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16. ABSTRACT

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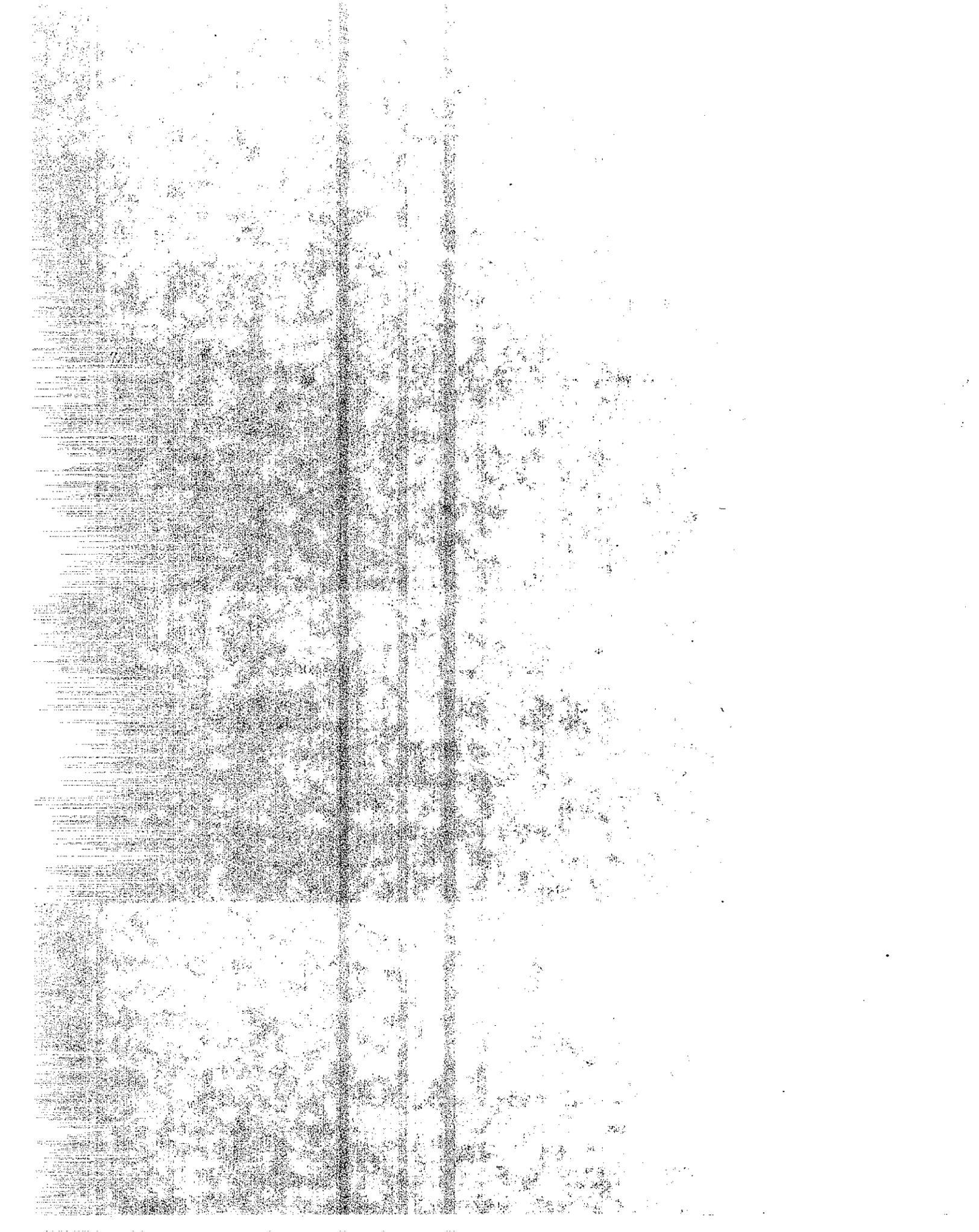
STATE OF CALIFORNIA
DEPARTMENT OF TRANSPORTATION
DIVISION OF CONSTRUCTION
OFFICE OF TRANSPORTATION LABORATORY

ASSESSMENT OF PHOTOVOLTAIC
SYSTEM CAPABILITIES

Study Sponsored by Enviro-Chemical Branch
Study Under General Direction of Mas Hatano, P.E.
Project Coordinator R. W. Bushey, P.E.
L. G. Kubel, P.E.

