trend in food intake for control wild Norway rats (Table 1B). Notice that the standard error of the sample is 1.268 for the control rats and 0.840 for test rats. This very slight difference in variability has no statistical or practical significance.

Drinking tests

Test rats consumed a mean of 32.88 milliliters of water per day and control rats 25.43 (Table 2A and Figure 2). Water consumption was more erratic from one week to the next for both test and control rats as compared to food consumption. The standard error of estimate for control rats is 3.57 and test rats 3.37 (Table 2B). The important point to notice here is that although water consumption varied from week to week for both control and test Wistar rats, the average deviation from the computed regression line is very close to being the same. The overall water consumption trend for control rats is very slightly downward (B= -0.17684). However, for test rats the computed trend is moderately upward (B= +0.64446).

Breeding tests

Test Wistar Norway rats begat 23 litters during the 14-week test and the control rats 22 litters. There were 273 rat pups born at the test site and 238 pups at the control site (Table 3). Eighty-seven percent of the control rat pups survived the 7 days from birth to sacrifice and test rat pups recorded a very close eighty-five percent. At sacrifice, control rat pups weighed 14.8 grams and test rats 14.5 grams. Test rats averaged 11.87 pups per litter and control rats 10.82.

Test Swiss-Webster mice begat 40 litters during the 14-week test period and the control mice 22. Test mice averaged 12.9 pups per litter and controls 9.0 pups per litter.

Wild free-ranging mice food consumption

A total of 388.5 grams of laboratory chow and TSD laboratory diet were consumed over the 14-week test period. All food cups were unavailable to birds but some consumption could have been made by cockroaches. Food intake was erratic and dwindled toward the end of the test (Table 5). However, by the end of the 14-week test, the weather had warmed up (June) and many of the unconfined rodents had moved outside.

Snap trap results

A total of 6 mice were caught at the end of the test within the 650-foot claimed zone of influence. All mice were caught at either Building 412 or 412-A. There were 3 deer mice (*Peromyscus leucopus*): male 8.5 grams, male 9.4 grams and female 24.5 grams. The others were house mice (*Mus musculus*) (male 8.0 grams, female 12.3 grams and female 20.6 grams). None of the females were pregnant but the deer mice males were just weaned and were in the typical charcoal grey color of very young *Peromyscus*.

Conclusion

Norway rats stationed within the 650-foot claimed zone of influence of the Nature Shield electromagnetic repeller consumed food, drank water and bred in quantities comparable to controls located 2 miles away. There was no practical difference in the results tabulated at both the control site and test site for Norway rats and therefore the device is not effective as claimed for rats.

House mice bred with a large amount of success at the test site and therefore the Nature Shield device failed to substantiate the claim that it will stop mice from breeding.

Also, the 6 wild mice trapped within the 650-foot zone of influence will dispel any pseudoscientific explanation that the Nature Shield does not affect caged animals but only those running around free.

TABLE 1A

Nature Shield feeding test, Sample Number 131904. Values shown are mean daily consumption (in grams) per rat, per day of a commercial laboratory chow. Test rats (sexes equal) were located within 26 feet of the electromagnetic repeller device. Control rats (sexes equal) were located 2 miles from the test site.

	Control rats			Test rats		
	Wild Norway rats n=10	Wistar Norway rats n=20	All control rats n=30	Wild Norway rats n=10	Wistar Norway rats n=20	All test rats n=30
Pre-test Period						
Week 1	18.11	21.98	20.69	14.30	23.20	20.23
Week 2	18.97	21.35	20.56	22.77	24.38	23.84
Week 3	19.53	24.36	22.75	21.44	26.47	24.80
Pre-test mean	18.76	22.34	21.15	19.27	24.76	22.93
Test period						
Week 1	19.61	23.23	22.03	21.53	25.41	24.11
Week 2	19.26	24.27	22.60	20.16	25.70	23.85
Week 3	17.70	21.89	20.49	20.53	26.43	24.46
Week 4	22.88	23.83	23.51	23.14	26.53	25.40
Week 5	21.05	23.65	22.58	21.18	25.77	24.24
Week 6	17.33	22.23	20.59	21.73	26.22	24.72
Week 7	21.42	22.64	22.23	22.90	26.64	25.40
Week 8	21.71	22.84	22.47	22.04	25.40	24.28
Week 9	19.74	19.56	19.62	20.69	24.50	23.23
Week 10	20.62	20.68	20.66	22.49	25.15	24.26
Week 11	20.22	21.15	20.84	20.17	22.94	22.01
Week 12	19.23	19.26	19.25	20.50	23.50	22.50
Week 13	21.49	22.77	22.35	19.74	22.93	21.87
Week 14	23.25	23.27	23.26	21.44	24.71	23.61
Test mean	20.39	23.23	21.61	21.30	25.13	23.85
Post Test Mean						
Week 1	23.15	23.28	23.23	19.77	22.03	21.28
Week 2	18.86	22.46	21.26	18.63	21.71	20.69
Week 3	21.12	22.40	21.98	21.22	22.64	22.17
Post-test mean	21.04	22.72	21.79	19.88	22.13	21.38

TABLE 1B

Nature Shield feeding test calculated trends according to the method of least squares (y = A+Bx). A and B are the least souare estimates, r is the sample correlation coefficient and Sy .x is the standard error of estimate. Trends are calculated from Table 1A data.

	Control rats			Test rats		
	Wild Norway rats n=10	Wistar Norway rats n=20	All control rats n=30	Wild Noway rats n=10	Wistar Norway rats n=20	All test rats n=30
B =	+.1591	-.1782	-.0635	-.0534	-.2296	-.1651
A =	19.2007	23.5699	22.0818	21.7031	26.874	25.0914
r =	+.3833	-.4805	-.1978	-.2092	-.754	-.6212
Sy. x =	1.5447	1.311	1.268	1.005	0.807	0.840
Calculated y when						
x = 1	19.36	23.39	22.02	21.65	26.64	24.93
x = 2	19.52	23.21	21.95	21.60	26.41	24.76
x = 3	19.68	23.04	21.89	21.54	26.19	24.60
x = 4	19.84	22.86	21.83	21.49	25.96	24.43
x = 5	20.00	22.68	21.76	21.44	25.73	24.27
x = 6	20.15	22.50	21.70	21.38	25.50	24.10
x = 7	20.31	22.32	21.64	21.33	25.27	23.94
x = 8	20.47	22.14	21.58	21.28	25.04	23.77
x = 9	20.63	21.97	21.51	21.22	24.81	23.61
x = 10	20.79	21.79	21.45	21.17	24.58	23.44
x = 11	20.95	21.61	21.38	21.12	24.35	23.27
x = 12	21.11	21.43	21.32	21.06	24.12	23.11
x = 13	21.27	21.25	21.26	21.01	23.89	22.94
x = 14	21.43	21.08	21.19	20.96	23.66	22.78

TABLE 2A

Nature Shield drinking test, Sample number 131904. Values shown are mean daily water consumption (in milliliters per rat, per day)*. Test rats (10 males, 10 females) were located within 26 feet of the repeller device, control rats (10 males, 10 females) were located two miles from the test site.

	Control rats	Test rat
Pre-test Period		
Week 1	33.11	26.56
Week 2	25.83	32.50
Week 3	27.50	27.86
Pre-test mean	26.67	29.58
Test Period		
Week 1	26.43	20.00
Week 2	26.79	31.96
Week 3	25.71	33.21
Week 4	29.29	31.96
Week 5	25.89	35.00
Week 6	26.71	31.96
Week 7	26.07	35.76
Week 8	23.21	34.46
Week 9	25.00	31.61
Week 10	15.00	34.29
Week 11	29.46	33.39
Week 12	25.71	32.68
Week 13	25.25	33.93
Week 14	26.64	40.94
Test mean	25.43	32.88
Post-Test Period		
Week 1	25.71	38.57
Week 2	17.32	25.54
Week 3	22.32	38.75
Post-test mean	21.79	34.29

* All rats are Wistar Norway rats.

TABLE 2B

Nature Shield drinking test calculated trends according to the method of least squares (y = A+B). A and B are the least square estimates, r is the correlation coefficient and Sy. x is the standard error of estimate. Trends are calculated from Table 2A data.

	Control Wistar rats n=20	Test Wistar rats n=20
B =	- 0.17684	+0.64446
A =	+26.76626	+28.10582
r =	- 0.19583	+0.61022
Sy. x =	+ 3.56957	+3.37277
Calculated y when		
x = 1	26.59	28.75
x = 2	26.41	29.39
x = 3	26.24	30.04
x = 4	26.06	30.68
x = 5	25.88	31.33
x = 6	25.71	31.97
x = 7	25.53	32.61
x = 8	25.35	33.26
x = 9	25.17	33.91
x = 10	25.00	34.55
x = 11	24.82	35.19
x = 12	24.64	35.84
x = 13	24.47	36.48
x = 14	24.29	37.13

TABLE 3

Number of Wistar Norway rat litters born and sacrified (7 days old) at the Nature Shield test site (TS) and and control site (CS). There were 12 pairs of breeders at each site. Test rats were stationed within 26 feet of the Nature Shield electromagnetic repeller. Sample number 131904.

		Number of litters born		Total number pups at birth		Number litters sacrificed		Total number pups at sacrifice		Mean pup weight (gms)	
	Week	CS	TS	CS	TS	CS	TS	CS	TS	CS	TS
Pre-test	1	2	1	16	13	1	1	14	3	17.8	15.4
	2	2	3	17	32	2	3	7	30	14.0	13.2
	3	2	3	27	29	2	3	26	29	14.3	15.1
	Sum	6	7	60	74	5	7	47	72	15.0	14.4
Test	1	2	1	18	12	2	1	18	12	19.0	15.4
	2	3	2	35	18	3	1	34	14	15.6	17.4
	3	0	1	-	14	0	1	-	13	-	17.9
	4	2	5	26	57	2	5	22	46	15.4	14.6
	5	5	1	52	9	4	1	41	9	12.5	15.9
	6	0	1	-	8	0	1	-	8	-	17.3
	7	0	5	-	64	0	5	-	56	-	14.0
	8	1	0	8	-	1	0	7	-	16.2	-
	9	4	1	46	13	4	1	43	13	15.9	15.1
	10	1	1	8	11	0	1	0	10	-	14.7
	11	1	2	9	24	1	2	9	24	10.6	13.4
	12	0	0	-	-	0	0	-	-	-	-
	13	2	2	23	31	2	1	22	16	13.9	9.7
	14	1	1	13	12	1	1	11	11	12.6	14.0
	Sum	22	23	238	273	20	21	207	232	14.8	14.5
Post-test	1	1	1	16	13	1	1	16	10	14.2	9.7
	2	1	1	10	5	1	0	10	0	16.8	-
	3	1	0	10	-	1	0	9	-	8.3	-
	Sum	3	2	36	18	3	1	35	10	13.4	9.7

TABLE 4

Number of Swiss-Webster house mouse litters born at the Naure Shield test site (TS) and control site (CS). There were 10 breeding cages at each site with 1 male and 2 females per cage. Test mice were stationed within 26 feet of the Nature Shield electromagnetic repeller. Sample number 131904.

	Number of litters born		Total number of pups		Mean pup weight (grams)	
Period	TS	CS	TS	CS	TS	CS
Pre-test						
Week 1	4	3	55	17	1.6	1.1
Week 2	2	0	23	-	1.6	-
Week 3	5	0	61	-	1.5	-
Sum	11	3	139	17	1.5	1.1
Test						
Week 1	3	2	50	14	1.5	1.7
Week 2	0	0	-	-	-	-
Week 3	4	2	56	18	1.4	2.3
Week 4	2	2	30	8	1.7	1.5
Week 5	2	0	24	-	1.7	-
Week 6	5	2	61	20	1.6	1.5
Week 7	2	4	30	27	1.7	1.6
Week 8	4	0	47	-	1.5	-
Week 9	4	1	53	10	1.8	1.5
Week 10	2	2	21	24	1.8	1.4
Week 11	3	1	45	10	1.5	1.2
Week 12	5	3	59	24	1.6	1.6
Week 13	2	2	24	30	1.9	1.4
Week 14	2	1	25	12	1.6	1.4
Sum	40	22	515	197	1.7	1.7
Post-test						
Week 1	2	2	29	31	1.5	1.7
Week 2	0	2	-	21	-	1.6
Week 3	4	1	43	15	1.9	1.6
Sum	6	5	72	67	1.7	1.7

TABLE 5

Food consumption (grams) by free ranging wild mice at Building 412 and Building 412-A. Both buildings were within 100 feet of the Nature Shield electromagnetic repeller.

Week	Building 412	Building 412-A	Total
Pre-test	-	89	89
Test period			
1	-	91	91
2	-	56	56
3	-	31	31
4	-	55	55
5	-	20	20
6	-	7	7
7	-	10	10
8	32	8	40
9	10	2	12
10	16	5	21
11	10	1.5	11.5
12	3	0	3
13	25	3	28
14	3	0	3
Sum	99	289.5	388.5

Figure 2

Nature Shield Drinking Trials

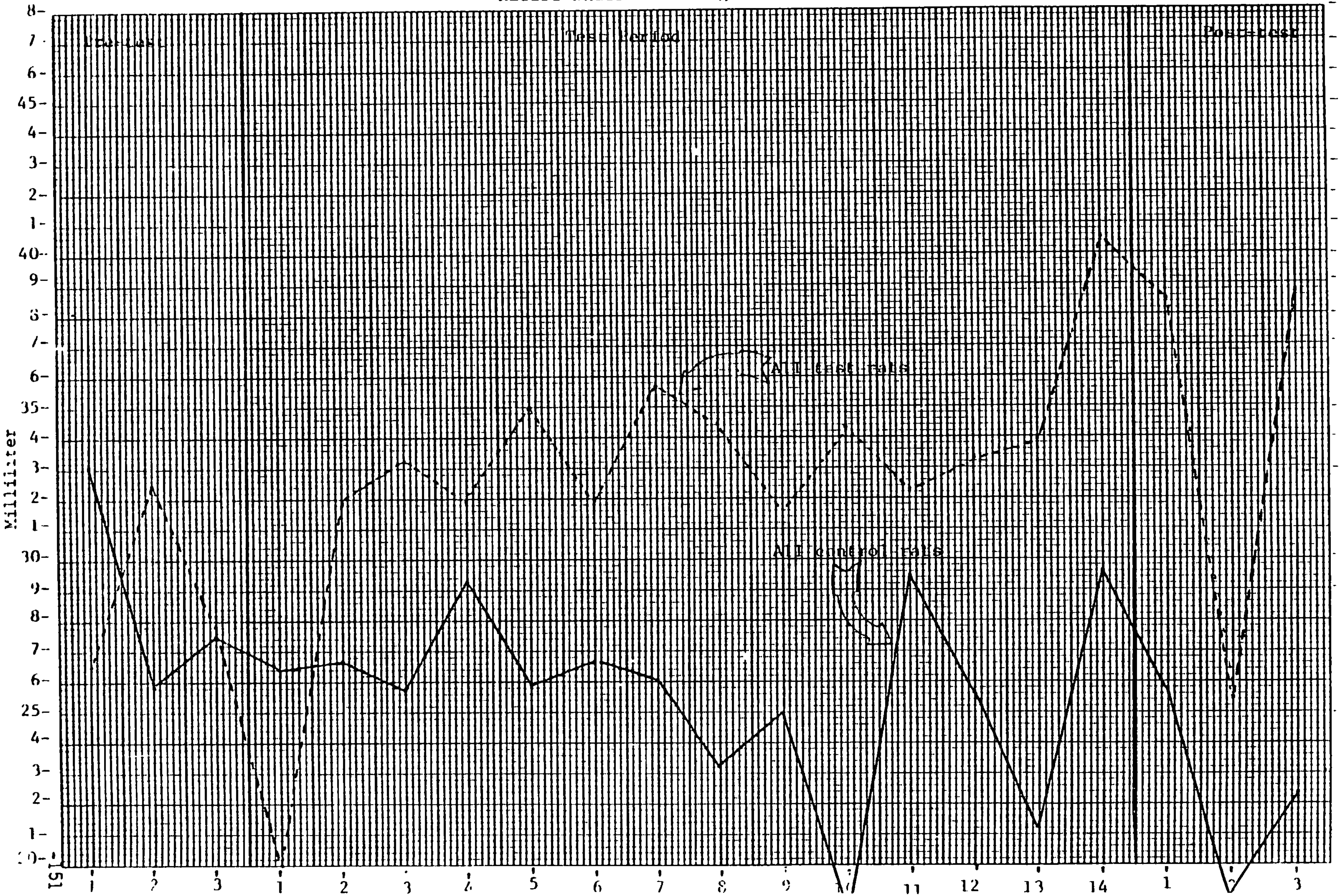
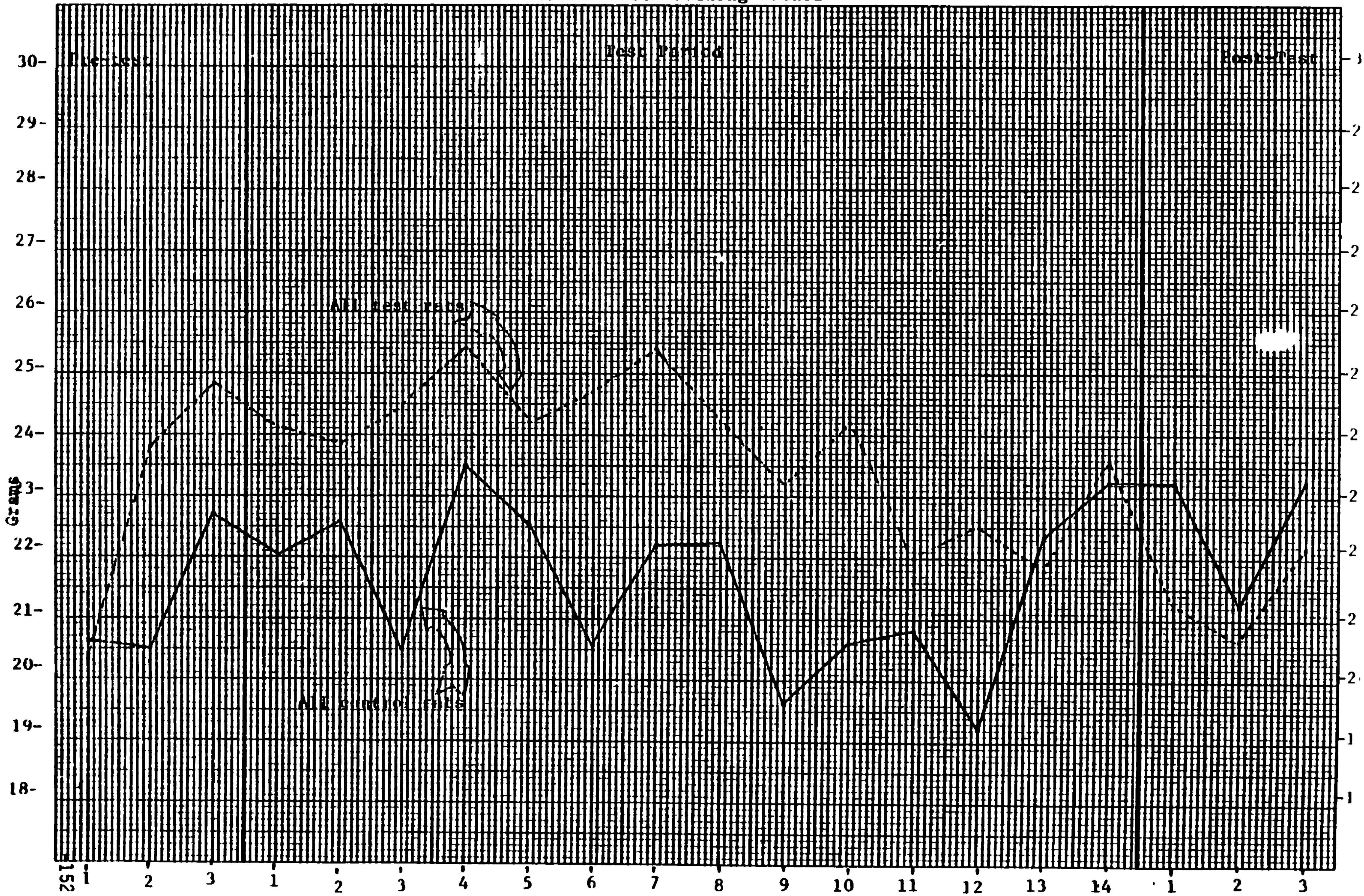


Figure 1

Nature Shield Feeding Trials



PERFORMANCE OF ELECTROMAGNETIC DEVICES AGAINST TERMITES, COCKROACHES AND FLOUR BEETLES[a/]

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INTRODUCTION

Representative electromagnetic devices were included in a series of laboratory and field control experiments to determine the utility of the devices against structural and household insect pests. These devices reportedly generate electromagnetic waves or radiations that interact with geomagnetic fields surrounding insects. Interference patterns from the devices purportedly affect the pest to such a degree as to grossly alter normal feeding, mating, or development. Although lone exposure to exceptionally high levels of electromagnetism near 240,000 times that of the geomagnetic field has been reported to cause some observable stress in insects, no significant effects have been recorded with lower levels (Kaufman and Michaelson 1974). The purpose of these tests was to determine differences in behavior, mating, feeding or survival of important representative household insects atributable to the output of electromagnetic devices. Laboratory studies simulating field conditions were done with each kind of insect to minimize variables often encountered under natural conditions. Measurements of various parameters for drywood termites, cockroaches, and flour beetles were taken after relatively short, as well as prolonged exposure to the devices. The same kinds of insects unexposed to the devices were also studied. Additionally, a field control study with the devices was done in apartments infested with German cockroaches. The following report is divided into sections according to the kind of insect exposed to the various devices tested. Most laboratory tests were begun in September 1978 and were terminated at different times, depending on the length of exposure desired. Some tests continued for 6 months. Field control trials against cockroaches in apartments were started in August and November 1978 and were continued for up to 12 weeks, except in instances where tests had to be discontinued because of complaints from tenants and the management of poor performance and alarmingly large numbers of cockroaches in some apartments.

METHODS

Devices and their installation for tests.--All laboratory tests were done on the campus of the University of California, Riverside. Field tests were done at an apartment house complex in Gardena, California. The devices were supplied by the Environmental Protection Agency and were kept under our control and security at all times. Particulars concerning the six devices tested are shown in Table 1.

An attempt was made to evaluate the devices under conditions as similar as possible to one another. Since it was desirable to conduct the tests simultaneously, the test sites had to be situated in different buildings. The closest direct, straight-line distance between units was about 200 feet, but the Nature Shield was more than 275 feet from any of the other devices. Each area where a device was tested was outside the purported range of the next closest unit being tested.

The Magna-Pulse device was installed on the bottom shelf of a 33-cubic-foot metal environmental chamber. The temperature outside the chamber was kept at about 74°F and the internal temperature was 82°F (27.7°C). The relative humidity in the chamber was not controlled and usually ranged between 50 and 60%, as measured and recorded on a calibrated Bristol rotary hygrothermograph. The only light impinging on experiments in the chamber was from fluorescent fixtures when the door of the chamber was opened.

The Nature Shield device was oriented to magnetic north with the aid of a precision, liquid-filled aircraft compass. The device was set in position on a concrete floor of a 6X9-foot room across a hallway from a 12X15X7.5-foot room in which the actual testing was done. The Nature Shield was situated about 27 feet from the experiments, but information from the maufacturer claims effects up to about 263 feet. The inside walls of the test room were stucco and the experiments exposed to the output of the device were kept on wooden shelves. The thermostatically regulated temperature in the test room was maintained at an average of about 82°F and the relative humidity usually fluctuated between 50 and 60%. The temperature was kept between 80.6 and 84.2°F by an air conditioning system that attained the minimum temperature approximately every 45 minutes. Overhead incandescent lights were left on for about 7 hours each working day in the chamber where the Nature Shield was tested.

A walk-in chamber room measuring 7.25X9.25X7.25 feet was used as the test room for the Sigma electromagnetic device. This room was lined with painted galvanized metal and is ordinarily used as a stored-product insect fumigation chamber. The regulated temperature in the room was maintained between 73.4 and 80.6°F on a 24 hour cycle, but temperature the majority of the time was near 80°F. Relative humidity in the room ranged from about 45 to 60%. Fluorescent lights in the test room were programmed with a timing device for 12 hours light: 12 hours dark.

A room in a building about 300 feet from the nearest electromagnetic device was used to house another metal, 33 ft^3 environmental chamber in which experiments left unexposed to the devices were kept. Air conditioning external to the chamber kept temperatures low so that thermostated internal heating could maintain a nearly constant 80°F. Relative humidity inside the chamber measured between 50 and 60%. The chamber was kept dark except for brief periods almost daily when the door of the chamber was opened for inspection or counting of the experiments.

Besides considerations of distance effects, conditions at each location where an electromagnetic device was tested were carefully monitored and stabilized for more than a month. An attempt was made to establish similar environmental conditions among the test locations. Minor variations in average temperature, temperature pattern, and humidity over long periods of time could contribute to variations in biological test data, but patterns of biological activity remain constant. Gross effects or differences in activity attributable to the devices should be evident and statistically separable, especially if environmental conditions during testing are similar. Conditions during these tests were maintained with much less variation than would be expected under actual field conditions. Standard statistical tests were performed in all cases where comparisons were appropriate. In most instances significance was measured to the 5% level of probability. Observations and records were kept in order to facilitate interpretation of data and to compliment statistical conclusions.

TERMITES

Termites constitute one of the most important groups of structural insect pests. Subterranean or drywood termites may be found throughout most of the world and represent substantial pests of field crops, trees and pastures as well as buildings. Although termites readily attack buildings, stored foods and household commodities, items left in storage may also be disfigured or destroyed by termites. Snyder (1948) documented 120 items composed of foods, wood, fabrics, leather, wool, or insulation materials that were attacked by termites. Besides a great deal of the customary kinds of damage attributable to termites, we have observed damage to library books, computer cards, and stored clothing. Not considering increased costs or inflation, Snyder (1961) estimated the damage to buildings in the U. S. nearly 20 years ago was about $250 million and Ebeling (1968) believed that termites cost U. S. taxpayers about half a billion dollars a year ten years ago. In California alone, the cost of termite inspections and structural repair in 1978 was in excess of $200 million (Wilcox 1979).

The kinds of control measures used for most similar groups of termites are extremely uniform throughout the world. Where possible, good construction practices are recommended to provide barriers between structures and termites. Termiticidal chemical sprays or dusts are sometimes used to prevent or control soil-nesting infestations. Fumigants such as methyl bromide or sulfuryl fluoride are often utilized to eliminate existing infestations of termites that do not usually require constant contact with soil. Most termite infestations are spotty and localized and are relatively difficult to detect before damage occurs. The tendency of the two common subterranean species (*Reticulitermes flavipes* [Kollar] in the east and *R. hesperus* [Banks] in the western U. S.) to colonize under buildings makes them particularly difficult to detect before damage occurs. Drywood termites, especially *Incisitermes* and *Cryptotermes*, are also often difficult to detect because they may initiate colonies in apparently sound, undecayed wood that contains little moisture. Colonies developing in hidden or covered ceiling or floor joists may go unnoticed for several years and, besides removing infested wood, fumigation is about the only satisfactory method of controlling drywood termites.

Colonies of drywood termites normally have very little direct contact with the exterior surfaces of wood they are attacking. Although male and female reproductive pairs of termites may walk around on the surface of wood they eventually tunnel into, their offspring remain encased in wood in which cavities are excavated. Small outlet holes about 0.059 to 0.079 inches across (1.5 to 2mm) bored by the termites are somethimes used to clear the cavities of accumulating fecal pellets.

Piles of the dry pellets are often the only external sign that wood was been infested by drywood termites. External holes are not always present, however, and pellets may be shifted to totally enclosed internal galleries. Small exit holes are also used when adult termites swarm from a maturing colony.

A series of tests were undertaken to determine the possible effects of representative electromagnetic devices on termites. Since the zone of influence and effect of each of the units we wanted to examine reportedly ranged from several feet up to nearly 263 feet, we believed optimal biological activity attributable to the devices should be discernible with constant exposures within 5 to .25 feet of the units. We used only healthy drywood termites, _Incisitermes minor_ (Hagen) for the tests. The termites were collected from walnut or sycamore logs that had evidence of termite activity. The logs were gathered in the southern California area. Each infested log was kept for up to several months before the termites were removed for these tests. The termites were carefully removed from the infested log and were housed 7 to 14 days before the tests on stacks of paper toweling (Crown Contract) in covered 9-cm diameter glass petri dishes or closed plastic food dishes.