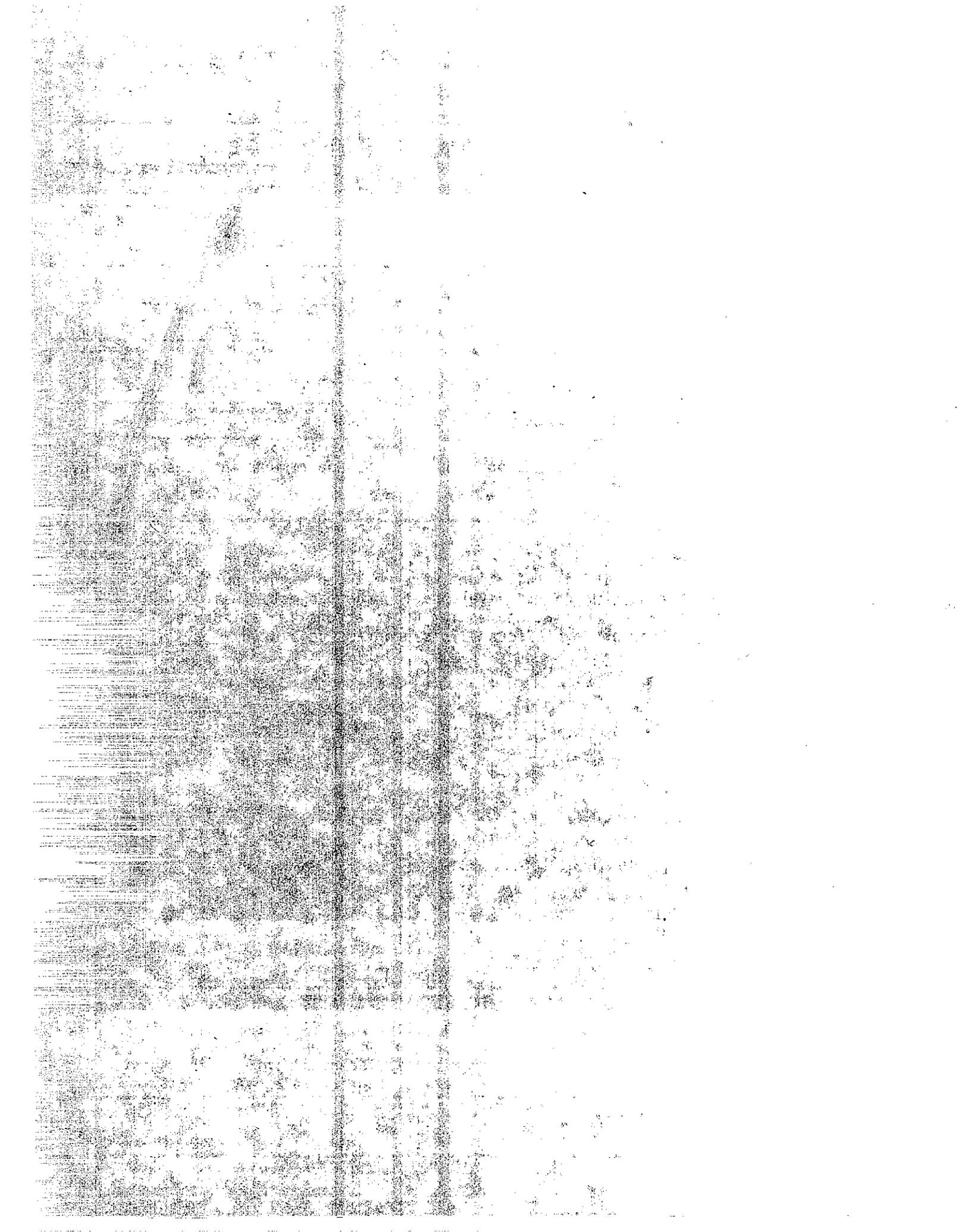


RAYMOND A. FORSYTH, P.E.
Chief, Office of Transportation Laboratory



TECHNICAL REPORT STANDARD TITLE PAGE

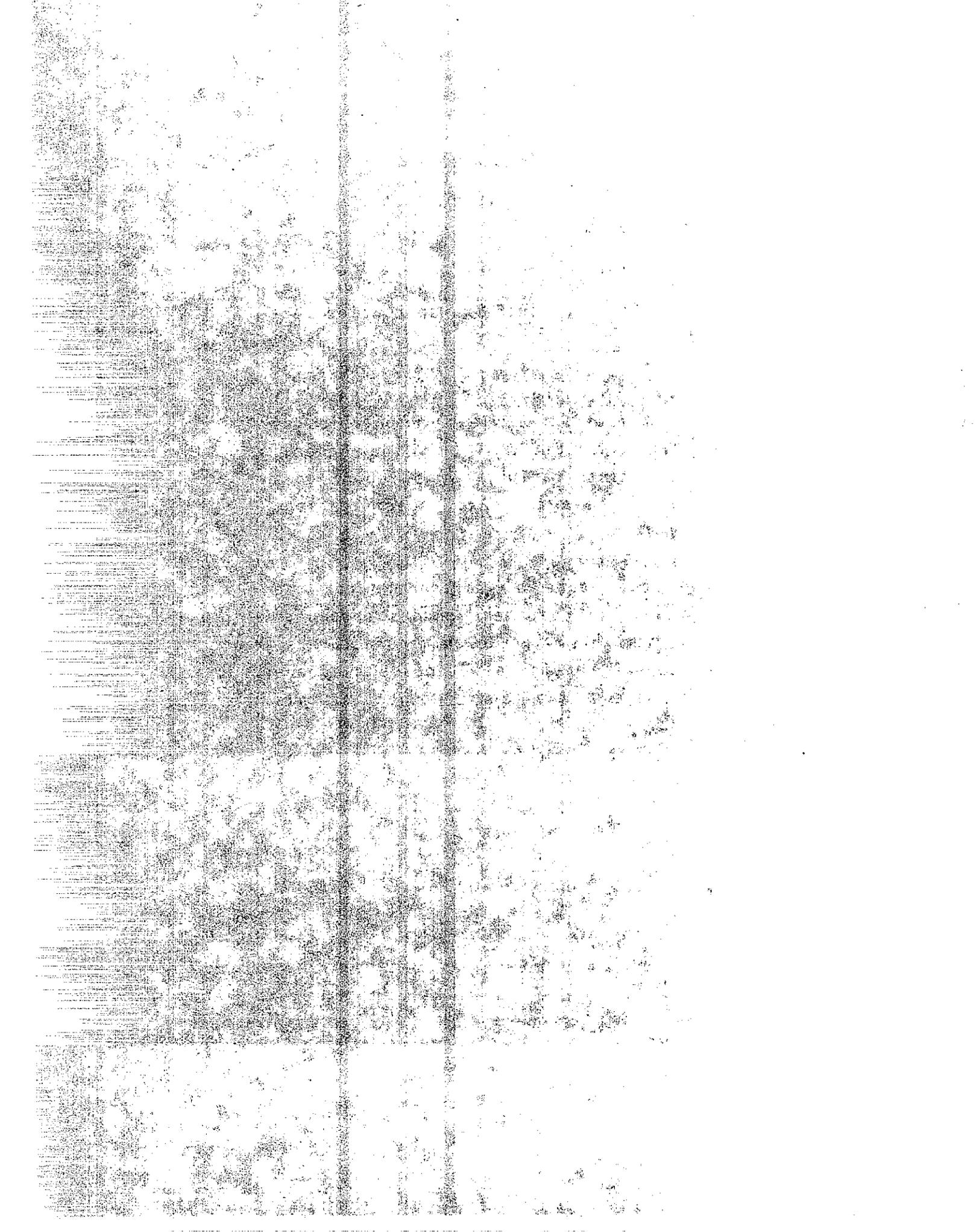
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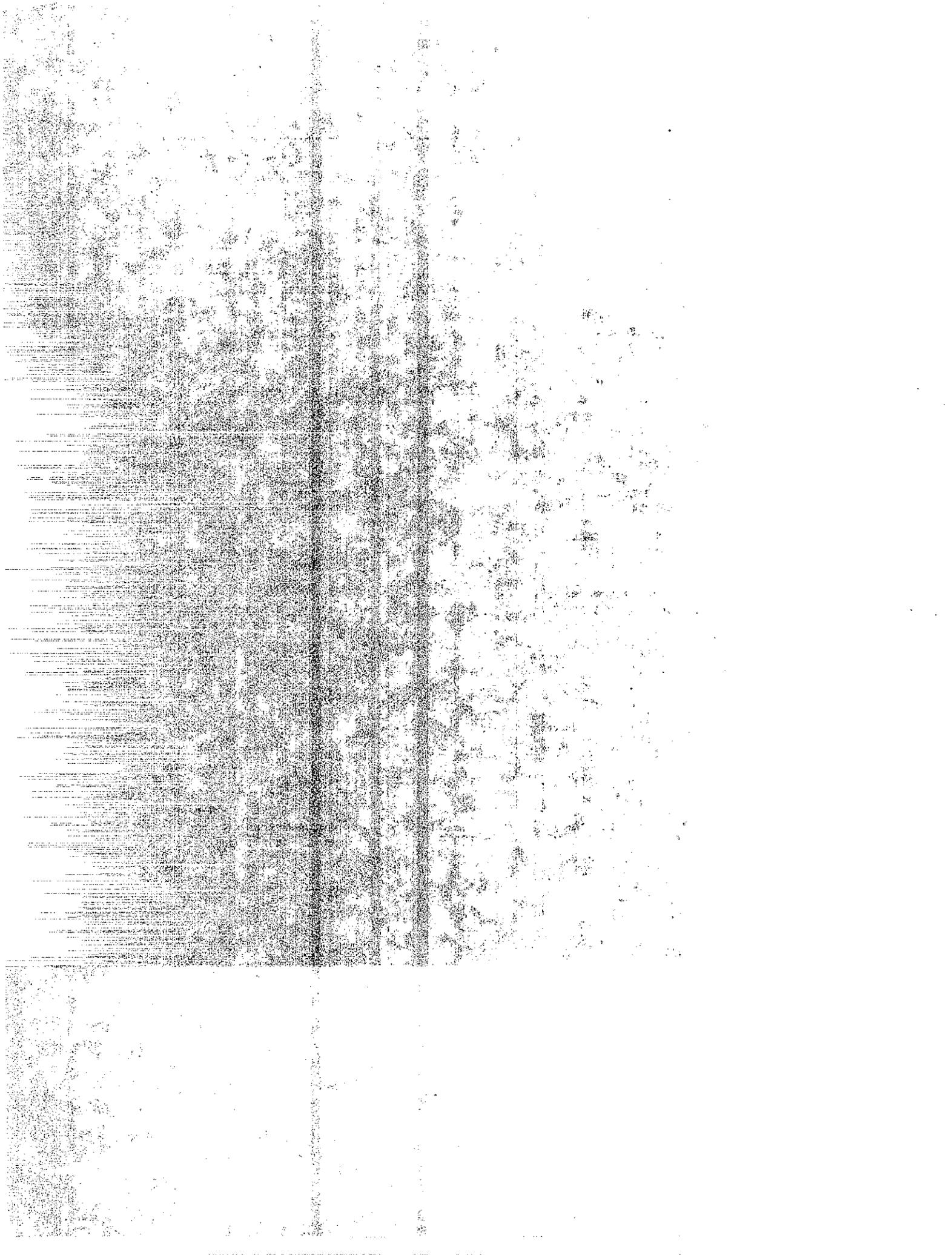
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CONVERSION FACTORS

English to Metric System (SI) of Measurement

<u>Quality</u>	<u>English unit</u>	<u>Multiply by</u>	<u>To get metric equivalent</u>
Length	inches (in) or (")	25.40 .02540	millimetres (mm) metres (m)
	feet (ft) or (')	.3048	metres (m)
	miles (mi)	1.609	kilometres (km)
Area	square inches (in ²)	6.432 x 10 ⁻⁴	square metres (m ²)
	square feet (ft ²)	.09290	square metres (m ²)
	acres	.4047	hectares (ha)
Volume	gallons (gal)	3.785	litre (l)
	cubic feet (ft ³)	.02832	cubic metres (m ³)
	cubic yards (yd ³)	.7646	cubic metres (m ³)
Volume/Time (Flow)	cubic feet per second (ft ³ /s)	28.317	litres per second (l/s)
	gallons per minute (gal/min)	.06309	litres per second (l/s)
Mass	pounds (lb)	.4536	kilograms (kg)
Velocity	miles per hour (mph)	.4470	metres per second (m/s)
	feet per second (fps)	.3048	metres per second (m/s)
Acceleration	feet per second squared (ft/s ²)	.3048	metres per second squared (m/s ²)
	acceleration due to force of gravity (G) (ft/s ²)	9.807	metres per second squared (m/s ²)
Density	(lb/ft ³)	16.02	kilograms per cubic metre (kg/m ³)
Force	pounds (lbs)	4.448	newtons (N)
	(1000 lbs) kips	4448	newtons (N)
Thermal Energy	British thermal unit (BTU)	1055	joules (J)
Mechanical Energy	foot-pounds (ft-lb)	1.356	joules (J)
	foot-kips (ft-k)	1356	joules (J)
Bending Moment or Torque	inch-pounds (in-lbs)	.1130	newton-metres (Nm)
	foot-pounds (ft-lbs)	1.356	newton-metres (Nm)
Pressure	pounds per square inch (psi)	6895	pascals (Pa)
	pounds per square foot (psf)	47.88	pascals (Pa)
Stress Intensity	kips per square inch square root inch (ksi√in)	1.0988	mega pascals√metre (MPa√m)
	pounds per square inch square root inch (psi√in)	1.0988	kilo pascals√metre (KPa√m)
Plane Angle	degrees (°)	0.0175	radians (rad)
Temperature	degrees fahrenheit (F)	$\frac{+F - 32}{1.8} = +C$	degrees celsius (°C)



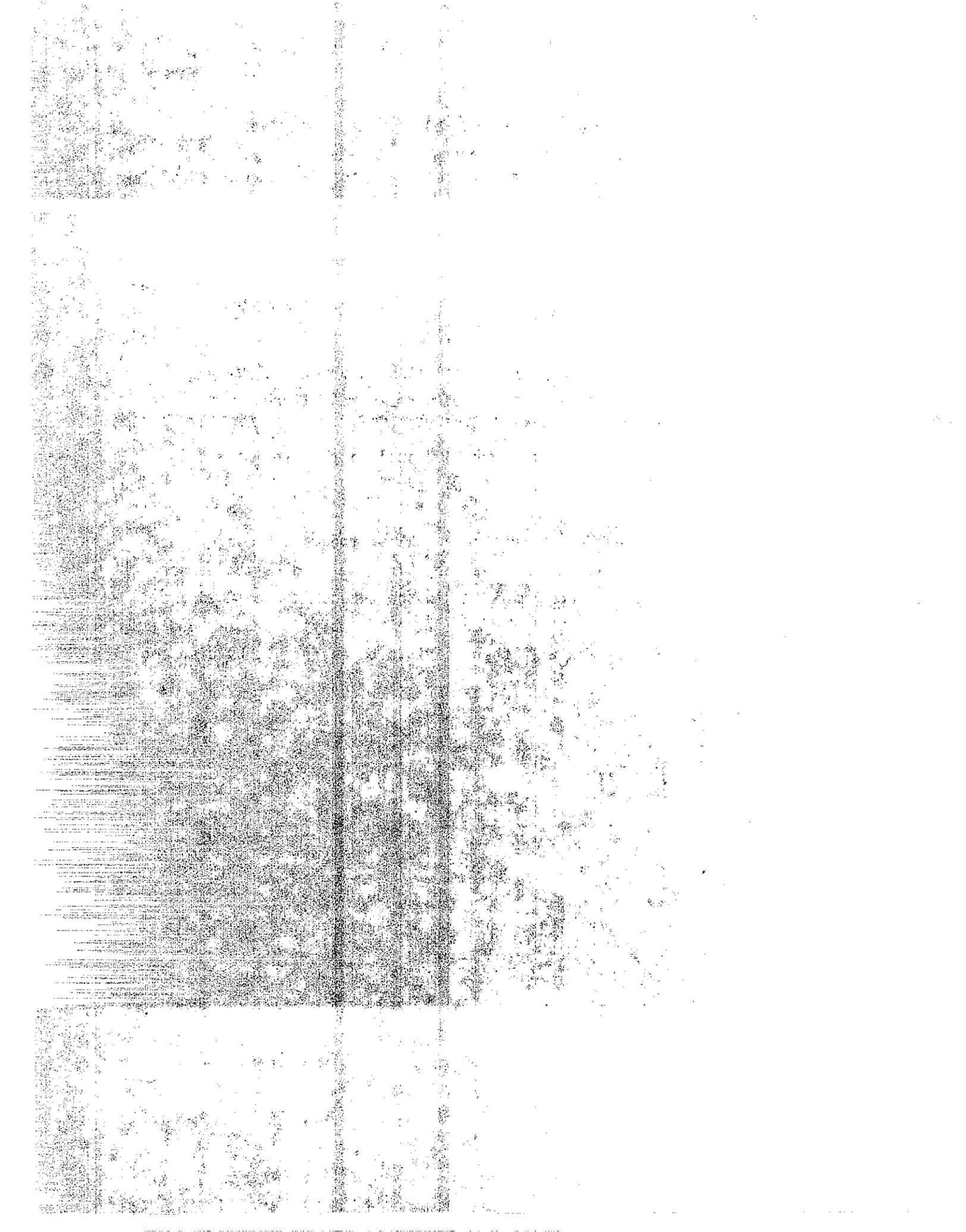
FINANCIAL DISCLOSURE STATEMENT

This research is jointly funded by the State of California, Department of Transportation (CALTRANS) and the Federal Highway Administration (FHWA). The ceiling amount for this contract, IRA 74A816-57D476 is \$42,400.