Tests exposing termites to the devices were performed concurrently with control groups kept outside the reported range of the devices. In one kind of test termites were allowed to feed upon small blocks (2X2X1-cm) of Douglas-fir construction grade lumber. In the other test, termites were allowed to feed inside larger laminated blocks (10X3.9X3.9-cm). The amount of wood consumed, the mortality within the group of termites, and changes in termite weight were exposed. Measurements with the small blocks were taken weekly for up to 8 weeks. Measurements with the larger blocks were taken at 1, 3 and 6 months to determine possible acute or chronic (i.e., long-term) effects that the devices might have on termites exposed to their outputs.

Termites exposed to electromagnetic devices while allowed to feed on small wooden blocks.--Blocks of Douglas-fir were cut on a band saw from lumber purchased at a local building supply center. A template was used to facilitate obtaining blocks of very nearly the same size. Each block measured about 2X2X1-cm. The blocks were weighed to the nearest 0.1 milligram before they were allowed to be fed upon and were reweighed periodically for up to 8 weeks. Ten middle-instar nymphal drywood termites that also were preweighed were placed on individual blocks in lightweight aluminum weighing pans (Fig. 1).

During exposure to the devices, all the replicates were kept inside large glass desiccation chambers in which the relative humidity was maintained at about 52% with a saturated solution of sodium dichromate. The humidity kept the insects from dehydrating rapidly at RH levels frequently encountered in the natural environment. Ten replicates, each containing ten termites, were used for exposure to each device. In order to leave some of the termites undisturbed for as long as possible, 5 replicates were examined at week 1, 2 and 3 (5 were left undisturbed),

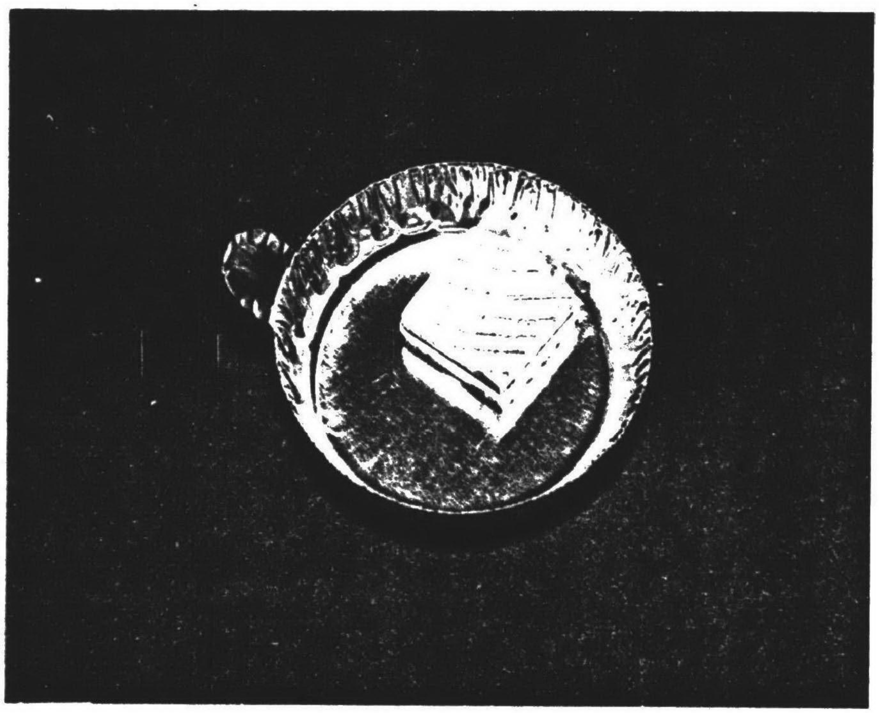

Fig. 1 - Douglas-fir block (2X2X1-cm) on which drywood termites were allowed to feed while exposed to electromagnetic devices. This block has been split for examination and is held together in reassembled position with a rubber band. Block is in aluminum weighing pan.

8 replicates were examined at week 4, and all replicates were examined weekly from week 5 through week 8.

Records were kept of the number of dead termites on each block, the weight of the live termites on each block, and the reduction in the weight of each block. A camel-hair brush was used to brush off termites, frass and fecal pellets from each block before the block was weighed. In some cases where termites tunneled into the blocks, a wood chisel was used to gently split the block so termites and frass could be removed. After measurements were taken, the blocks were put back together in a configuration close to original (i.e., with split surfaces put back together) and were held in place with a small rubber band. Termites removed from the blocks were replaced on the same blocks from which they had been removed. It was assumed that the differences in the weight of each block would be due primarily to the feeding of termites. It was also assumed that significant differences between the number of termites dying on blocks exposed to electromagnetic devices and termites dying on unexposed blocks would be due to the devices themselves. It was theorized at the start of the test that it is possible that there would be no detectable differneces in the mortality produced among groups of exposed or unexposed termites, but that surviving termites would weigh much more or less than their counterparts. Calculations were therefore made of the average change in the total live biomass (i.e., total weight) of termites in each group to determine any overt effect of the devices on the groups of termites.

Termites inside laminated wood blocks while exposed to electromagnetic devices.--Termites in the small block test were kept exposed on the surface of the blocks or could construct only rudimentary tunnels because of the small size of the blocks. A test was therefore designed to complement the small block test described previously. Termites were placed in special laminated blocks so they were entirely enclosed by wood while being exposed to the various electromagnetic devices being evaluated. This condition more closely simulated actual conditions where the termite would be found. Blocks for this test were cut from clean Douglas-fir nominal 2X2-in. construction grade lumber purchased from a building supply company in Riverside, CA. Sections of wood about 4 inches long were cut longitudinally on a band saw so that 7 layers, each about 3/16-inch thick, provided multilayered blocks about 1-5/8 inches square (Fig. 2). The layers (i.e., laminas) were fitted together with cut surfaces facing one another so that the general pattern of growth rings remained similar to the pattern of the uncut wood. The blocks were held together by two 3/16-inch diam. countersunk metal machine bolts inserted through holes drilled throughout the blocks. The holes were perpendicular to the wide surface of each lamina. The bolts were centered about 9/16-inch from the ends of each block and were held in place by hexagonal nuts tightened onto flat washers. A 3/8-in. diam. chamber about 1 in. long to house termites was drilled into each block. The chamber was drilled equidistant and perpendicular to each bolt and was centered on the middle lamina section. The outer portion of the

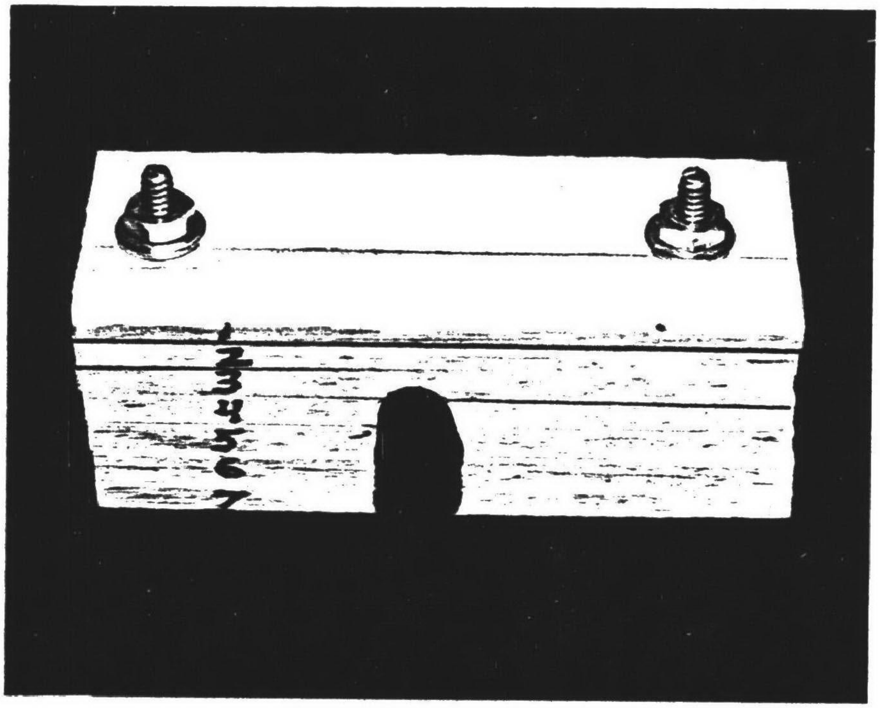

Fig. 2 - Laminated Douglas-fir block used to house drywood termites while being exposed to electromagnetic devices. Block is about 4 inches long and about 1-5/8 in. square. Machine bolts were used to hold laminas together.

chamber was sealed with a no. 000 rubber stopper trimmed to just fit into the hole. The design of the block allowed examination of the interior portions of the wood after termites had been allowed to feed on it. Figure 3 shows the components of one of the laminated blocks (except for the rubber stopper) to show position of bolt holes and termite chamber.

Twenty preweighed nymphal _I. minor_ from the same wood sources as were used in the small block test were placed in the central chamber of each laminated block. Five replicates were used for exposure for 4, 12, and 24 weeks to each device we evaluated. Five replicates were also left unexposed, receiving only the usual amount of background magnetism. Therefore, there were 5 different blocks and groups of termites evaluated at each of the three specific time periods.

Parameters measured at 4, 12, and 24 weeks included a) the number of dead termites, b) the average weight of the termites that were still alive in each group of blocks, c) the change in the overall biomass of the termites in each group, and d) the amount of feeding on the wood in which the termites were housed. It was assumed that significant differences in mortality, weight, or feeding of exposed or unexposed termites over a period of up to 6 months may be attributable to the devices. Data were transformed and analyzed with an analysis of variance.

The average biomass was determined gravimetrically on a Mettler balance. The change in biomass at each test interval was determined from differences in the weight of the groups of termites compared to their initial weight. Consumption was measured volumetrically by filling all feeding scars, pits, and tunnels found in each lamina with modeling clay. Excess clay was scraped away and the weight of clay used to fill the cavities was determined. Based on the density of the clay (1.695g/ml), the volume of wood consumed was calculated.

Results

Termites on small blocks.--There was no measureable effect on the pattern of mortality, the amount of feeding, or on the rate of change in biomass of the termites over the 8-week period of the test during which the insects were exposed to the various electromagnetic devices. At 4 weeks there was 11% mortality among unexposed termites and ca. 15% mortality among exposed insects (Table 2). There was nearly equal overlap in the number of termites dying in each group of replicates. For instance, among replicates of unexposed termites at 4 weeks, there was 30% mortality in 1 replicate, 20% in 2, 10% in 2, and no mortality in 3. Among replicates exposed to the Nature Shield device for the same length of time, there was also 30% mortality in 1 replicate and 20% in 3, 10% in 3 and none in 1 replicate. The total difference in mortality at 4 weeks, therefore, between unexposed termites and ones exposed to the Nature Shield device was 3 termites. Similarly, the difference between unexposed termites and ones exposed to the Magna-Pulse or Sigma device was only 2 termites and 4 termites, respectively.

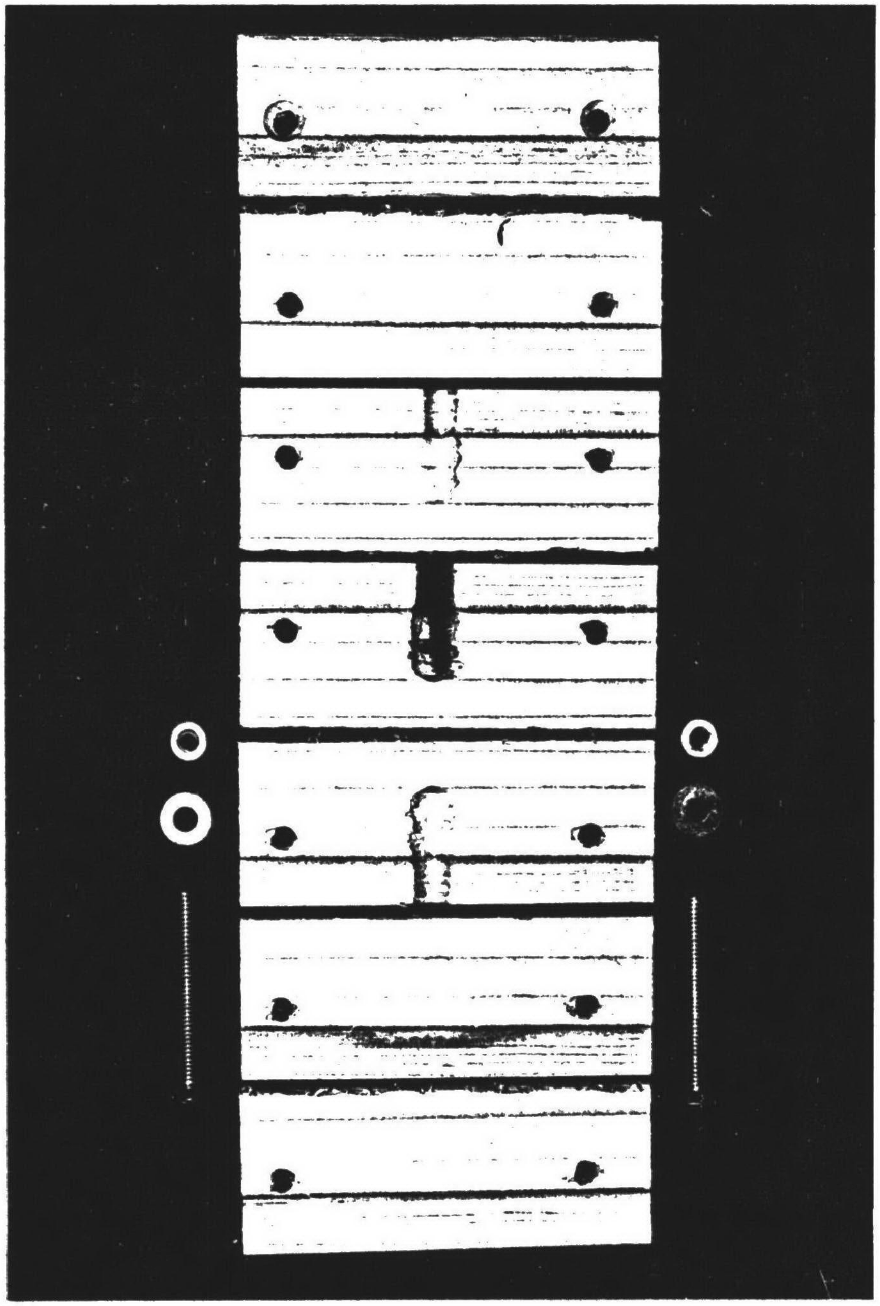

Fig. 3 - Components of Douglas-fir laminated block used to house drywood termites while being exposed to electromagnetic devices.

The range of total initial biomass of the termites used in each series of exposure tests was 1253.3 to 1350.5 milligrams for 100 termites. Slight differences among the weights of groups of termites from the same colony is normal and is due to various factors such as age and size, fat content, and amount of recent feeding. Attempts were made at the time the insects were selected for testing to use about equal numbers of similar sized nymphal insects for each replicate series. Additional variation was avoided by not utilizing mature insects (i.e., ones with wings or wing pads) or soldiers.

No statistical differences of biomass reduction were found between exposed and unexposed termites. The percent reduction (R) in termite biomass was calculated as follows:

$$R = \frac{Wt_i - Wt_w}{Wt_i} \times 100$$

where Wt_i = the initial average biomass (mg) and Wt_w = the average measured biomass (mg) at the week being considered.

The average % change in biomass among the termites is shown in Table 3. It can be seen in the table that, at any given week, the cumulative reductions of biomass were exceedingly similar. No significant differences in the pattern of loss or in the actual biomass lost could be determined statistically with an analysis of variance. Based on these calculations, termites exposed to the devices 4 weeks had reductions that ranged from only 3.6% more than unexposed termites (Nature Shield) to 0.7% less loss (Magna-Pulse). At 8 weeks the range was from 5% greater loss to 2.1% less.

The amount of wood consumed during the test was also measured. The average initial weight of each small wood block on which the termites were allowed to feed ranged from 2104.60 to 2173.9 mg. An average of only 6.4 to 8.0% of each block was eaten within 8 weeks and similar amounts of feeding were observed among exposed and unexposed replicates.

Table 4 summarizes the total amount of wood consumed at various periods of time during the test. The only statistically significant difference in consumption occurred at week 2 where there was actually more wood eaten from blocks while exposed to the Nature Shield device than to the others. There were no significant differences at any other point in the test.

<u>Termites in laminated blocks</u>.--Blocks constructed for this test were <u>assigned randomly to the various</u> exposure treatments to circumvent differences in effects that might result form variations in the composition of the wood from which the blocks were cut. The initial weights of termites used in these tests were within 5.7% of one another, the average weight per termite being 0.203 mg. This similarity in weight between

groups was generally maintained during measurements of exposed or unexposed termites at 4, 12, and 24 weeks (Table 6).

The average number of laminas fed upon and volume of wood consumed by the termites at 1, 3, and 6 months are shown in Table 6. In blocks either exposed or unexposed to the electromagnetic devices, the termites tunneled into about 5 to 6 of the laminas within one month and into almost all the laminas by 6 months. They consumed an average of 0.64 to 0.96 ml of wood during the first month and 1.44 to 1.92 ml by six months. There was no significant difference between the amount of wood consumed from any of the blocks at any given period of examination.

The numbers of termites dying in the blocks at specific times were also similar. Unexposed termites lost an additional 31% of their original biomass between 4 and 24 weeks, so that the final weight of the unexposed termites was 72.8% less than the original group. The exposed groups lost an additional 32.1-38.9% biomass between 4 and 24 weeks and ended with biomass reductions between 69.5 and 75.9%. No statistically significant differences could be determined between the rates of mortality or the changes in the weights of the groups of termites during exposure to the electromagnetic devices.

COCKROACHES

Cockroaches are industrial and household pests associated with man in nearly every part of the world. They tend to prefer warm and relatively humid places and they can survive and multiply under the fairly uniform environmental conditions found inside many homes, apartments, warehouses, etc. There are only about 7 major pestiferous species of domiciliary cockroaches, the German cockroach, *Blattella germanica*, (L.), being the most widespread and troublesome. This cockroach is extremely common in kitchens and is often associated with materials used for food preparation. It is also found in bathrooms and places that are often dirty or contaminated. The German cockroach has been directly and indirectly implicated as an allergen and as transmitting several kinds of disease (Ebeling 1975) and has been listed by the pest control industry as being the household insect most often encountered and most difficult to control (NPCA 1966).

Claims by some manufacturers of electromagnetic devices indicate that disruption of the magnetic field near or surrounding cockroaches will cause disorientations that will result in gross changes of their reproduction, feeding and harborage selection. Since there are no known chemicals or devices that are presently available to consistently cause the changes claimed for electromagnetic devices, we devised laboratory and field experiments to monitor the performance of some devices against German cockroaches.

Tests in the Laboratory

Repellency and alteration of movements in choice boxes.--German cockroaches tend to avoid light and to congregate in darkened protected places. A series of new wooden choice boxes (1 ft^2), similar to those used by Ebeling, Wagner and Reierson (1966) and Reierson and Rust (1977a), was used to monitor behavioral changes during exposure of cockroaches to output from the test devices (Fig. 4). The boxes consist of 2 compartments separated by a vertical panel and joined by a central 1/2-inch hole. Each compartment was covered with transparent sheet plastic and one compartment was also covered with an opaque panel to keep it dark. Cockroaches in the undarkened side of untreated choice boxes usually move to the dark compartment within 48 hours. By using various insecticides or treatments in the dark side, we could ascertain the amount of increased or decreased movement cockroaches would exhibit when exposed to the output from electromagnetic devices. Additive effects of cockroach control substances in conjunction with the devices could also be determined with choice boxes.

A relative performance of each treatment was determined by the Performance Index (PI) that takes into account the number dead and alive and their position in the boxes. The PI for cockroaches in the choice boxes on any given day was calculated from the following formula:

$$PI = 1 - \left[\frac{\text{no. alive + no. alive in light side}}{\text{no. dead + initial number}} \right] \times 100$$

Electromagnetic devices having any effect on the cockroaches should influence their behavior so that the insects either succumb more quickly or survive longer when allowed access to representative repellent and nonrepellent toxicants. A lack of difference among cockroaches in treated choice boxes exposed to electromagnetic devices, compared to ones in unexposed boxes, would indicate a lack of additive effect of magnetism and toxicant.

Adult male German cockroaches selected from 30-gallon containers housing several thousand individuals were used for each test. These cockroaches have no detectable degree of insecticidal resistance and offspring of this strain (UCR) have been used for several years for various evaluations of insecticidal efficacy and repellency. Twenty cockroaches (n=3) were used for each choice box evaluation test.

Representative repellent or non-repellent insecticidal powder (10 cc) was spread evenly over the floor of the dark compartment and coackroaches were released in the untreated compartment. They were allowed access to the treated side 2 hours later. Finely divided silica aerogel (Dri-Die 67) was used as a repellent material and technical boric acid powder was used as the nonrepellent insecticide. The number of live and dead cockroaches in each side of each box was recorded daily for up to 21 days so that the PI could be calculated.

Alteration of avoidance behavior in choice arenas.--Transparent lucite olfactometers called chemometers (Rust & Reierson, 1977a, b) were used to study the short-term effects of the electromagnetic devices on cockroach

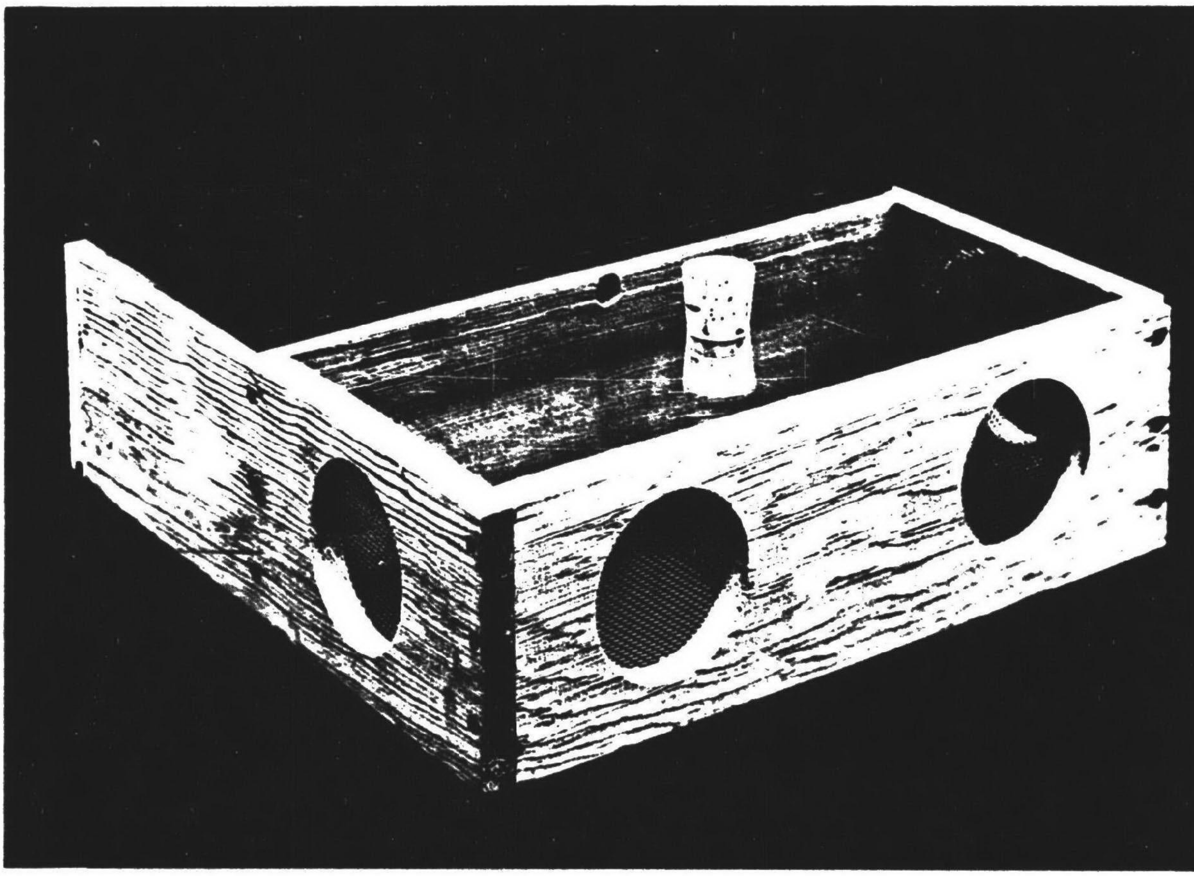

Fig. 4 - Wooden choice box used to monitor behavioral changes during exposure of cockroaches to output from test devices.

avoidance behavior. The chemometers consist of 12 covered chambers about 1 X 2 1/2 inches evenly spaced around a central staging arena in which cockroaches are initially released (Fig. 5). The arena and chambers are connected by clear plastic tubes. Depending on toxicity and repellency, various insecticidal materials placed in only 3 of the outer chambers usually result in varying degrees of mortality in the unit and within an additional 6 days in clean holding jars. Using known repellent and nonrepellent chemicals, the activity of electromagnetic devices was studied by observing differences in the effects on cockroaches in chemometers tested near the electromagnetic devices compared to effects in chemometers tested in unexposed locations. Changes in the apparent insecticide detection capability of cockroaches was determined by using materials or dosages of repellent material which would normally be avoided and dosages of nonrepellent material that are usually effective.

As in the choice box test described previously, Dri-Die 67 and boric acid powder were used as representative repellent and nonrepellent insecticides, respectively. Three randomly selected peripheral chambers of a chemometer were treated with 0.1 cc of a given powder and cockroaches were allowed to encounter or avoid the deposits. Twenty-five adult male cockroaches were allowed to make their choice during the night (dark phase) and the number dead the following morning was recorded. All the live cockroaches were transferred to holding jars that were subsequently kept in an unexposed location and the number dead 6 days later (i.e., latent mortality) was also recorded. Each test was replicated 3 times. The significance of the various treatments was determined to the 5% level with an analysis of variance.

Effects on reproduction, fecundity and life span.--Some manufacturers of electromagnetic devices claim that their devices produce relatively long-term effects on insect populations. For these tests, replicated series (n=3) of ten opposite sex pairs of German cockroaches and groups of 20 nymphal cockroaches in another test were maintained in containers exposed and unexposed to electromagnetic radiation from the test devices. The insects were allowed to develop with adequate shelter, food and water. Counts of the number of their progeny in each container were made at 4, 12 and 24 weeks to determine effects on maturation, mating, hatching and emergence, oogenesis, or life-span and on the eventual resultant number of cockroaches among exposed or unexposed cockroaches.