IMPLEMENTATION

The findings of this research will be implemented through continuing research. Three major benefits of this research were: 1) production of a versatile portable photovoltaic (PV) panel tester, 2) production of a user-friendly PV system analysis program, and 3) compilation of an insolation database compatible with the PV analysis program.

The testing equipment provided by this research is immediately useful in ongoing PV research and will be made available for use by district personnel. The PV system analysis program will, in the future, be verified and modified to provide a direct PV system design. The analysis program and its associated insolation database will then be distributed for use by district personnel.



PHOTOVOLTAIC SYSTEMS CAPABILITY PROJECT

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FINAL REPORT

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Department of Environmental Resources Engineering
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August 31, 1987

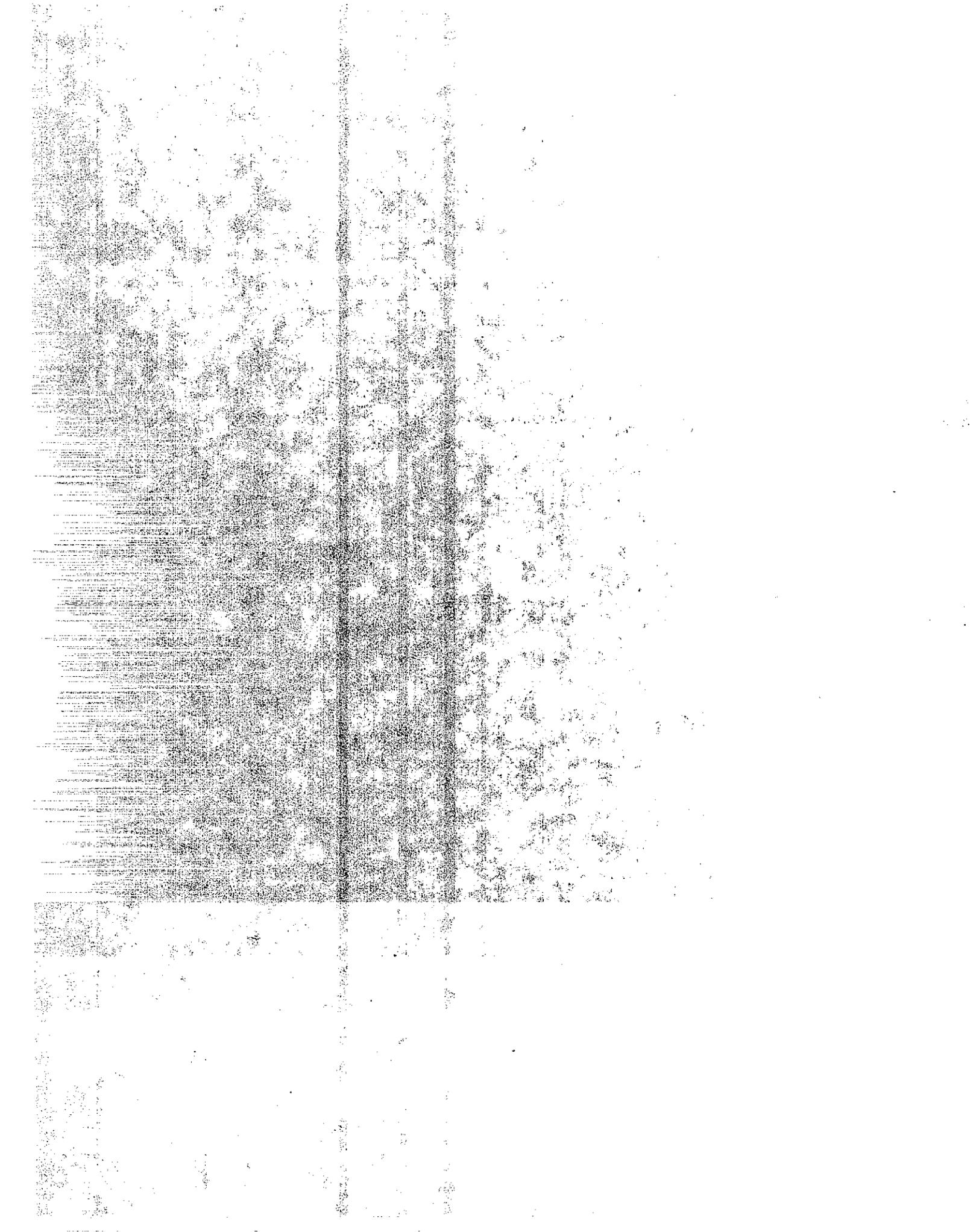
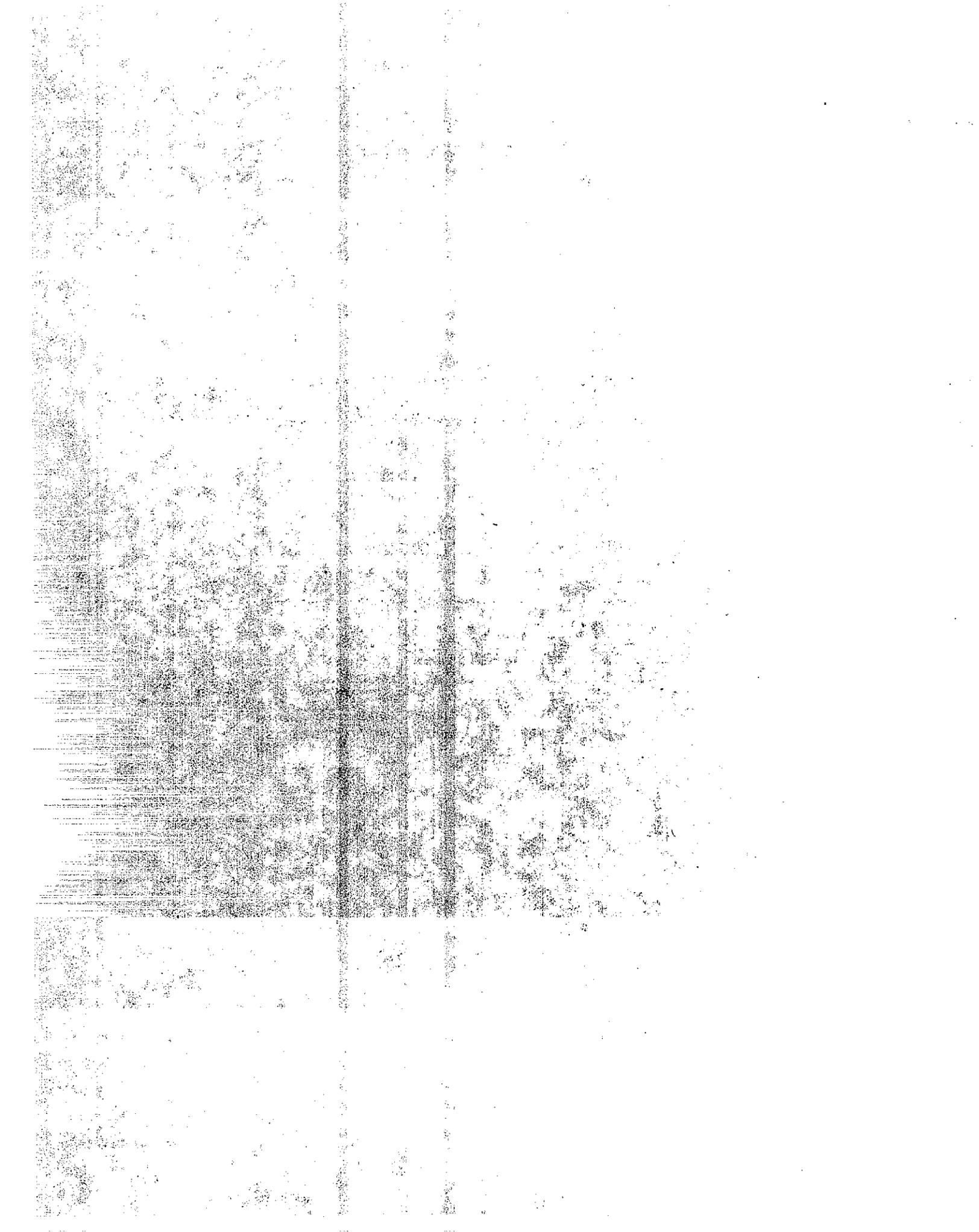


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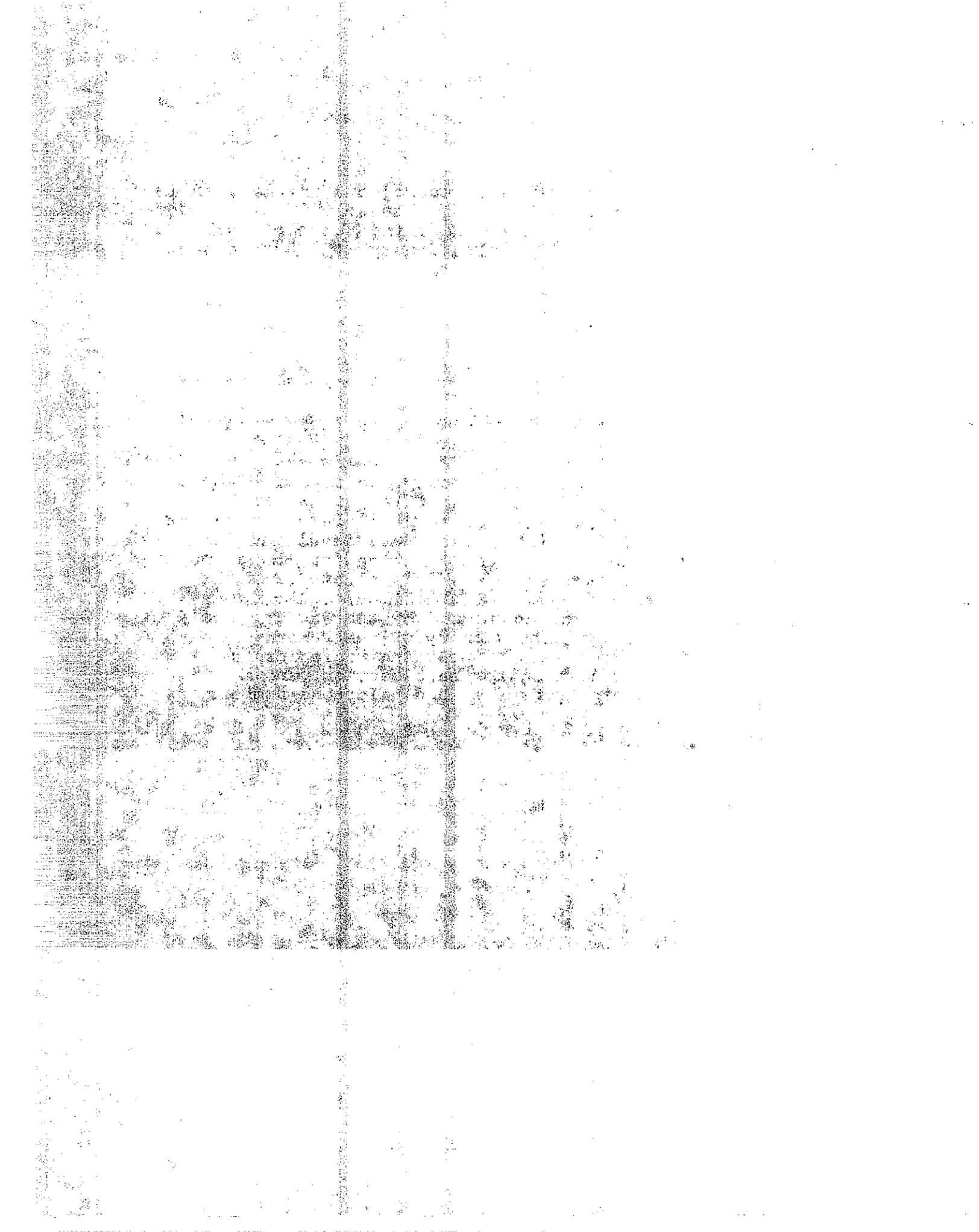
INTRODUCTION

Scope of Report

The report will cover all the various subprojects involved in the Photovoltaic Systems Capability Project. These include: (1) Compilation and analysis of field data concerning the performance of photovoltaic energy systems in Humboldt County, (2) Development of the photovoltaic system design program, PVINTER, and compilation of relevant weather data files, (3) Design and construction of a portable photovoltaic system analyzer, and (4) Compilation of a Photovoltaic Power Systems and Accessories Guide.