In a related test, the number of nymphal American cockroaches, Periplaneta americana (L.), emerging from groups of 10 egg capsules exposed to the electromagnetic devices was determined. Unemerged young in capsules from the German cockroach will usually succumb if separated from the female, but those of the American cockroach are usually deposited for prolonged incubation. To eliminate influence of the female on the capsule and its embryos and to study effects of electromagnetic radiations on cockroach embryonic development, individual egg capsules from American cockroaches were placed in corked glass shell vials near the devices. Observations of hatch were made daily to determine if the devices inhibited, enhanced or had any detectable effect on the hatch or emergence of cockroaches from the egg capsules. The number of capsules that hatched and the average

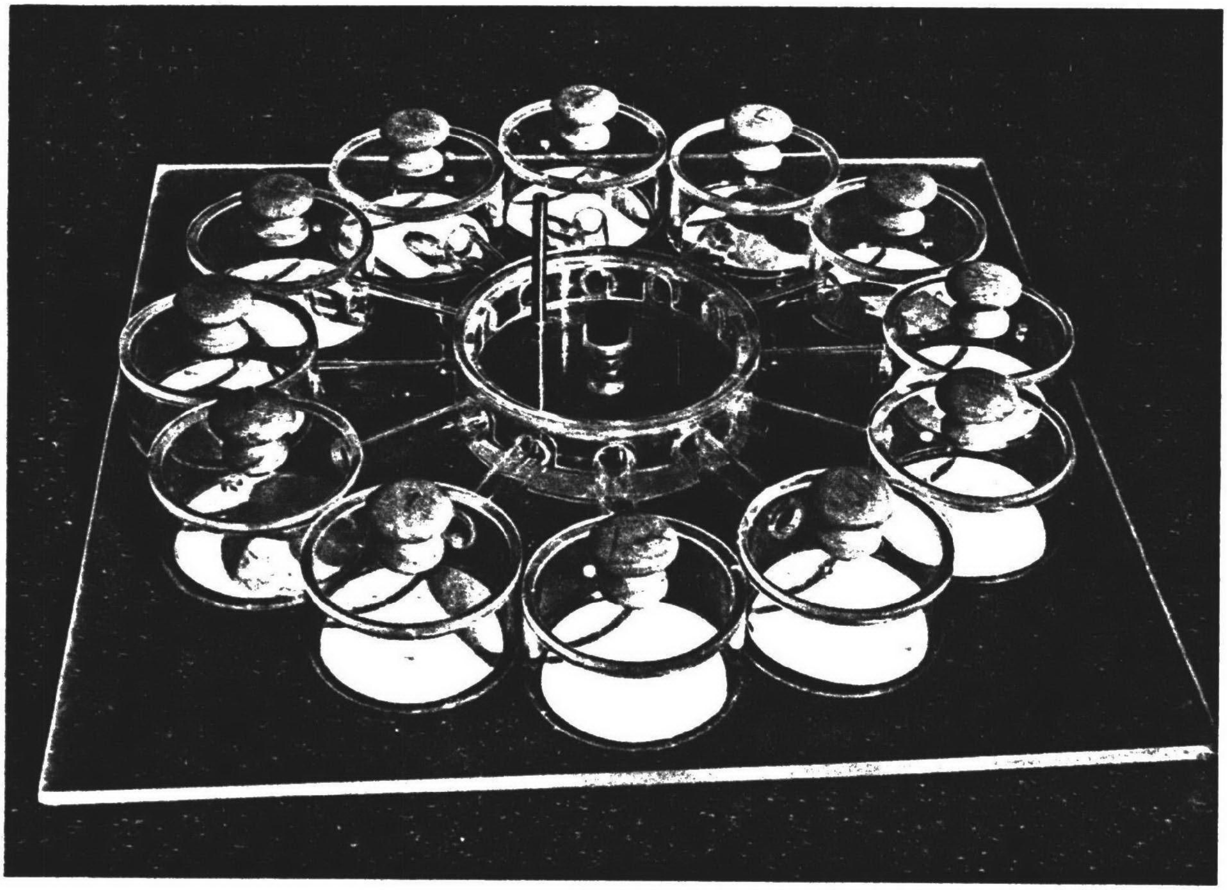

Fig. 5 - Top view of chemometer showing central staging arena and peripheral chambers in which toxicants had been applied (Rust and Reierson 1977a).

number of nymphs that emerged from each hatched capsule was determined over a period of about three months.

Tests Under Actual Field Conditions

Tests in apartments.--Efficacy trials in apartments consisted of cockroach population counts in conjunction with the installation of electromagnetic units in apartment buildings known to be infested with German cockroaches. The tests were conducted in 2-story buildings that contain 7 to 10 individual apartments, each about 800 ft^2. The complex of apartments is located in Gardena, California (about 20 miles west of Los Angeles Civic Center).

Devices evaluated in the field experiment were installed as close as possible to the recommendations made by each manufacturer and the devices were left operating continuously throughout the test period. A small red lamp on each device indicated the unit was operational. The Magna-Pulse unit was placed on the bottom wooden shelf of the cabinet just to the right of the kitchen sink in one apartment. The Nature Shield unit was positioned on the floor of an attached garage of an apartment and it was oriented to magnetic north with an aircraft compass. The Sigma device was set on the floor behind the stove in an infested apartment and a wattmeter was used with it to measure the power being consumed by the device (Fig. 6A). The position of the stove relative to the kitchen countertop is shown in Fig. 6B and a wattmeter used to measure power consumption of the Sigma device is shown in Fig. 7.

Cockroach population counts before and after installation of electromagnetic devices were made with two 1-qt. wide-mouth glass jar traps placed in specific sites in the kitchen of each apartment of a treated building as well as in apartments of an adjacent building. The traps were baited with a piece of fresh white bread. Cockroaches attracted to the bread are caught in a layer of dry clay in each trap and are counted after the traps are left in place in kitchen cabinets 7 days. Fresh traps were positioned in the same places for each period of evaluation. Trapping was done 4, 8, and 12 weeks after the devices were installed. Counts were also made of trap catches in apartments treated with 0.5 Dursban 2E (chlorpyrifos) insecticide or boric acid technical powder. We have used trapping to monitor effectiveness for several years and it provides the least disruptive method currently known for evaluating populations indoors (Reierson & Rust, 1977b).

The statistical significance of changes in the number of cockroaches caught per apartment was determined by Wilcoxon's signed-ranks test. This type of analysis allows for variations of levels of infestation among apartments and is capable of detecting consistent effects.

Results

Repellency, alteration of movement, and alteration of avoidance behavior.--No measurable difference in the pattern of avoidance activity

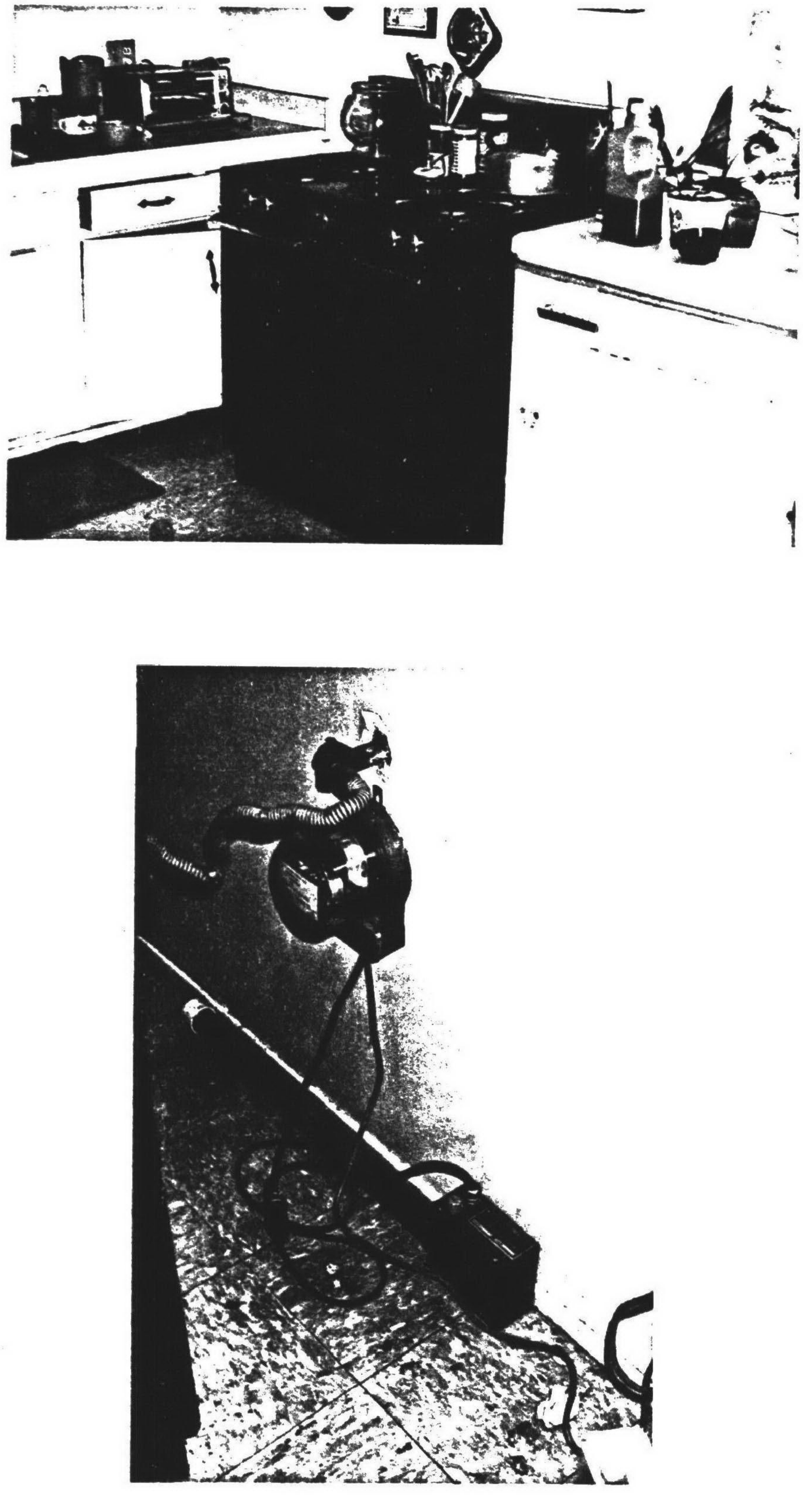

Fig. 6 - Installation of Sigma electromagnetic pest control device in an apartment kitchen. A, gas stove behind which device was placed; B, device and wattmeter in position with stove moved away from wall for photograph.

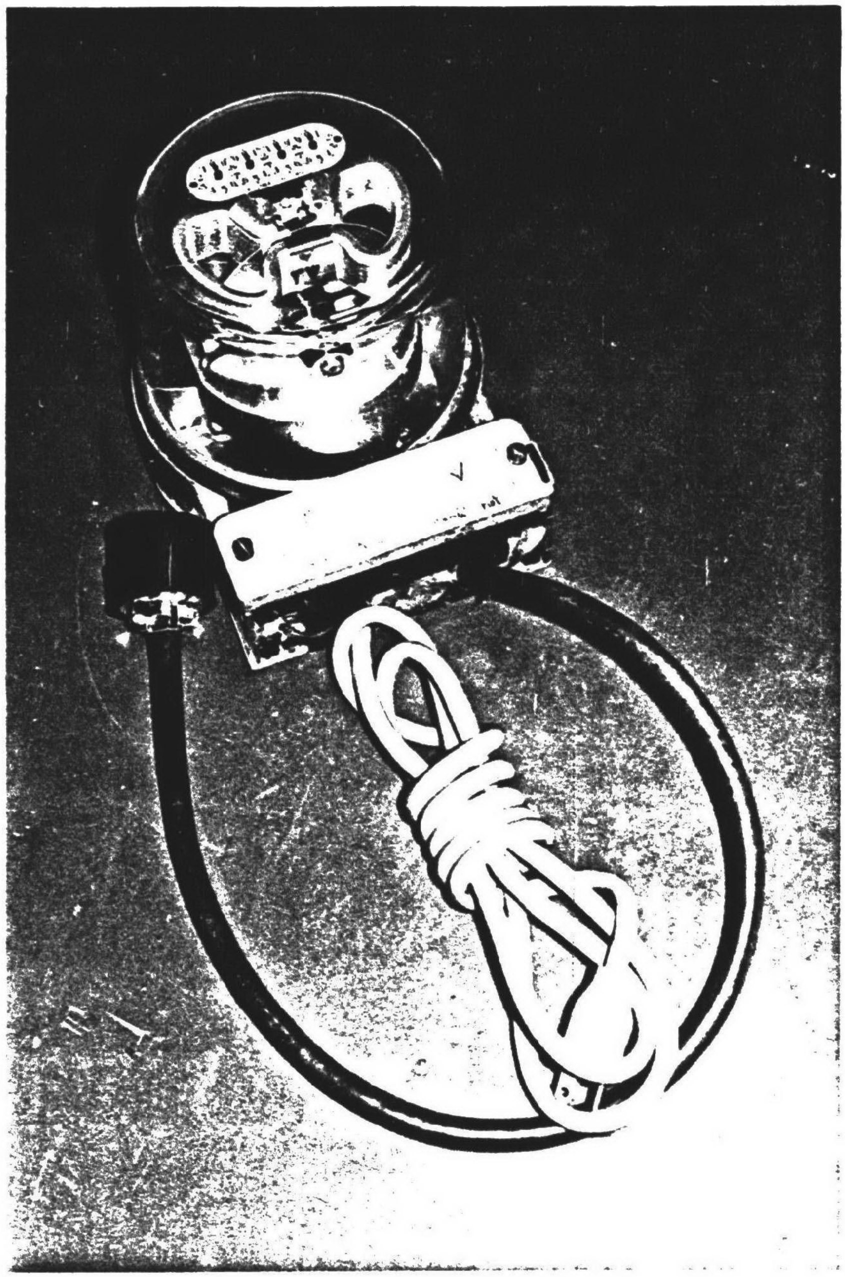

Fig. 7 - Wattmeter used to measure power consumption of Sigma electro-
magnetic device.

of cockroaches was produced when the insects were exposed to any of the devices. Cockroaches avoided repellent insecticides and did not avoid nonrepellent ones, independent of the presence of an electromagnetic device.

In choice box tests, a performance index (PI) of +100 is produced by a very effective treatment, while -100 is produced by ones less effective. Table 8 shows that regardless of the toxicant used, the electromagnetic devices produced no signficant differences among the various treatments. The repellent powder was consistently ineffectual. This suggested that the devices did not increase movement to such an extent that the cockroaches would scurry into deposits of repellent powder. Similarly, very good effects were obtained with the nonrepellent powder. Tests with untreated boxes showed nearly neutral effects with or without devices being present. These choice tests indicated, therefore, that the electromagnetic device did not overtly alter cockroach behavior or have any measurable additive effect on repellent or nonrepellent chemicals used to control cockroaches.

Choice tests with chemometers provided the same kind of information as obtained with choice boxes. Table 8 shows the acute (18-hour) and latent (7-day) effects on cockroaches produced by each kind of powder when tested three times during exposure to the electromagnetic devices. Although there was some variation among replicates of the same treatment, distinct patterns of performance were evident. Dri-Die was not effective under any condition and screened boric acid was always relatively effective. As shown in Table 9, the average % mortality of cockroaches in these tests illustrate patterns of activity in which the nonrepellent powder worked best, with or without an electromagnetic device. The latent mortality produced by boric acid compared to the effects at 18 hours is due to the slow action of the powder. The high mortality 7 days after initial contact with boric acid is common since complete mortality among groups of cockroaches even continuously confined to the powder may not be achieved for 18 or more hours. The devices apparently did not have any measurable effect on cockroach movement or on their ability to discern and avoid insecticidal deposits.

Effects on reproduction and hatch of egg capsules.--In tests started with either adult or nymphal cockroaches, tremendous increases in the total number of live cockroaches at 4, 12 and 24 weeks were observed, independent of exposure to electromagnetic devices. Increases were less pronounced among replicates begun as nymphs because of the time lag factor involved in the maturation of the initial group of nymphs. Table 10 (starting with adults) and Table 11 (starting with nymphs) show that, at any given period of exposure, the increases in numbers of cockroaches per replicate were similar and that the overall population increases were independent of electromagnetic devices. The resultant proportion of nymphs of each population also remained unaffected by the elecromagnetic devices. Generally, each group of cockroaches was between about 80 to 93% nymphal. This coincides with the proportion of nymphs we usually encounter under field conditions or in the laboratory where populations of cockroaches have been allowed to equilibrate. Increases of 148- to 190-fold (2900 to 3800 cockroaches) were obtained in groups of exposed or unexposed cockroaches within 6 months from groups that initially contained only 10 adult females.