Description of Appendices

Various materials are included in appendices as their bulk and subject matter preclude their inclusion in the regular text. These include: (1) Text of the paper, "Field Measurements of Flat Plate Module Performance in Humboldt County, California," by P.A. Lehman and C.E. Chamberlin, (2) Raw data files of the field measurements conducted during this project, (3) Descriptions of the Design Meteorological Year (DMY) Data Sets developed for the PVINTER design program, and (4) Program listing for the computer program, SIMPGEN, which generates the DMY data sets from the Solar Radiation Monitoring Project (SIMP) files. SIMP is an ongoing data collection project conducted by the Pacific Gas & Electric Company, and (5) Contents summary of the "Photovoltaic Power Systems and Accessories Guide" including copies of the table of contents, product listing for each section, and a listing of the manufacturers' addresses and telephone numbers.



COMPILATION AND ANALYSIS OF FIELD DATA

Rationale

A portion of the project entailed measurement and analysis of the performance of flat plate PV modules which had been in use in small energy systems throughout Humboldt County for up to 7 years. The rationale for these measurements was to answer the question: Does the performance of PV modules degrade with age? If so, this would affect the design of PV systems, especially those whose probability of failure must be very low. This in turn would affect the design program which was developed during this project.

Data Collection and Analysis

To answer the above question, a program was carried out in which the performance of 112 flat plate modules was measured and analyzed. These modules ranged in age from new to 7 years and the care with which they had been maintained ranged from extensive to nil. As such, this situation was a good test of the durability of this technology. The conclusion we drew from our data is that PV module performance does not deteriorate with age, even for production line modules which are utilized in less than ideal circumstances. This is an important conclusion for the utilization of the design program we have developed. It indicates that a design based on true initial module output would continue to be an accurate design for many years.

Other results of our study include the effect of surface dirt on module performance, the types and numbers of failure modes we observed, and anecdotal information, gleaned from interviews with system owners, concerning system component performance and reliability.

Details of our study, its experimental techniques, data analysis, results, and conclusions are contained in a paper entitled, "Field Measurements of Flat Plate Module Performance in Humboldt County, California." This paper, authored by P. Lehman and C. Chamberlin, was presented at the 19th IEEE Photovoltaic Specialists Conference on May 8, 1987, and is included as Appendix I in this report. Acknowledgement of support for the research is contained in the paper.

Raw Data

Field data for the measurements were compressed into data files for computer storage and later analysis. A complete set of these raw data files is included as Appendix II of this report. In order to be useful, the format of the files must be explained so they can be interpreted.

The beginning of each line of the compressed data files is preceded by a colon and eight digits which represent a line number; they contain no data. Immediately following are 16 hexadecimal numbers (of 2 digits each) which represent eight voltage-current data pairs. The voltage number always precedes the current number. The last two digits in each line are an artifact of the SDK-51 development system used to collect data; they are meaningless. This tabulation of voltage-current pairs continues until the ending flag, FFFF, is reached. This flag signifies the end of the test; all numbers subsequent to the flag are meaningless.

The data file concludes with two additional lines which contain descriptive and additional quantitative information about the test. Each piece of information is separated from the others by asterisks. The information is arranged in the following manner:

1st Line:

* Test # * Module Wattage * Module Age (yrs) * Solar Insolation *
Initial Temperature (°C) * Final Temperature (°C) *

2nd Line:

* Owner's Name * Location * Module Manufacturer * Module Serial #
* Date * Time * Comments *

In order to interpret the voltage, current, and insolation measurements, calibration equations are necessary. These are derived from the characteristics of the measuring instruments and are given below:

$$\text{Voltage (volts)} = 0.09804 * (\text{HEX voltage value})$$

$$\text{Current (amps)} = 0.01876 * (\text{HEX current value})$$

Runs #1-35

$$\text{Current (amps)} = 0.01866 * (\text{HEX current value})$$

Runs #35-112

$$\text{Insolation (KW/sq-m)} =$$

$$0.6973 * (0.0233 * [\text{Insolation value}] - 0.056) \quad \text{Runs \#1-13}$$

$$\text{Insolation (KW/sq-m)} =$$

$$0.6973 * (0.0198 * [\text{Insolation value}] + 0.012) \quad \text{Runs \#14-112}$$

PVINTER PHOTOVOLTAIC SYSTEM DESIGN PROGRAM

Description

One of the main tasks of the project was to develop a design capability which would allow design of photovoltaic energy systems. This was accomplished by modifying an existing PV simulation program, PVFORM, which was developed at Sandia National Laboratories. The major difference between PVINTER and PVFORM is that PVINTER is run interactively while PVFORM is run in batch. The interactive feature allows much more convenient use of the program for design work.

PVINTER allows the user to interactively simulate the performance of PV systems for stand-alone or for grid connected applications. The emphasis is on stand-alone systems as these systems are likely to be more cost effective in the near future.

In using PVINTER, the designer furnishes the following information to the program: (1) system location, (2) appropriate weather file (see below), (3) load to be met including power demand and seasonal and diurnal variations, (4) AC or DC power, and (5) appropriate failure rate. The failure rate depends on the permitted frequency of failure and the definition of failure for the particular system. PVINTER then allows system design, that is, the number and type of PV modules necessary, the amount of battery storage, inverter rating, etc. which will meet system requirements for the least cost.

Weather Files

One important aspect of PV design is the meteorological data for the site being considered. After considerable investigation and negotiation, we obtained solar insolation and temperature data for 46 sites in California. Of these, 34 were obtained from the Solar Energy Research Institute and were the result of a five year monitoring program undertaken by Southern California Edison. The remaining 12 weather files were obtained from Pacific Gas & Electric and are part of their ongoing Solar Insolation Monitoring Project (SIMP).

A detailed description of how these files were constructed from the raw data, the listing of the sites, and a map showing their locations are contained in Appendix III of this report, Design Meteorological Year (DMY) Data Sets. In addition, the computer code for constructing the data sets from SIMP files is given in Appendix IV. The program is entitled SIMPGEN. This program code is included because the SIMP work is ongoing and it may be appropriate, as described below, to update the files periodically.

Deliverables

The design package includes PVINTER on program disks and hard copy. Also included are the original PVFORM program (both disk and hard copy), a documentation file called README (both disk and hard copy), and a comprehensive user's manual entitled, "PVINTER: An Interactive Photovoltaic System Simulator. User's Guide and Programmer's Reference." Weather files, as described above, were furnished on disk.

This package, taken as a whole, provides a powerful design tool which is a standard throughout the world. It is recommended, however, that the weather files be updated and/or additional files be added as new data becomes available. More accurate weather files will permit more accurate design.

PHOTOVOLTAIC SYSTEM ANALYZER

Description

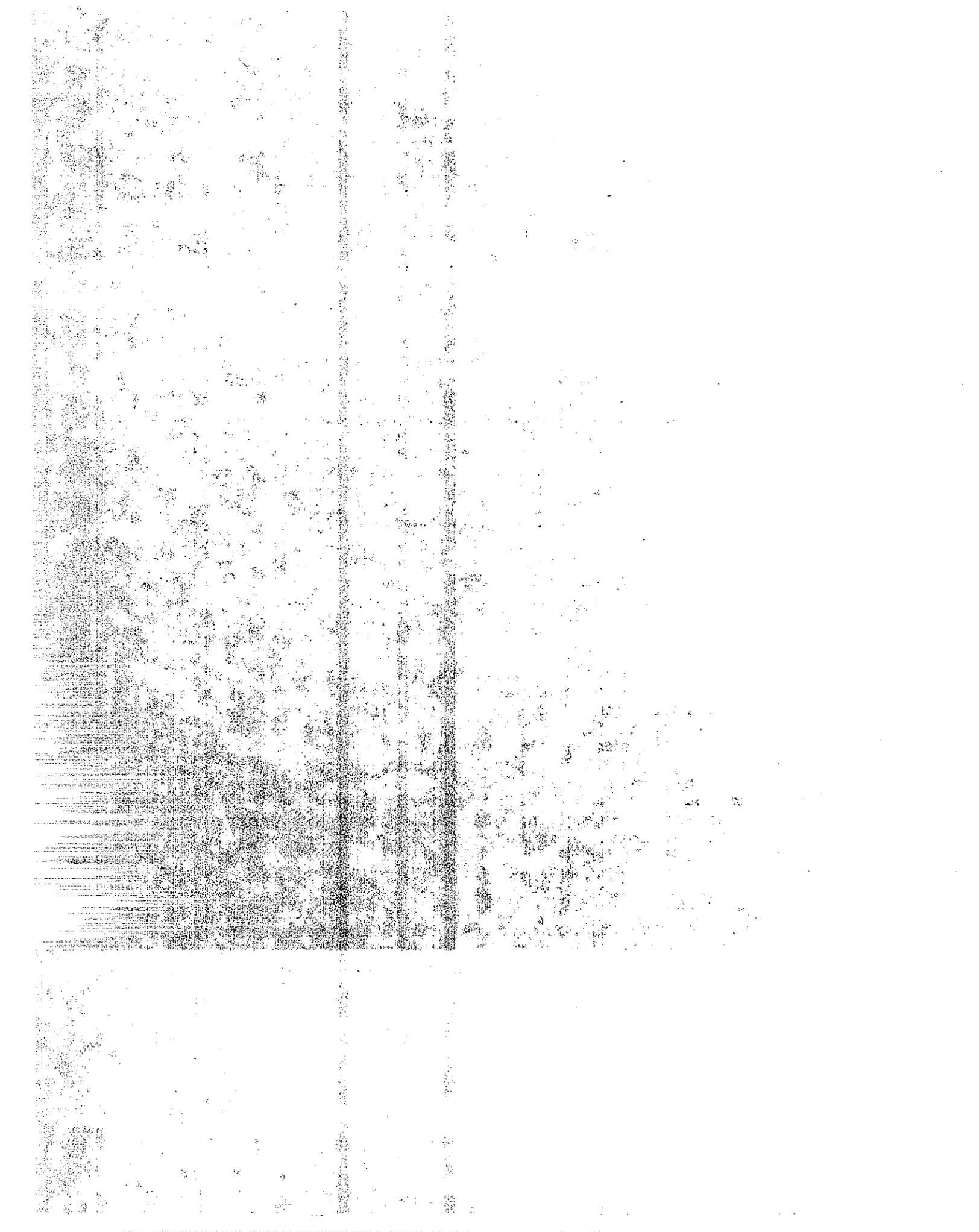
The HSU Energy Resources Group designed and constructed a portable photovoltaic system analyzer for use in evaluating and maintaining PV systems. The analyzer is patterned after the instrument developed for the field testing portion of this project with notable improvements in capability and convenience.

The PV system analyzer is an I-V curve tracer equipped with a pyranometer, a thermocouple, and an on-board computer. The instrument is capable of fast, routine measurement and analysis of PV arrays with currents as high as 100 amps and voltages as high as 200 volts. Operator control is through use of user-friendly software loaded into the on-board computer. Instrument outputs include: I-V curve, short circuit current, open circuit voltage, maximum power, current at maximum power, voltage at maximum power, series resistance, parallel resistance, and ideality factor. All outputs are available for actual running conditions or can be normalized to standard conditions of 25°C cell temperature and 1000W/sq-m insolation. The entire unit is self-contained in a rugged polyethylene case, weighs 35 pounds, and is small enough to qualify as carry-on luggage.

Deliverables

The analyzer is supplied with a complete operating manual and troubleshooting guide as well as a complete technical reference manual. The operating manual describes all of the operating modes of the instrument, safety precautions in its use, and includes a troubleshooting section which will allow its outputs to be interpreted to locate PV system faults. A bibliography is included for further reference. The technical reference manual includes all circuits used in the instrument, described by circuit diagrams and by operating principles, and all program codes used in the on-board computer. A complete list of all components is also included.

The PV system analyzer will allow users to operate a quality control program for any PV modules it obtains by testing them to ascertain that they meet manufacturers' specifications. It will also facilitate a maintenance testing program for any operating PV systems, especially in remote sites.



PHOTOVOLTAIC POWER SYSTEMS AND ACCESSORIES GUIDE

Description

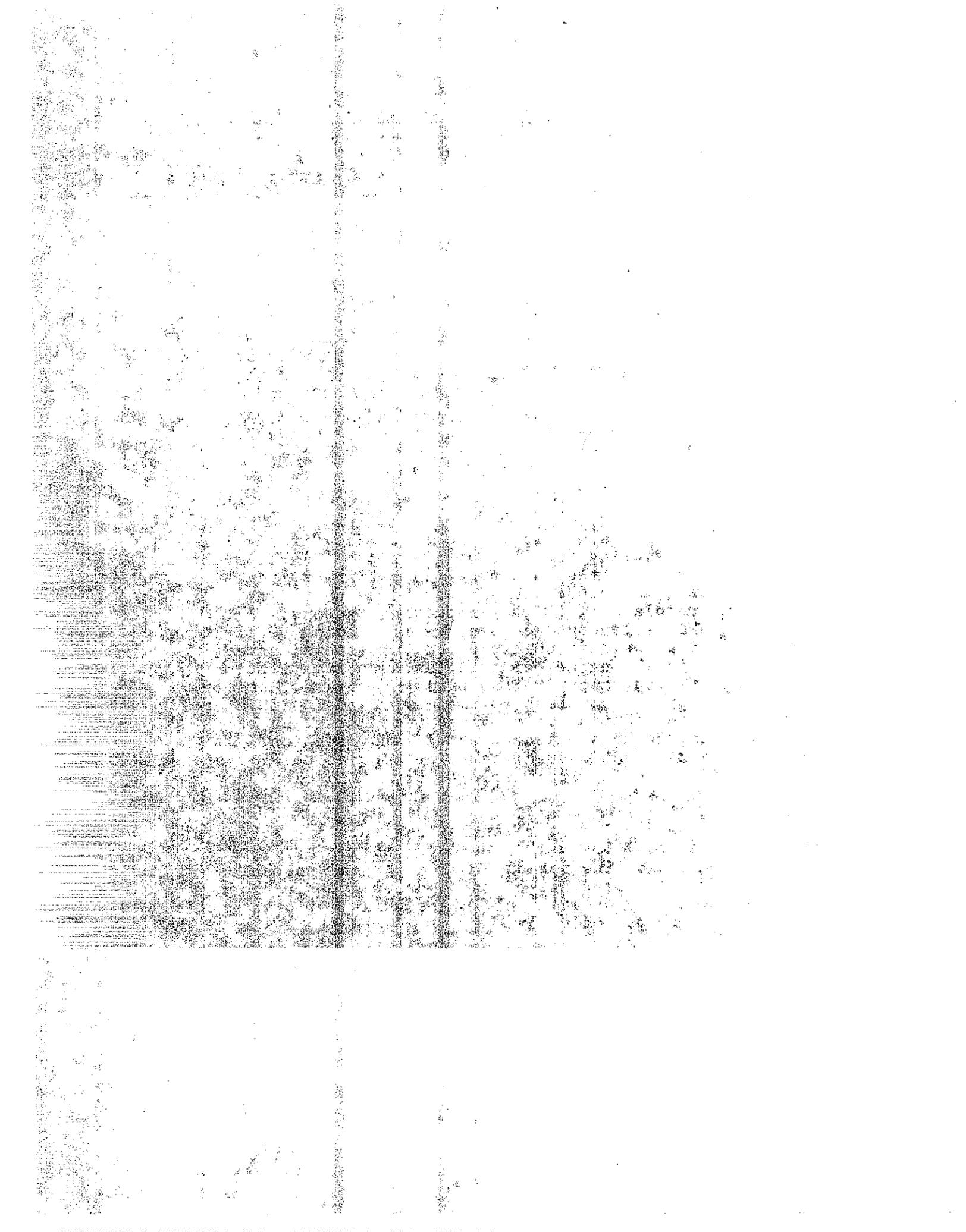
The final phase of the project involved the compilation of a products and accessories guide concerning PV and other stand-alone power systems.

The guide consists of two volumes of product information, specification sheets, price lists (when available), installation and maintenance information, and general information regarding stand-alone power systems. Nearly 100 separate manufacturers and suppliers were contacted in assembling information for the guide. This information was supplemented with material obtained at the 19th IEEE Photovoltaic Specialists' Conference held in New Orleans last May. It contains as complete and as up-to-date information as is available.

Deliverables

The guide was delivered as a two volume set. The first volume contains sections covering the following topics: (1) Photovoltaic modules, (2) Array support structures, (3) Batteries, and (4) Inverters. The second volume contains section covering: (1) Controllers and regulators, (2) Water pumping systems, (3) Generators, (4) Miscellaneous accessories (including DC lighting, mobile power generators, cathodic protection systems, street lighting, track signalling, electronic flashers, ventilation systems, refrigeration, and wire and wiring hardware), and (5) Miscellaneous information. Each volume is provided with a table of contents and each section is provided with a listing of manufacturers and products which appear in that section. It should be emphasized that though the guide focuses on PV systems, much of the information is applicable to any stand-alone power system.

The guide should be a valuable resource in assembling equipment for stand-alone power. However, a word of caution is in order. The PV industry is evolving rapidly. Products and companies change frequently at this stage of the technology. In order to maintain the usefulness of material in the guide, efforts should be made to update it periodically.

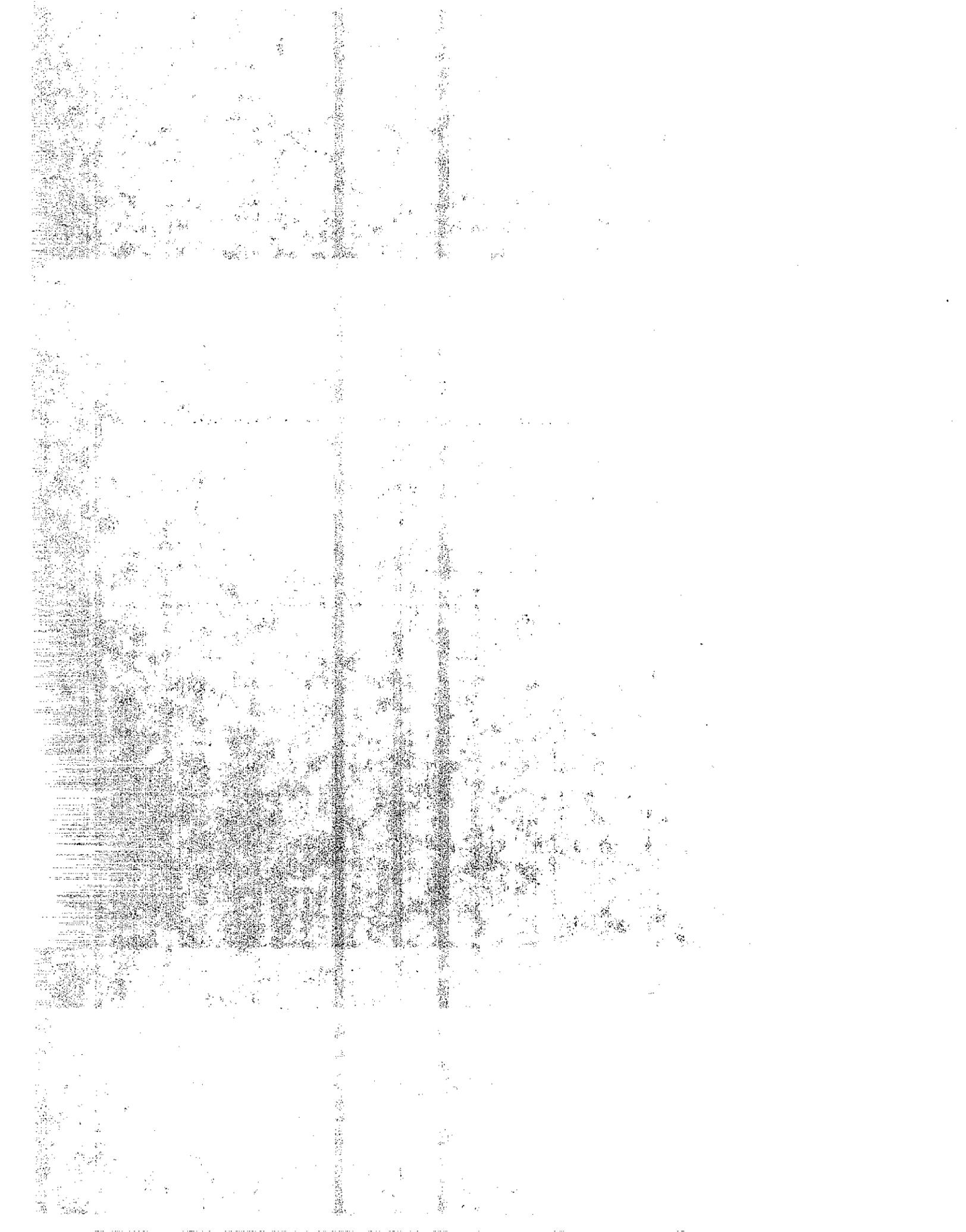


APPENDIX I

Field Measurements of Flat Plate Module Performance
in Humboldt County, California

Peter A. Lehman and Charles E. Chamberlin

Presented at the
19th IEEE Photovoltaic Specialists' Conference
New Orleans, May 1987



FIELD MEASUREMENTS OF FLAT PLATE MODULE PERFORMANCE
IN HUMBOLDT COUNTY, CALIFORNIA

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Abstract

We have measured and analyzed the field performance of over 100 flat plate photovoltaic modules located in Humboldt County, California. Performance data were obtained on-site through use of a portable I-V curve tracer and were analyzed through use of a five parameter model.