Ten fully formed egg capsules from American cockroaches were exposed to each electromagnetic device (or left unexposed) for more than 6 months, but all of the hatching took place within the first 3 months. Unhatched capsules were held an additional 3 months for latent hatch. Four unexposed capsules hatched and 4 to 6 of the exposed capsules hatched. Table 12 shows the number of capsules that hatched and the average number of young produced per capsule were exceedingly similar. These data indicated that expsoure to electromagnetic devices had no effect on the maturation of cockroach embryos nor on the ability of cockroaches to emerge from capsules.

Scrutiny of these data leads us to the conclusion that none of the electromagnetic devices evaluated against cockroaches had any discernible effect on behavior, reproduction, maturation, or emergence of young cockroaches. None of our observations or statistical analyses indicated effects that could be attributable to the devices. Variations that did occur were probably due to minor differences in temperature, humidity, or other environmental factors that could not be maintained identical at all times.

Tests in apartments.--Although no effects were observed with the electromagenetic devices under laboratory conditions, the results did not preclude possible effects under field conditions. Most residual insecticidal sprays are effective for less than 8 weeks, but some powders applied in locations kept dry may remain active for many months. As mentioned previously, comparions in this test series were made between the effectiveness of electromagnetic devices and some conventional sprays and a powder against cockroaches.

Each of the devices used in the laboratory and in the field were operational and in apparent good working condition for the duration of the test. The indicator lamp on each device flashed at the beginning of the test and was flashing when the tests were terminated. The Sigma (AC) device consumed an average of about 66.7 watts per hour (11.2 kilowatt hours per week).

Initial cockroach trap catches in buildings where the Nature Shield, Sigma and Magna-Pulse devices were to be installed were 79, 14, and 48, respectively. In immediately adjacent buildings, counts before installation of the Nature Shield were 107 and for the Sigma they were 317. No adjacent buildings were monitored in the test with the Magna-Pulse. The number of cockroaches trapped before and after installation of the devices are shown in Table 13. No significant effects were produced by any electromagnetic device tested. Good reductions, however, were accomplished with 0.5% Dursban spray and with boric acid dust. Examination of specific apartments showed that reductions occurring in a few instances in buildings near where the devices were installed were due to spot spraying of cockroaches by the tenants or to drastic changes in sanitation. Significant reductions were never observed throughout series of apartments exposed to electromagnetic devices.

Trap counts from individual apartments within the purported range of effectiveness for each of the devices are shown in Table 14. The two apartments closest to the Nature Shield (i.e., apartments 1 and 4) had a combined increase in cockroach trap catch from 50 before installation to 190 at 4 weeks, 130 at 8 weeks, and 97 after 12 weeks of exposure. Very high levels of cockroach infestation were evident within 4 weeks of installation (average = 49.6 cockroaches per apartment) and the average number of cockroaches trapped per apartment increased from about 11 before installation of the Nature Shield to more than 77 (a 600% increase) by week 12. Similar patterns of increase were observed after installation of the Sigma and Magna-Pulse devices. In the buildings left untreated, the average number of cockroaches per apartment at the beginning of the test was 6.4. Within 4 weeks the average number of cockroaches increased to 15.3 and by week 8 and 12 the average numbers were 35.6 and 27.3, respectively. Compared to the initial number, the number of cockroaches trapped in untreated apartments increased 324% by week 12.

Data from the field control trials with the electromagnetic devices indicated that none of the devices contributed to cockroach control. The devices had no apparent effect in the apartments in which they were installed or in adjacent apartments or buildings. Populations of cockroaches where the devices were installed generally doubled or tripled within 4 to 12 weeks and had the same pattern of increase as populations in apartments where no electromagnetic devices were used. Single applications of either of two standard insecticides provided >90% reductions within 4 weeks and 87.4 to 95.6% reductions monitored 3 months after application.

FLOUR BEETLES

Various stored product insect pests represent an extremely important group of damaging insects. These insects invade grains, cereals, and flour while they are being harvested, stored, processed, or shipped. Since some of the pests are capable of going through their entire life cycle in a stored product, very large numbers of all stages of the insect are eventually present in the commodity and render it unsuitable for sale or consumption. Besides rendering the product unsightly, stored product insects may carry diseases and pathogens and may significantly reduce the nutritive value of the food they have infested (Scott 1962-63).

According to Strong (1970), one of the most common beetles associated with processed food is the confused flour beetle, *Tribolium confusum* du Val. We utilized this beetle in a series of tests with the electromagnetic devices to determine if exposure to the devices would have any measurable effect on the eventual number of beetles developing in a standard rearing mixture. Compared to unexposed beetles, reductions in feeding or mating activity or actual lethal effects of beetles exposed to the devices should become evident as a resultant total lower number of live individuals.

Exposure of beetles to electromagnetic devices.--Confused flour beetles from laboratory colonies maintained continuously at UCR for more than 25 years were used in these tests. Pupae removed from rearing media composed of corn meal, refined flour, and yeast were segregated into groups of males and females. Ten days later, 10 male and 10 female adult beetles that had emerged in the segregated containers were placed in 4-oz glass jars with 2 tablespoonsful fresh media and were positioned near each electromagnetic device. The number of live adults, larvae, and pupae that developed in each jar (n=3) was determined 28 and 40 days later by counting the number of beetles in the media that were retained by a 16-mesh sieve screen.

Results.--The number of beetles developing in the media after 28 and 40 days is shown in Table 15. Under optimum conditions female flour beetles lay only about 3 to 5 eggs per day and egg laying is drastically curtailed when the temperature falls below 78 F. Exposure to the devices had no measurable effect on adults, 99.4% of the original number of adults being alive for the duration of the test. The total number of live stages of beetles (i.e. adults, larvae and pupae) in unexposed media increased from 20, at the beginning of the test, to 240 (1100% increase) at 40 days. Corresponding increases among beetles constantly exposed to the Magna-Pulse, Nature Shield, and Sigma devices were 1175%, 1270%, and 1360%, respectively. There was an average of 133 larvae in unexposed media, compared to 109-113 larvae in media exposed to the devices. By 40 days the number of larvae in each replicate nearly doubled from the number present at 28 days. No pupae were formed by day 28 because development from egg to pupa takes 35 to 120 days (Ebeling 1975).

Similar results with flour beetles were obtained in an earlier test in which environmental conditions in each location where the devices were installed were being monitored and stabilized. The test was begun 26 July 1978 with each replicate containing 10 male and 10 female pupae placed on fresh media and left constantly exposed to the devices. At 28 days, there was an average of 16 live adults and 81 larvae in the unexposed groups. With the Magna-Pulse there was an average total of 60 alive (18 adults) and with the Nature Shield there were 106 (18 adults). In the chamber with the Sigma device there was an average of only 28 live stages (18 adults). Close examination of conditions at each test location showed that the chamber where the Sigma unit was being tested was initially being maintained a high proportion of the time below 78 F even though the average temperature (based on maximum and minimum values) was about 80°F. Similarly, the average temperature with the Magna-Pulse was initially only about 78°F.

These tests indicated that the devices had no measurable effect on adult flour beetles and that emergence from pupation and subsequent mating and oviposition would proceed normally while the insects were exposed to electromagnetic devices.

CONCLUSIONS CONCERNING ELECTROMAGNETIC DEVICES

No biological effects under laboratory or field conditions were found with any of the electromagnetic devices tested. Acute and relatively long-term tests were performed and, compared to insects left unexposed, electromagnetic devices had no observable or statistically discernible effect on the following aspects:

1. Drywood termite mortality, weight loss, or consumption of wood.

2. German cockroach behavior, mortality, or sensitivity to insecticides.

3. Development and population size of German cockroaches.

4. American cockroach embryo development and emergence from egg capsules.

5. Cockroach control in apartments infested with German cockroaches.

6. Development and population size of confused flour beetle.

We conclude that these electromagnetic devices (Magna-Pulse, Nature Shield, and Sigma) had no measurable biological effect on any of the insects we tested and we believe they would, therefore, probably also have no effect on other structural and household insect pests.

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Table 1.—Identification of electromagnetic devices used in laboratory and field tests against various household insect pests.

Device[a]	Model	Manufacturer	IPM numbers		Test
			Serial	EPA sample	site
Magna-Pulse	MPC-1000	Bell Products	1698	131919	Lab
			1729	131919	Field
Nature Shield	-	Solara, Inc.	3126	131916-sub 6	Lab
			3215	131918-sub 5	Field
Sigma	RH-27	Orgolini Mfg.	1750	131920-sub 4	Lab
			1749	131920-sub 5	Field

a/ Electromagnetic devices listed by brand name, as supplied by EPA.

Table 2.--Mortality of drywood termites exposed to electromagnetic devices.

Device	Initial no. termites	% mortality at indicated week[a]							
		1	2	3	4	5	6	7	8
Magna-Pulse	100	2	4	10	14	19	25	29	37
Nature Shield	100	2	2	12	15	14	20	21	28
Sigma	100	0	0	12	16	15	18	22	25
None	100	2	6	7	11	13	16	21	29

[a] Ten replicates on 2x2x1-cm Douglas-fir blocks for each device. Each replicate with 10 nymphal Incisitermes minor (Hagen). Examined 5 to 8 replicates at weeks 1-4; all 10 were examined subsequently. Tested at ca. 80° ± 1° F, 52% RH. Test begun 5 September 1978.

Table 3.—Change in the total biomass of drywood termites[a] feeding on Douglas-fir blocks while exposed to electromagnetic devices.

Device[b]	Initial biomass (mg)	Termite biomass reduction (%) by indicated week							
		1	2	3	4	5	6	7	8
Magna-Pulse	1253.3	9.9	23.3	34.0	39.8	45.8	51.8	57.3	63.9
Nature Shield	1299.7	12.4	24.3	36.8	42.7	44.7	50.1	54.3	59.0
Sigma	1446.7	11.3	21.6	35.9	35.2	43.4	48.6	52.7	56.8
None	1350.5	9.3	23.9	31.6	39.1	41.8	47.7	53.5	58.9

[a] Used 10 replicates, each with 10 nymphal *Incisitermes minor* (Hagen), for each electromagnetic device. Each block measured ca. 2x2x1-cm. Test begun 5 September 1978.

[b] Electromagnetic devices, listed by brand name. Tested at ca. 80° ± 1° F, 52% relative humidity.

Table 4.--Total amount of Douglas-fir consumed by drywood termites[a/] exposed to electromagnetic devices.

Device	Amount of wood consumed(g) at week[b/]				
	1	2	4	6	8
Magna-Pulse	0.42	1.01 ab	1.09	1.33	1.45
Nature Shield	0.44	1.21 b	1.11	1.30	1.41
Sigma	0.25	0.85 a	0.96	1.33	1.51
None	0.43	1.08 ab	1.24	1.56	1.69

[a/] Test started 5 September 1978 with 10 nymphal Incisitermes minor in each of 10 replicates with a 2x2x1-cm block with each device. Figures based on average difference of weight lost by indicated week. Tested at ca. 80° ± 1° F, 52% RH.

[b/] HSD Test, 5% level. Values in a column followed by different letters are significantly different; in columns with no letters, differences are not significant.

Table 5.--Effects of electromagnetic devices on wood consumption of 20 nymphal western drywood termites, Incisitermes minor (Hagen), in Douglas-fir laminated blocks[a].

	$\bar{x}$ no. laminas fed upon[b]			Avg. volume wood eaten (µl)[b]		
	4 weeks	12 weeks	24 weeks	4 weeks	12 weeks	24 weeks
Magna-Pulse	4.6	5.2	6.2	706.5	933.9	1915.9
Nature Shield	4.8	6.0	6.4	817.4	937.4	1598.4
Sigma	5.4	5.6	6.6	964.4	910.6	1435.3
None	4.2	5.0	6.2	641.2	989.9	1462.5

[a] Each block ca. 1.5 inches square, about 4 inches long, and with 7 horizontal laminas of nearly equal size that were held together tightly with bolts. Insects, introduced into block in hole 3/8-in. diam. x 1-in. centered in middle lamina, retained by rubber stopper. Test begun 1 September 1978.

[b] Within columns, no significant differences of any values at 5% level (Kruskal-Wallis Test).

Table 6.--Effects of electromagnetic devices on nymphal drywood termites in Douglas-fir laminated blocks[a].

		4 weeks		12 weeks		24 weeks	
Device	Initial biomass (mg)	Biomass decline (%)	% dead	Biomass decline (%)	% dead	Biomass decline (%)	% dead
Magna-Pulse	359.1	35.2	17.0	68.7	48.0	69.5	42.0
Nature Shield	357.4	40.5	21.0	53.8	24.0	72.6	45.0
Sigma	377.7	37.0[b]	23.0	51.9[c]	33.0	75.9[c]	55.0
None	364.0	41.8	21.7	63.2	41.0	72.8	48.0

[a] Each block (n=5) initially with 20 _I. minor_ for each device and age.

[b] n=3.

[c] n=4.

Table 7.--Performance of standard toxicants against German cockroaches, *B. germanica*, in choice boxes while exposed to electromagnetic devices.

Toxicant[a/]	Device	Performance Index (PI) at day[b/] 3	7	14	21
Repellent (SG-67)	Magna-Pulse	-33.3	-33.8	-47.8	1.3
	Nature Shield	-93.4	-58.2	-28.8	15.5
	Sigma	- 0.9	20.8	26.8	35.5
	None	-27.9	-19.2	0.0	9.9
Non-repellent (boric acid)	Magna-Pulse	96.6	100.0		
	Nature Shield	75.0	98.3	100.0	
	Sigma	83.2	100.0		
	None	92.1	100.0		
Untreated	Magna-Pulse	3.2	-15.6	-11.4	0.0
	Nature Shield	-25.0	-25.0	-23.2	22.9
	Sigma	- 1.0	- 9.4	- 8.7	7.5
	None	3.0	-23.9	-20.9	- 3.9

a/ Repellent = 10 cc SG-67 silica aerogel/0.5 ft^2 on floor of dark side of choice box; Non-repellent = 10 cc freshly screened boric acid technical powder on floor of dark side.

b/ PI (maximum = +100, minimum = -100) takes into account both mortality and repellency and is calculated as follows:

$$1 - \left[\frac{\text{No. alive + No. alive in light side}}{\text{No. dead + Initial no. alive}}\right] \times 100$$

Table 8.--Mortality of German cockroaches in individual test chemometers partially treated with representative insecticides while exposed to electromagnetic devices.