The primary goal of our study was to determine the effect of aging on module performance in a typical domestic situation. The conclusion drawn from our data is that module performance does not deteriorate with age even under these less than ideal conditions.

Other results reported include the effect of surface dirt on module performance, types of failure modes observed, and anecdotal information concerning system performance and reliability.

INTRODUCTION

The performance and durability of flat plate PV modules have been measured and documented in various government sponsored testing programs [1,2]. These programs have certain characteristics in common: (1) the purchase of modules in large blocks from manufacturers, (2) the deployment of the modules in large centralized arrays, and (3) the performance of installation and maintenance work by trained personnel.

The situation in Humboldt County stands in contrast to these programs. Humboldt County is located along the Pacific coast, 250 miles north of San Francisco. Though sparsely settled, it contains over 1000 stand-alone PV energy systems. These systems are small (most are comprised of 2 to 20 flat plate modules) and have been in place for up to 7 years. All system modules were purchased through regular retail or wholesale outlets. Some systems are expertly installed and cared for; others are not.

As such, these systems provide an opportunity to study module performance in a typical domestic environment. This is one of the environments that would be expected if the use of PV technology is to become widespread in our society.

EXPERIMENTAL TECHNIQUE

Data Gathering

The I-V curve tracer used for the measurements was a standard capacitive load device which has been described [3,4]. An SDK-51 development system was used to control the measurement process and temporarily store the I-V data pairs. Because the development system contained no nonvolatile memory, these data were then downloaded to a Tandy Model 100 computer for permanent field storage.

The time required for the measurement of an I-V curve was 5 to 8 seconds depending on the specific module being tested. This was a short enough so that the insolation striking the module was essentially constant during a run. Insolation measurements were made with a photovoltaic pyranometer mounted in the module plane and as close to the module as practicable. Runs were carried out under clear sky conditions with insolation values at or near one full sun. Sun angles to the module plane were not greater than 30° from normal. These conditions tended to minimize any errors which would be caused by spectral reddening and surface reflection.

To insure accurate insolation readings the pyranometer was calibrated versus the LAPSS apparatus at the Jet Propulsion Laboratory [5].

The performance of each module was measured at 25°C. This was accomplished by cooling the module to approximately 20°C and allowing it to warm in the sun to the desired temperature. The temperature rose approximately 0.4°C during a run.

Initial and final temperature readings were recorded for each run and averaged to give a mean run temperature.

Temperature measurements were made with an Omega fast response thermocouple. The thermocouple was mounted in an insulated housing and secured to the back of the module using a conductive paste to insure good thermal contact. Accuracy of the temperature measurement was checked by comparing the thermocouple output to an NBS standard thermometer. They were found to agree to within 0.1°C over the entire temperature range used in this study.

Temperature and insolation measurements were made manually during a run. These data along with descriptive information about the module being tested (module make, age, power rating, model #, location, etc.) were input into the Model 100 computer at the time the I-V data pairs were transferred. All this information was stored as a compressed data file for later retrieval and analysis.

In order to determine the effect of surface dirt on module output power, 20% of the modules, chosen randomly, were tested while dirty. They were then cleaned and retested. These tests were conducted while the modules were hot, i.e., at their steady state operating temperatures under a strong sun. This was done because it would have been difficult to leave the surface dirt layer undisturbed while cooling the panel. This method had the additional advantage of a constant temperature during a run.

The measurement of the I-V curve of 10% of the modules, also selected randomly, was repeated five times as a check on experimental precision. These tests were all run at 25°C.

Data Analysis

Upon return from the field, the compressed data files were downloaded to a larger microcomputer for interpretation and analysis.

The current values in each I-V data pair were normalized to one full sun using the insolation value for that run. Since runs were conducted at insolation near one full sun, this involved only a small correction.

A curve was fit to the normalized I-V curve using the following five parameter model [6,7]:

$$I = [IL - (Voc/Rp)] \{ \exp((V - IRs) * Ekt) - 1 \} / [\exp(Voc * Ekt) - 1] + (V - IRs) / Rp - IL$$

where:

- I = module current
- V = module voltage
- IL = light induced current
- Voc = open circuit voltage
- Rs = series resistance
- Rp = parallel resistance
- Ekt = electronic charge/Boltzmann's constant*temperature*ideality factor per cell

Model fit was excellent; an example is shown in Figure 1.

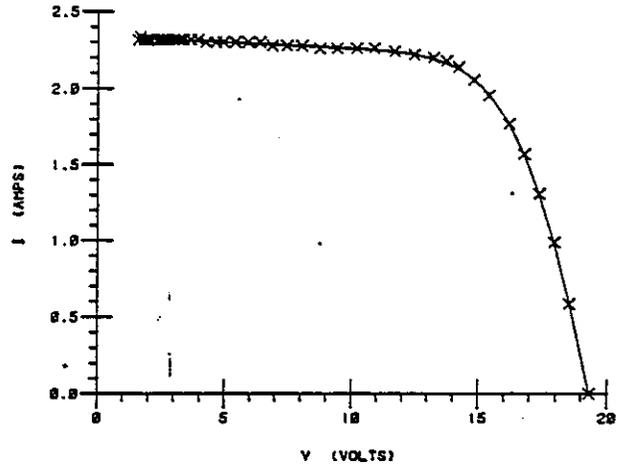


Figure 1. Results of typical test run. Points are experimental; curve is the fitted model.

The maximum power point for each module was calculated from the fitted curve.

As described above, precision of the measurements was checked by performing replicate runs. The results for one such series of replicates is shown in Figure 2.

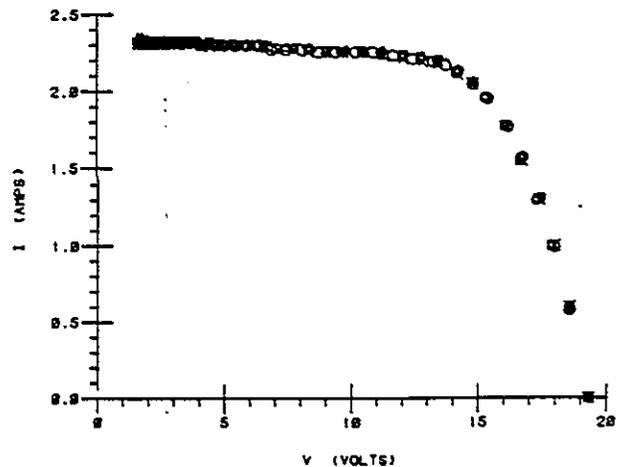


Figure 2. Results of five replicate runs on a single module.

In order to show the precision more explicitly, the residual of each data point was calculated as the difference between the measured current and the current predicted by the fitted model. In Figure 3, these residuals are plotted versus voltage for the five replicate runs shown above. As can be seen, the scatter in the points is approximately 20 milliamps. This is equal to the bin width of the 8-bit analog-to-digital converter used in recording the data and shows that no additional sources of random error are affecting the measurements.

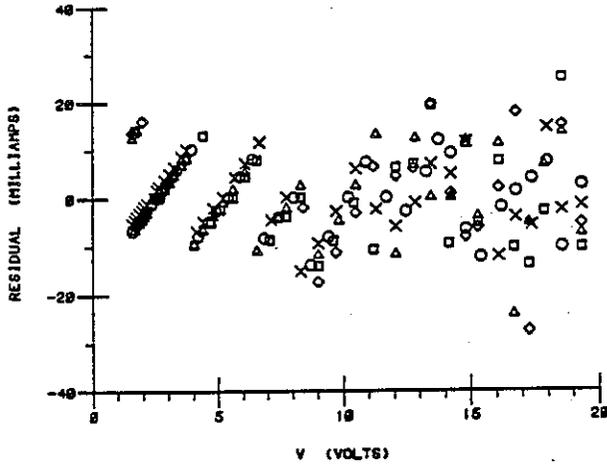


Figure 3. Residuals plotted versus voltage for five replicate runs.

RESULTS

Module Output Power vs. Age

The main result of our study is shown below. Maximum module output power is plotted versus module age.

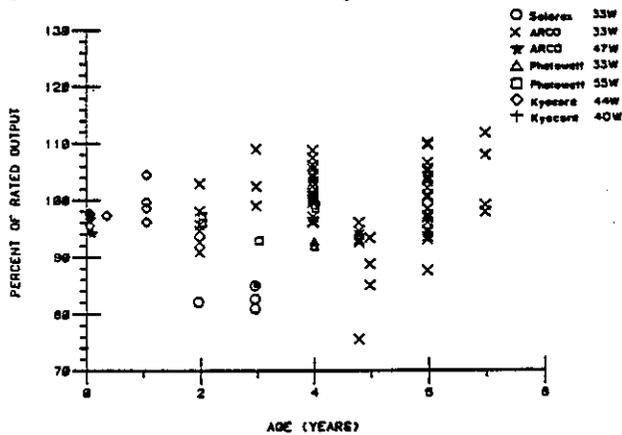


Figure 4. Plot of maximum module output power, shown as a percentage of its rated power, versus module age.

The correlation equation relating percent-age power to module age is:

$$(\% \text{ Power}) = 0.951 + 0.00643 * (\text{Age})$$

Several facets of this result should be noted. First, the correlation of power with age is positive, albeit quite small. This surprising result is probably explained by the fact that manufacturers are now more careful about testing and rating their modules than was the case seven years ago. Thus, it is less likely that a module would now leave the factory with a power output greater than its rating. This is born out by the value of the intercept of the correlation line of 0.951. This shows that the average new module we tested had a power output 5% less than its rating. No new module had a power output greater than its rating.

Regardless of the above discussion, however, the main conclusion to be drawn from this result is that module performance does not significantly deteriorate with age. This is true even for production line modules utilized in less than ideal circumstances. Some of the modules we tested had been poorly installed and not maintained to the point of neglect. Despite this, they continued to produce rated power. Our experience causes us to be inspired about the durability of this technology.

Effect of Surface Dirt

As described, we tested 20% of the modules while dirty and then after cleaning to determine the effect of surface dirt on module output power. The results are shown in Figure 5 below.

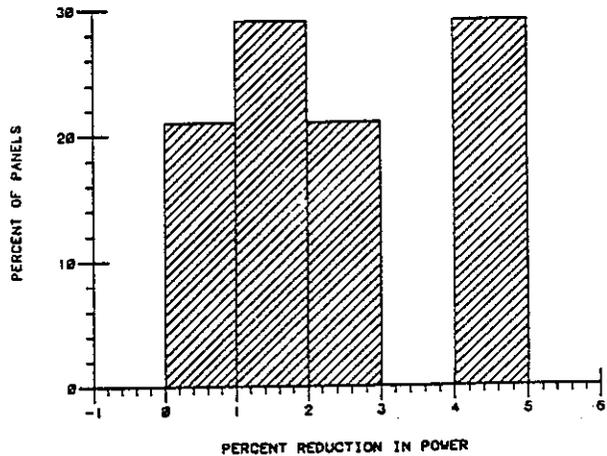


Figure 5. Histogram relating the percentage of modules with a given power loss when dirty to the percentage of power lost.

The average power loss was 2.4% and no module had greater than a 5% loss. This was despite the fact that some modules appeared to be quite dirty.

The area where these modules are located is rural and has generally excellent air quality. However, many of the roads are dirt or gravel and vehicular traffic causes significant amounts of dust. The area's climate consists of a winter rainy season and a summer dry season. Our measurements were conducted during the summer when it had not rained for several months. In spite of dust and lack of rain, however, power loss due to surface dirt was minimal.

Effect of Corrosion

During this study 112 modules were tested. Of that number 19 exhibited a brownish corrosion, mainly on the contact wires on the faces of the cells. The amount of corrosion varied from small, affecting a single cell, to fairly extensive, affecting nearly half the cells in the module. The corrosion appeared most often in the older modules; none was observed in modules less than 4 years old.

To determine the effect of corrosion on module output power, a group of 11 modules which exhibited corrosion was compared to a similar group of 16 modules which were corrosion free. Both groups were identical in age, manufacturer, and model. The results are shown in Figure 6 below.

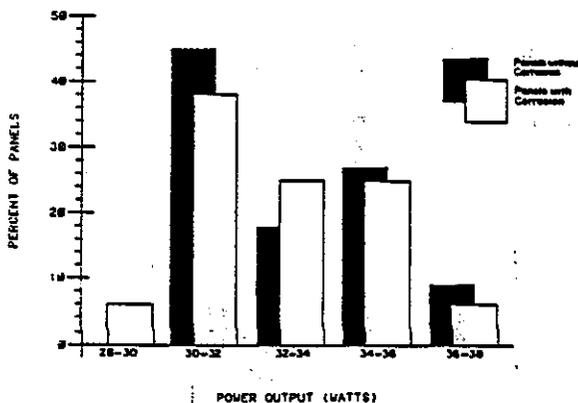


Figure 6. Histogram showing the effect of corrosion on output power for two otherwise identical groups of modules.

As can be seen in Figure 6, the two groups are similar. The mean power exhibited by the corrosion free group is 1.1% higher than the corrosion group. This small difference is statistically

insignificant, considering the scatter in the data. (The 95% confidence interval for the difference in the means is 8.4 times larger than the difference itself.) The conclusion to be drawn is that this type of corrosion has little or no effect on module output power.

Module with High Rs

One module we tested showed interesting and unusual behavior and is worthy of note. It was a 33W Arco, 16-2000 module that had been operating for over 4 years. It was installed in series with 7 other 33W modules to form a 115 volt power system. Outwardly it looked fine; it showed no corrosion, no cracked cells, and no other signs of problems. Its I-V curve is shown in Figure 7.

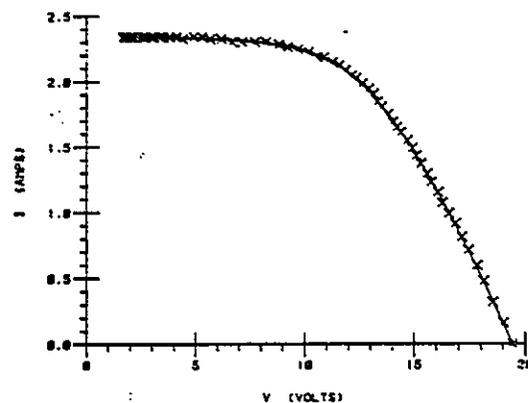


Figure 7. I-V curve of module with high series resistance.

Obvious from the I-V curve shown above is the relatively small slope at the high voltage end of the curve indicating a high series resistance. In fact, the series resistance for this module was 2.1 ohms. Most other modules tested had series resistances between 0 and 0.5 ohms. The high resistance lowered this module's output power to 24.9W, the lowest we measured.

The most interesting behavior, however, occurred when we tested this module at varying temperatures. Figure 8 shows this behavior.

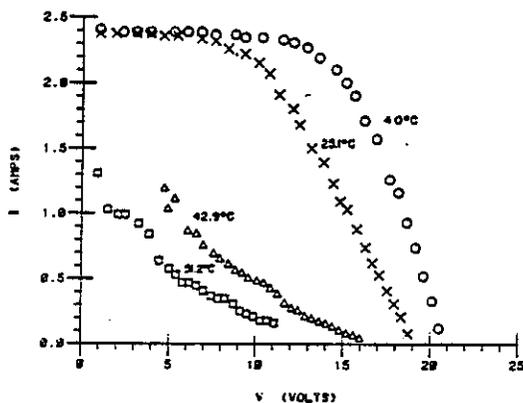


Figure 8. I-V curve of module with high series resistance at four temperatures: 4.0°C, 25.1°C, 42.9°C, and 51.2°C.

Clearly, some profound change occurs when the module is heated. The reason for this behavior remains unknown. Perhaps an unseen crack caused the high resistance and this crack was enlarged by thermal stresses. What is certain is that this module contributed little output at its normal operating temperatures. Further, because it was in a series string, it effectively robbed the entire system of its productivity.

Module Defects

In addition to the 19 modules which exhibited corrosion and the high R_s module described above, we found various other module defects in our study. Of the 112 modules tested:

- 4 had broken terminals and showed no output.
- 1 had a broken terminal which showed intermittent output. Output was normal when connected.
- 1 had a badly corroded terminal which showed normal output.
- 1 had a badly corroded cell and showed no output.
- 2 had a cell split by a visible crack but showed normal output.

Anecdotal Information

During the course of this study we collected anecdotal information concerning performance of PV system components from owners and users. The most useful of this information is condensed here.

Batteries generally worked well. The only exceptions were automobile batteries which did not hold up well when deep cycling occurred. However, batteries intended for deep cycling such as golf cart or fork lift batteries (which have a high antimony content) were reported to be reliable and durable.

System regulators also worked well. There were problems reported with early models which stemmed from their complexity but modern models are simpler and more reliable.

The major problem in these domestic systems was the inverters. Early models were notoriously unreliable, with the most common failure being blown power transistors. The early electronic inverters were so unreliable that some owners opted for motor generators, preferring the large inefficiency of these units (around 50%) to the fragility of the electronic inverters. Most of these problems, though, seem to be in the past. Modern electronic inverters were reported to be much more reliable and this together with their high efficiency (80-90%) have returned them to favor.

We encountered two Freon type passive trackers in our study and owners praised their performance. However, many owners felt that the enhancement in performance afforded by the trackers did not justify their high purchase price. They opted instead for additional modules. Often, too, stationary array mounts we saw were hinged and adjusted several times a year for enhanced performance.

CONCLUSIONS

Based on this field study, we make the following conclusions.

1. Photovoltaic modules, even production line modules which are utilized in less than ideal circumstances, are durable and effective in producing power. We saw no decrease in module output power relative to rated power over the age of the modules tested.
2. In the rural, nonpolluted but dusty area where we conducted our field measurements, cleaning of the modules would increase output power an average of 2.4%. At best, cleaning would add 5% to output power.
3. A portable I-V curve tracer is a useful and necessary tool for measuring module performance. For some types of module failures, measurement of the I-V curve is the only method of detection.

ACKNOWLEDGEMENTS

Support for this work from the California Department of Transportation is gratefully acknowledged.

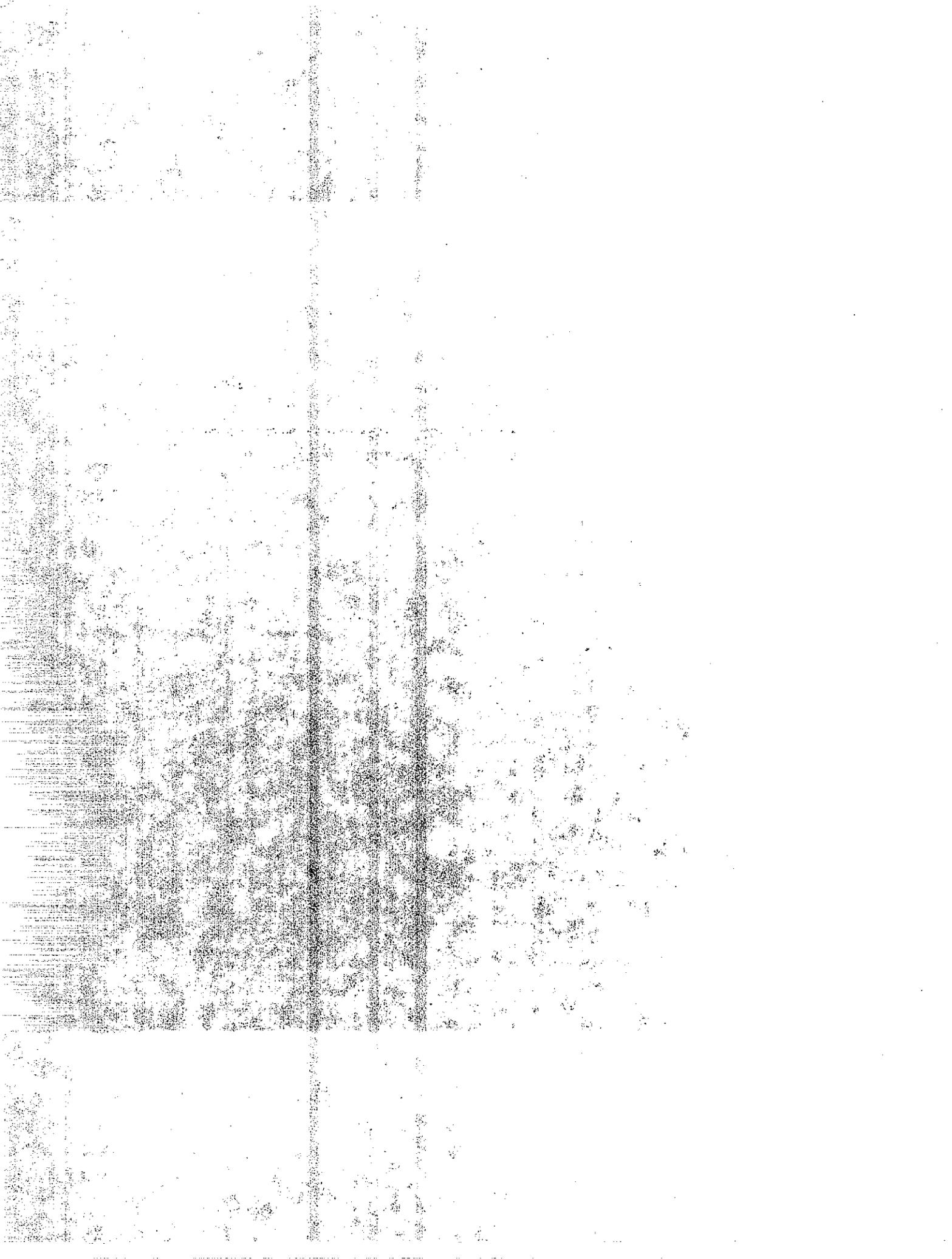
We wish to thank Clifford Sorenson for technical assistance and engineering students David Johnson, Richard Mayberry, Haydee Hampton, Brien Hamilton, and Martin Watson for assistance in carrying out this research.