Device	% dead after choice exposure to treatment[a/]					
	Repellent (Dri-Die 67)		Nonrepellent (Boric Acid)		Untreated	
	18 hours	7 days	18 hours	7 days	18 hours	7 days
Magna-Pulse	12	50	18	72	0	7
	12	48	0	12[b/]	0	0
	4	4	4	100	0	8
Nature Shield	0	36	0	48[b/]	0	24
	0	20	12	100	0	0
	8	16	0	100	0	4
Sigma	20	56	0	100	0	8
	0	0	0	96	4	8
	0	8	0	96	0	16
None	8	32	0	40[b/]	0	12
	9	13	0	100	0	4
	8	16	0	96	0	24

[a/] Allowed 25♂ B. germanica to encounter or avoid 0.1 cc powder in 3 randomly selected chambers of 12 in a clear plastic choice device. Tested Nov. 13-Dec. 16, 1978. Within columns, no significant differences at 5% level between mortality with no device and with any test device (analysis of variance).

[b/] Powder not screened before the test. In all other instances with boric acid, technical powder was passed through a No. 22 screen just before it was used in choice tests.

Table 9. Mortality of German cockroaches in chemometer choice tests while exposed to electromagnetic devices[a/].

	Average % dead after exposure to treatment[b/]					
	Repellent		Non-repellent		Untreated	
Device	18 hours	7 days	18 hours	7 days	18 hours	7 days
Magna-Pulse	9.3	34.0	7.3	86.0	0.0	5.1
Nature Shield	2.7	24.0	4.0	82.7	0.0	9.3
Sigma	7.0	6.7	0.0	97.3	1.3	10.7
None	8.3	20.3	0.0	78.7	0.0	13.3

[a/]Used 25 adult ♂ B. germanica for each choice test (n=3) in transparent lucite chemometers. For each test, treatments were in 3 randomly selected chambers of 12. Repellent = 0.1 cc silica aerogel; non-repellent = 0.1 cc technical boric acid powder. Tested 13 November to 16 December 1978.

[b/]Within columns, no significant differences at 5% level (analysis of variance).

Table 10.--Fecundity of 20 adult German cockroaches[a] and offspring continuously exposed to electromagnetic devices.

Device	Exposure (weeks)	Avg. no. cockroaches/replic. Nymphs	Adults	Increase factor[b]
Magna-Pulse	4	218.3	15.7	10.7
Nature Shield	4	179.3	15.3	8.7
Sigma	4	196.0	17.0	9.7
None	4	163.7	16.0	8.0
Magna-Pulse	12	758.7	160.3	45.0
Nature Shield	12	747.3	197.3	46.2
Sigma	12	623.0	173.7	45.0
None	12	771.7	192.7	47.2
Magna-Pulse	24	2668.0	465.3	155.7
Nature Shield	24	3256.4	567.9	190.2
Sigma	24	2539.4	442.9	148.1
None	24	2657.8	463.5	156.1

[a] Used 10 ♂ + 10 ♀ *B. germanica* without visible oothecae (n=3) for each device and exposure period. Test begun 31 August 1978.

[b] Factor based on total number of cockroaches, compared to initial number. Calculated as $\frac{\text{final total number-initial number}}{\text{initial number}}$

Table 11.--Fecundity of 20 nymphal German cockroaches and offspring continuously exposed to electromagnetic devices.

Device	Exposure (weeks)	Avg. cockroaches/replic. Total	% nymphs	Increase factor
Magna-Pulse	4	20.0	33.3	0.0
Nature Shield	4	18.0	1.9	0.0
Sigma	4	19.3	34.5	0.0
None	4	19.0	15.8	0.0
Magna-Pulse	12	387.3	95.4	18.4
Nature Shield	12	374.3	93.2	17.7
Sigma	12	311.3	94.3	14.6
None	12	308.3	94.4	14.4
Magna-Pulse	24	2478.7	85.2[a]	122.9
Nature Shield	24	2476.0	85.2[a]	122.8
Sigma	24	2155.0	85.2[a]	106.8
None	24	1546.0	87.4	76.3

[a] % nymphs determined from avg counts of ten 15-cc samples of cockroaches from one replicate exposed to Sigma device.

Table 12.--Emergence of American cockroach nymphs, *Periplaneta americana*, from oothecae (n=10) exposed to electromagnetic devices.[a]

Device	Hatched capsules	Emerged nymphs	
		Total number	Avg. no. per capsule
Magna-Pulse	6	83	13.8
Nature Shield	4	51	12.8
Sigma	6	82	13.7
None	4	51	12.8

[a] Test begun 7 September 1978 with 10 fully formed oothecae. Capsules kept in corked glass shell vials at 81° F. Test discontinued 15 December 1978.

Table 13.—Relative effectiveness of electromagnetic devices against infestations of German cockroaches in low-income apartments.

Test Series	Placement[a]	No. Apts.	No. cockroaches trapped at week: Before	4	8	12	% control[b]: 4 wks	12 wks
Nature Shield	Garage	7	79	347	385	543	0.0	0.0
Nature Shield	Next bldg.	7	107	77	64	29	28.0	72.9
Nature Shield	(combined)	14	193	431	449	472	0.0	0.0
Sigma	Apt. 1	8	14	34	46	126	0.0	0.0
Sigma	Next bldg.	10	317	815	476	48	0.0	84.9[c]
Sigma	(combined)	18	331	849	522	174	0.0	47.4
Magna-Pulse	Apt. 3	10	48	201	144	disc.	0.0	
Dursban, 0.5%	Aerosol	12	199	20	19	25	90.0*	87.4*
Boric acid, 99%	Dust	9	432	39	2	19	91.0*	95.6*
Untreated	Bldg. A	10	23	66	48	27	0.0	0.0
	Bldg. B	8	22	41	201	164	0.0	0.0
	(combined)	18	45	107	249	191	0.0	0.0

a/ Test series begun as follows: Nature Shield, Sigma and untreated 2 August 1978; boric acid, 31 August 1978; Dursban, 16 November 1977; Magna-Pulse, 8 November 1978. Each device installed on ground floor, as per instructions provided by manufacturer. Term "next bldg." refers to closest possible infested building, within 45 feet of building in which device was actually installed.

b/ * = significant reduction at 5% level (Wilcoxon signed-ranks test). No mark indicates no significant change. Disc. = discontinued test.

c/ Most of reduction occurred in one apartment where count declined from 232 to 14.

Table 14.—Trap counts of German cockroaches from individual apartments within the purported range of effectiveness of electromagnetic devices.

Device	Exposure	Number of cockroaches trapped in indicated apartment										Total
		1	2	3	4	5	6	7	8	9	10	
Nature Shield (garage)	Before	0	4	13	50	3	3	6				79
	4 weeks	77	2	80	113	7	60	1				340
	8 weeks	84	0	181	46	44	15	8				378
	12 weeks	52	68	158	45	28	182	10				543
Nature Shield (next bldg.)	Before	5	0	2	97	1	1	1				107
	4 weeks	2	0	4	70	0	0	1				77
	8 weeks	0	0	0	58	0	0	6				64
	12 weeks	19	1	0	3	0	1	5				29
Sigma (Apt. 1)	Before	2	0	4	5	0	0	0	3			14
	4 weeks	2	0	0	8	0	0	0	24			34
	8 weeks	0	0	0	16	0	1	0	29			46
	12 weeks	0	0	0	67	0	0	0	59			126
Sigma (next bldg.)	Before	6	0	232	15	0	0	0	2	50	12	317
	4 weeks	56	0	130	13	0	3	3	147	461	2	815
	8 weeks	4	1	23	9	3	9	8	49	357	13	476
	12 weeks	3	0	14	12	4	3	0	2	5	5	48
Magna-Pulse (Apt. 3)	Before	3	0	14	12	4	3	0	2	5	5	48
	4 weeks	63	0	0	29	30	9	0	6	11	53	201
	8 weeks	88	0	0	9	1	1	0	2	7	36	144
Untreated[a]	Before	13	0	1	7	2	0	11	0	10	1	45
	4 weeks	4	7	0	54	0	20	18	2	0	1	106
	8 weeks	0	4	0	42	0	185	9	5	2	0	247
	12 weeks	0	3	0	24	0	90	18	2	30	34	191

[a] Apartments from 2 buildings.

Table 15.--Effect of electromagnetic devices on groups (n=3) of 20 adult confused flour beetles[a] and their progeny.

Device	Exposure (days)	No. live beetles/replicate			
		Adults	Pupae	Larvae	% increase
Magna-Pulse	28	20	0	113	565
Nature Shield	28	20	0	134	670
Sigma	28	20	0	109	545
None	28	20	0	133	665
Magna-Pulse	40	20	19	216	1175
Nature Shield	40	20	37	217	1270
Sigma	40	19	11	262	1360
None	40	20	33	187	1100

[a] Began test 20 September 1978 with each replicate containing 10♂ + 10♀ *Tribolium confusum* ten days old.

WILL ELECTROMAGNETIC PEST CONTROL DEVICES INHIBIT ACTIVITIES OF TERMITES AND WOOD-DESTROYING BEETLES?

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SUMMARY

Electromagnetic devices placed in field conditions where subterranean termites (Reticulitermes sp.) were plentiful did not deter termites from attacking and damaging wooden stakes placed in the ground near the units. Wood-destroying beetles, Xyletinus peltatus, also were not affected by the electromagnetic devices.

INTRODUCTION

During the past 2 years, manufacturers of electromagnetic devices have claimed in trade journals that their electromagnetic devices will control rodents and insects. Some advertisements state that electromagnetic devices in or on the soil cause termites to stop feeding or in some way eliminate them from around the unit (up to 12 hectares).

If electromagnetic devices are effective, their use could better control wood-destroying insects. But further investigations into the usefulness of these devices are needed because no data from soundly conducted research are available to confirm these claims.

Becker (1976, 1977) has reported on the only bona fide research that suggests that magnetic fields may affect termites. From laboratory studies, he suggests that termite gallery building was affected and that termites could perceive differences in alternating magnetic fields (50 Hz) within their containers.

OBJECTIVES

The overall objective of this cooperative study between the Southern Forest Experiment Station and the Environmental Protection Agency was to gain data either supporting or refuting manufacturers' claims of termite control with electromagnetic devices. Specific objectives were to determine effects of three magnetic devices on: (1) gallery building of subterranean termites (Reticulitermes) under field conditions, (2) feeding of subterranean termites under field conditions, (3) egg-laying by Xyletinus peltatus (Harris) adults, and (4) feeding by X. peltatus larvae.

MATERIALS AND METHODS

Test Units

For termites, three units were evaluated:

1. Nature Shield, Solara Electronics, Costa Mesa, Calif.

2. Sigma, Orgolini Manufacturing Company, Inc., Sparks, Nev.

3. Magna Pulse, Bell Products, Sparks, Nev.

For beetles, only the Nature-Shield unit was used.

Test Procedures

Effects on gallery building of subterranean termites (Reticulitermes).--About 3,000 termites (workers, soldiers, and other castes that were present) were placed in liter-size containers filled with moist pine sawdust. After the termites had become well established in the sawdust, we removed all termite tubes from inside the container. Five containers (with all tubes freshly removed) were placed near one of the operating electromagnetic units. As controls, five containers were placed out of range of the units. The containers were examined weekly for 4 weeks. The length and size of tubes found on the exposed and unexposed containers were compared.

Effects on feeding of termites under field conditions.--Plots were set up in forested areas known to be infested with subterranean termites (Reticulitermes sp.). Each plot contained twenty 2.54- x 5.08- x 46-cm pine stakes driven about 8 cm into the ground. Stakes were placed 1.5 m apart in each of four lines (five stakes per line) radiating outward 7.5 m (N-W-S-E) from the center point (Fig. 1). The plot centers were at least 200 m apart. Two separate tests were conducted.

The first test was to determine if the machine would prevent initial attack to wood by subterranean termites under field conditions. This test used the battery-powered electromagnetic units (Nature Shield [Fig.2] and Magna Pulse [Fig. 3]). At the time that the stakes were driven into the ground, units were installed (according to the manufacturer's instructions) at the intersection of the four lines of stakes. The three plots used were a control plot (no unit) and a separate plot for each unit. Every 10 days for 60 days we examined the stakes within each plot and recorded the number of stakes attached and the intensity of attack to each stake. Intensity of attack was based on the following scale:

0 = No termite attack (0% damage)

1 = Surface nibbling by termites (1-5% damage; average 2.5%)

2 = Light penetration into wood (6-10% damage; average 8.5%)

3 = Medium penetration into wood (11-40% damage; average 25%)

4 = Heavy penetration and feeding of wood (41-80% damage; average 60%)

5 = Major belowground portion of stake completely destroyed (81-100%; average 90%)

The second test was to determine if the machine would slow or stop existing infestations. Plots were set up as above but we allowed at least 60 days before installation of the units to allow stakes to become infested with termites. From many plots installed, three plots were selected that had equal attacks in terms of number of stakes and intensity of attack on the stakes. Plots were assigned randomly to one of the three treatments (Nature Shield, Magna Pulse, and untreated control).

Every week for 6 weeks we recorded the number of stakes attacked and the intensity of termite attack. The units were then moved to new plots and the inspection procedure repeated for 6 weeks. We repeated this rotation four times so we had four replicates. Differences were determined by Analysis of Variance (ANOV) at 0.05 significance.

Analysis of variance for randomized complete block with four blocks in time and three treatments was conducted with nine response variables considered:

% stakes attacked - beginning (A)
end of 6 weeks (B)
differences (B minus A)

Mean % termite damage - beginning (A)
end of 6 weeks (B)
differences (B minus A)

Mean termite rating - beginning (A)
end of 6 weeks (B)
differences (B minus A)

The electrical powered unit (Sigma) was placed in an area known to be infested with termites. Each week for 6 weeks we checked the wooden stakes near the units to determine if the termite feeding or activity had declined.

Effects of the Nature Shield on beetles.--A properly operating unit was centrally placed on the ground in a roofed crawl space--an area 30.2 m^2 enclosed by a concrete chain wall but ventilated by openings on two opposing sides between the pitched roof and chain wall.

Adult beetles were collected from infested buildings at the U.S. Naval Construction Battalion Center, Gulfport, Mississippi. Five beetles of undetermined sex were confined in small oviposition cages on each of 30 blocks (2.54 x 5.08 x 7.62 cm) of air-dried yellow-poplar sapwood that had been prepared for beetle egg-laying as described by Williams and Mauldin (1974). Within 24 hours after beetle collection, we placed oviposition cages in the following locations:

1. Three cages directly on the unit.

2. Three cages in each corner of the crawl space with the unit.

3. Three each in a corner of four other crawl spaces that were 7.6 m away from the crawl space with the unit (cages were placed in the corner nearest the crawl space with the unit).

4. As controls, three oviposition cages were exposed about 3 km away in a crawl space of a Harrison Experimental Forest headquarters building.

The beetles were removed after 2 weeks; sexes and mortality were recorded. Development of larvae was determined by radiographs taken 9-12 months later. The number of eggs laid on each block and number of female beetles per cage at each location were used for calculating the mean number of eggs laid per female per location. Differences in the number of eggs laid per female at each of the nine locations near the unit and in the control cages were tested for significance by ANOV ($P = 0.05$).

In a second experiment, we tested how the Nature Shield affected feeding and movement of X. peltatus larvae within wood. To select blocks with only a few isolated large larvae, we radiographed blocks of yellow-poplar sapwood that contained larvae of unknown age. Blocks varied in size. Then we stapled 1.3^2 cm mesh hardware cloth to each of 26 blocks and radiographed them again. Concurrently with a field test of the Nature Shield unit for termites, three blocks were exposed adjacent to each pine stake (Fig. 1). As controls, three blocks were exposed outdoors more than 200 m away from the unit and three more blocks were kept in a heated building. Each week for 10 consecutive weeks from October 27, 1978, to January 5, 1979, all blocks were radiographed. Because the hardware cloth caused a distinct gridlike overlay, changes in the position of an individual larva could be followed by comparing successive radiographs with those taken the previous week.

RESULTS AND DISCUSSION

The effects on gallery building of subterranean termites (Reticulitermes).--The termites in the jars placed near the units exhibited no unusual behavior when compared to the termites in the jars placed in an unexposed area. In all cases, termites tubed vigorously to the top of the containers, and the total activity was comparable in all containers. This test was discontinued after 4 weeks when it became apparent that termites were not being affected by the electromagnetic device.

Effects on subterranean termites (Reticulitermes) feeding under field conditions.--Neither Magna Pulse nor Nature Shield prevented termites from attacking pine stakes during the 10-week period (Table 1). The number of stakes attacked and the damage ratings were similar for both test units and the control. Also, termites were found tubing on one of the machines tested in the forested area (Fig. 4).

When termites were allowed to attack the stakes before installation of the test units, similar results were obtained with no differences (Table 2) between the number of stakes attacked or the intensity of attack on stakes placed in different plots.

The only significant difference was in percentage of stakes attacked at the end of 6 weeks. More stakes were attacked in the plots in which the Nature Shield was operating than in the other plots. The most important test responses are the differences between initial attack and attack at test closure, and these differences were not significant.

Effects on wood-destroying beetles.--Exposure for 2 weeks to the Nature Shield unit apparently did not harm *X. peltatus* beetles. Radiographs showed that larvae were developing normally in each block, but were still too small for accurate counts. Although the movement of larvae could only be roughly estimated by the technique we used, no effect on larval activity was detected.

As expected, most of these short-lived beetles died, but a few were alive after being near the unit and a few survived in the control cages outside the claimed effective range of the unit. Because the number of eggs laid per female did not differ significantly by location (Table 3), we can assume the unit did not affect adult beetle activity.

CONCLUSION

Under the conditions of our study, which consisted of evaluation of electromagnetic devices under the native habitat of subterranean termites, we found no evidence that a properly operating Nature Shield, Magna Pulse, or Sigma had any adverse effect on termites (*Reticulitermes* sp.). One species of wood-destroying bettle, *X. peltatus*, was not affected by Nature Shield.

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Table 1.--Number of stakes attacked by termites and percentage of damage to pine stakes at the end of 10 weeks.

Treatment	No. stakes attacked	Av. percentage of damage on attacked stake[1]	Av. attack rating[1]
Nature Shield	8	12	2.2
Magna Pulse	7	15	2.4
Control - no unit	6	30	3.1

[1] Based on the following scale:

0 = No termite attack (0 percent)

1 = Surface nibbling by termites (1-5% damage; average 2.5%)

2 = Light penetration into wood (6-10% damage; average 8.5%)

3 = Medium penetration into wood (11-40% damage; average 25%)

4 = Heavy penetration and feediing of wood (41-80% damage; average 60%)

5 = Major belowground portion of stake completely destroyed (81-100% damage; average 90%)

Table 2.--Number of stakes attacked by subterranean termites and percentage of damage to pine stakes at 6-week intervals.

Treatment	No. and percentage of stakes attacked				Av. percentage of damage on attacked stakes		Av. attack rating[1]	
	Beginning		Ending		Beginning	Ending	Beginning	Ending
	No.	%	No.	%				
				Test period - 9/9-10/26, 1978				
Nature Shield	10	50	12	60	9	16	2.1	2.4
Control - no unit	9	45	11	55	16	16	2.4	2.4
Magna Pulse	7	35	9	45	12	18	2.3	2.6
				Test period - 10/26-12/8, 1978				
Nature Shield	16	80	17	85	49	60	3.7	3.9
Control - no unit	12	60	14	70	19	25	2.6	3.1
Magna Pulse	12	60	13	65	25	46	3.1	3.6
				Test period - 12/8/78-1/18/79				
Nature Shield	12	60	12	60	17	18	2.5	2.6
Control - no unit	11	55	11	55	25	28	3.0	3.1
Magna Pulse	6	30	6	30	13	17	2.3	2.5

Table 2.--Continued.

Treatment	No. and percentage of stakes attacked				Av. percentage of damage on attacked stakes		Av. attack rating	
	Beginning		Ending		Beginning	Ending	Beginning	Ending
	No.	%	No.	%				
				Test period - 1/18-4/27, 1979				
Nature Shield	12	60	15	75	18	25	2.6	2.4
Control - no unit	7	35	9	45	25	42	3.1	3.4
Magna Pulse	10	50	12	60	17	22	2.5	2.8

[1] Based on the following scale:

0 = No termite attack (0 percent)

1 = Surface nibbling by termites (1-5% damage; average 2.5%)

2 = Light penetration into wood (6-10% damage; average 8.5%)

3 = Medium penetration into wood (11-40% damage; average 25%)

4 = Heavy penetration and feeding of wood (41-80% damage; average 60%)

5 = Major belowground portion of stake completely destroyed (81-100% damage; average 90%)

Table 3.--Egg-laying activity by *Xyletinus peltatus* beetles during 2 weeks exposure to the Nature Shield unit.

Block exposure location	Mear Number eggs laid/block	Mean number eggs laid/female
NE[1]	39.0	11.7
NW	29.7	8.1
SE	53.2	16.8
SW	29.7	8.1
On unit	16.3	7.0
Control	13.0	4.3

[1] Data in first four rows are means for six replicates and last two rows are means for three replicates.

Figure 1.--Plot for evaluating electromagnetic units

(X = a pine wooden stake)

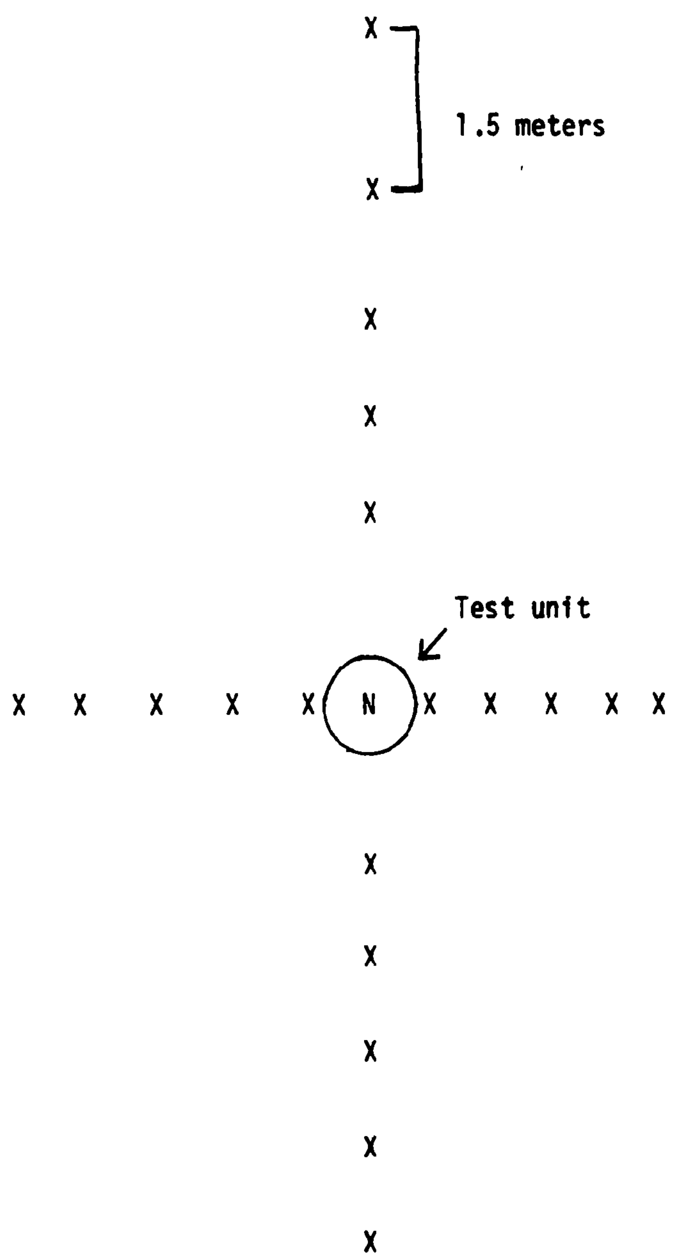


Figure 2.--Nature Shield in place between pine stakes in field study.

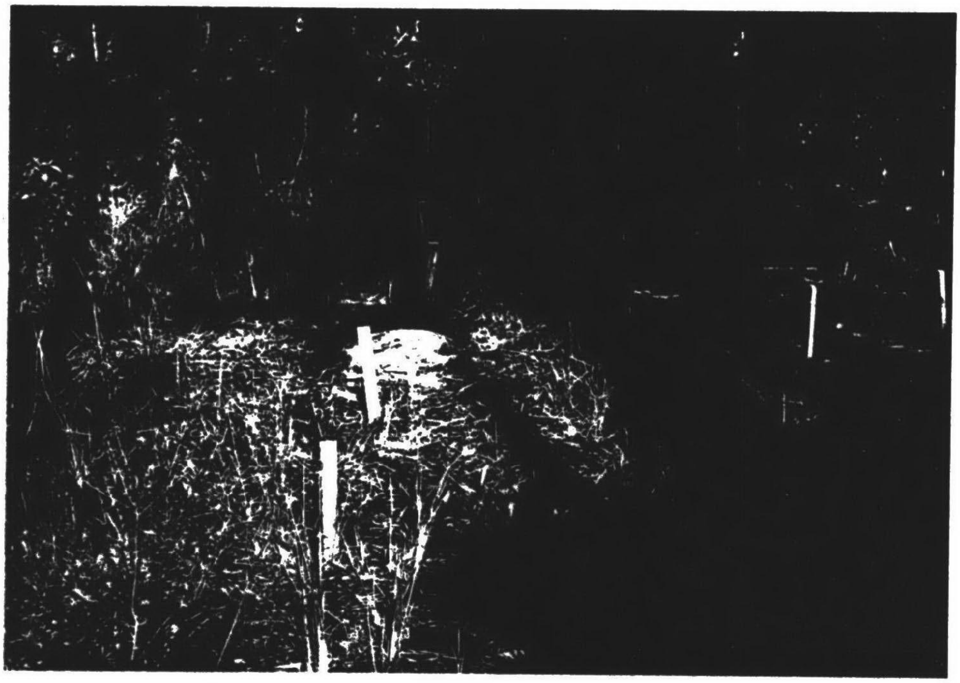
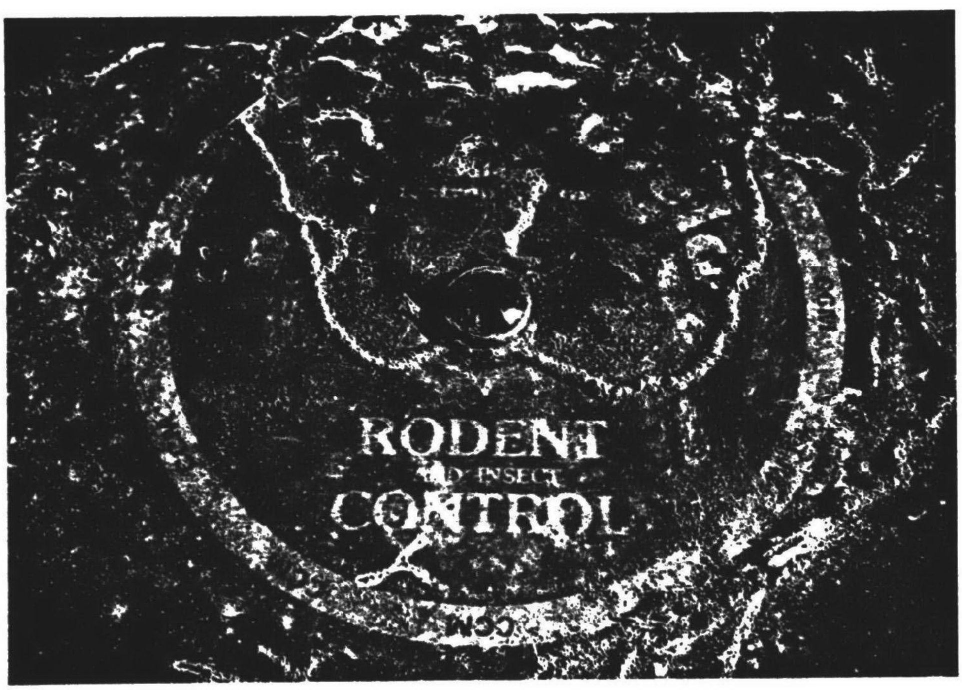


Figure 3.--Magna Pulse in field study.

Figure 4.--Subterranean termite shelter tubes on operating Nature Shield.



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