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APPENDIX II

Raw Data Files of Field Measurements



```

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:10043000215C1C5C195C165C145D135C115C105C27
:100440000F5C0E5CFFF30C0B0C030C030C030C0A9
* 1 * * * 57.2 * 24.0 * 24.8 *
JOHN * * SOLAREX * *07/16/85*11:30*
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:10041000AC4CA5529D579859925B8A5D7F5E725E87
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:100430002460205F1C6019601660156020601160E8
:1004400010600F600E5FFFFB0C030C030C030C022
* 2 * * * 60.3 * 24.0 * 26.0 *
JOHN * * SOLAREX * *07/16/85*12:03*
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:10041000E24EAB53A3589D5A975C8E5E825F735F5A
:10042000665F5B5F515F47603F5F366030601260C0
:10043000116010610F600E60FFFF15602060116099
* 3 * * * 62.1 * 24.0 * 25.2 *
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* * * ARCO * 16-2000 *07/16/85*14:00*
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:10042000566F4F70496F42703D70387033702F7146
:100430002B712771247021701E711C701B71197132
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* 5 * * * 58.1 * 24.0 * 25.6 *
* * * ARCO * 16-2000 *07/16/85*14:15*
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* 6 * * * 57.0 * 24.0 * 25.8 *
* * * ARCO * 16-2000 *07/16/85*14:25*
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:10043000286F256F216F1F6E1C6F1B6F196F186F50
:10044000176F146F136E126F116F106FFFFF127220
* 7 * * * 55.7 * 24.0 * 26.2 *
* * * ARCO * 16-2000 *07/16/85*14:41*
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:100420004F6B486B416B3B6B366B316B2C6B286CA5
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* 8 * * * 54.4 * 24.0 * 25.2 *
* * * ARCO * 16-2000 *07/16/85*14:55*
:10040000C100BB1CB530AF3FA84CA3529D57965CB2
:100410008E5F876280637964716567655D66536628
:100420004C6644663E67376732672D6727672467E7
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* 9 * * * 53.6 * 24.0 * 25.6 *

```

*

* ARCO * 16-2000 *07/16/85*15:00*

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* 10 * 33 * 4 * 57.1 * 24.0 * 26.0 *
JOSHUA KINCH*ALDERPOINT ROAD*ARCO*16-2000*07/17/85*12:03* YAY
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* 11 * 33 * 4 * 58.5 * 24.0 * 25.4 *
JOSHUA KINCH*ALDERPOINT ROAD*ARCO*16-2000*07/17/85*12:18*
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* 12 * 33 * 4 * 59.0 * 24.0 * 25.2 *
JOSHUA KINCH*ALDERPOINT ROAD*ARCO*16-2000*07/17/85*12:27*MISSED SOME POINTS
:10040000C700C11DC030B840B44DB058A962A06B40
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* 13 * 33 * 4 * 59.4 * 24.0 * 26.0 *
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* 14 * 33 * 6 * 66.3 * 24.0 * 25.6 *
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* 15 * 33 * 6 * 67.5 * 24.4 * 25.8 *
FRED RADLOFF*TELEGRAPH RIDGE*ARCO*16-2000*07/18/85*10:41*PANEL WITH BROKEN TERMINAL -FIXED BEFORE TEST
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:10044000196D186E176D146D136D126E116E106D9F
:100450000F6EFFFF1072FFFF30C0704010C030C041
* 16 * 33 * 4 * 66.9 * 24.0 * 25.4 *
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* 17 * 33 * 4 * 66.1 * 24.0 * 25.2 *
FRED RADLOFF*TELEGRAPH RIDGE*PHOTOWATT* 0 *07/18/85*11:14*SOME POINTS MISSING
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* 18 * 55 * 3 * 69.9 * 24.0 * 25.4 *
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* 19 * 33 * 6 * 67.3 * 24.0 * 25.4 *
MARK WINTHERS*TELEGRAPH RIDGE*ARCO*16-2000*07/18/85*12:39*BROWN CORROSION ON CEL
L WIRES
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:10041000976F8E7288748074787571766A7662765A
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* 20 * 33 * 4 * 68.1 * 24.0 * 26.2 *
MARK WINTHERS*TELEGRAPH RIDGE*ARCO*16-2000*07/18/85*12:50*EXTRA POINTS
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:100440001E781D781B78177816781578147713782E
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* 21 * 33 * 3 * 68.7 * 24.0 * 26.2 *
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* 22 * 33 * 6 * 68.9 * 24.0 * 26.2 *
MARK WINTHERS*TELEGRAPH RIDGE*ARCO*16-2000*07/18/85*13:37*BROWN CORROSION ON CEL
L WIRES;SOLDERED LEAD ON PANEL;FIXED BEFORE TEST
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* 23 * 33 * 6 * 67.9 * 24.0 * 26.4 *
JOE RUBY*VALLEY*ARCO*16-2000*07/18/85*16:02*6 YRS OLD, BUT USED ON 3 YRS;FIXED B
EFORE TEST(BROKEN)
:10040000D600D123D038CA48C756C462C26CBF7662
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:100440002DB42BB42AB429B4FFFF1475137512769A
* 24 * 55 * 2 * 67.3 * 24.0 * 25.4 *
JOE RUBY*VALLEY*PHOTOWATT* ? *07/18/85*16:13*MANY POINTS MISSING
:10040000D600CE38C856C26BBD7DB88BB197AA9EB8
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:100430003BB335B332B42FB32DB42CB42AB429B4A2
:1004400028B4FFFF2AB429B4FFFF14751375127680
* 24.1 * 55 * 2 * 67.3 * 24.0 * 25.4 *

JOE RUBY*VALLEY*PHOTOWATT* ? *07/18/85*16:18*SECOND RUN, SIMILAR TO FIRST
:10040000C600C01EBB34B643B250AD5BA6659E6D40
:1004100097718F748875817679767277687762774D
:100420005B7754784D78477841783D7838783478E0
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:100440001C791B781A791779157914781378127931
:100450001179FFFF1075FFFF30C030C030C030C0D1
* 25 * 33 * 3 * 67.4 * 24.0 * 25.8 *
JOE RUBY*VALLEY*ARCO*16-2000*07/18/85*16:25*WE'RE (SIC) DONE OUR FIRST TRIP

:10040000C700C11CBD30B93FB54CB058AB62A36B3F
:100410009D6F95728E7488757F7578767076687624
:1004200060765A7753774D77477642773D773877BE
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:100440001E771C771B771A77167815781478137730
:1004500012781178FFFF30C030C030C030C030C0DB
* 26 * 33 * 3 * 64.3 * 24 * 25.8 *
CAROL AND LES SCHER*ETTERSBERG RD*ARCO*16-2000(264984)*07/24/85*10:04:45*
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:10043000357531752D752A752775247521751F75CC
:100440001D751C751B751A7519761675157514753D
:100450001375127511761075FFF30C030C030C0B3
* 27 * 33 * 4.8 * 66.1 * 24 * 25.6 *
CAROL AND LES SCHER*ETTERSBERG RD*ARCO*16-2000(252584)*07/24/85*10:21:33*
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:10044000217A1F7A1E7A1D7A1C7A1B7A1A7A177AF9
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* 26.1 * 33 * 3 * 67 * 26.8 * 26.8 *
CAROL AND LES SCHER*ETTERSBERG RD*ARCO*16-2000(264984)*07/24/85*10:31:08*INITIAL
T = 24.6, CHECKED AGAIN BECAUSE OUTPUT SO HIGH
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:1004400019741874187418741574147413741275117562
:100450001075FFF147A137A137B127B117AFFFF5A
* 28.1 * 33 * 4.8 * 67.1 * 63.8 * 63.8 *
CAROL AND LES SCHER*ETTERSBERG RD*ARCO*16-2000(252547)*07/24/85*10:35:48*HOT AND
DIRTY
:10040000AC00A70FA41CA0269D309A38973F9445B6
:10041000914B8F518C56885B855F81637D67796ACC
:10042000746D6D70657261735B73567450744A7548
:10043000457540753B75377633762F762C76297661
:100440002876237621761F761D771C771B761A7700
:100450001976167715771477137712771177FFFFD0
* 28.2 * 33 * 4.8 * 67.2 * 64.2 * 64.4 *
CAROL AND LES SCHER*ETTERSBERG RD*ARCO*16-2000*07/24/85*10:44:50*HOT AND CLEAN
:10040000C500BD1DB731B141AB4EA5589D61976682
:10041000916A8C6C876D7F6E776F6F70687060709B
:10042000597052714C71467141723C72377232721E
:100430002F722B7228732573227320731E731C7303
:100440001B731A7319731873157314731373127360
:1004500011741073FFF1477137712771177FFF72
* 28.3 * 33 * 4.8 * 66.9 * 24 * 25.8 *
CAROL AND LES SCHER*ETTERSBERG RD*ARCO*16-2000(252547)*07/24/85*10:53:08*COOL AN
D CLEAN - START OF REPLICATES
:10040000C500BD1EB732B141AB4EA459A06297677B
:10041000916A896D836E7B6F73706B7163715C71B0
:1004200055714F72497244733E733A733573317329
:100430002D732A732674247421741F741D741B7405
:100440001A74197416741574147413741274117464
:100450001074FFFFF1477137712771177FFF8
* 28.4 * 33 * 4.8 * 67.6 * 24 * 25.8 *
CAROL AND LES SCHER*ARCO*16-2000(252547)*07/24/85*11:01:51*
:10040000C500BD1DB632B041AA4DA4599C62976784
:10041000916A896D836F7B6F73716B7164715C71AD

```

:1004200055724F724C7243723E7339733573317328
:100430002D7329732674247421741F741D741B7406
:100440001A7416741574147413741275117410756B
:10045000FFFFFFFFF1477137712771177FFFF7E
* 28.5 * 33 * 4.8 * 67.2 * 24 * 25.6 *
CAROL AND LES SCHER*ETTERSBERG RD*ARCO*16-2000(252547)*07/24/85*11:05:32*
:10040000C500BD1EB632B041AA4EA4599C62976782
:10041000906A896E826F7B7072706A7162715C71B2
:1004200055724F72487243733E733973347330732D
:100430002D7429732674247421741F741D741C7404
:100440001A74197419741874167415741374127458
:10045000117411751074FFFF137712771177FFFF76
* 28.6 * 33 * 4.8 * 67.3 * 24 * 25.8 *
CAROL AND LES SCHER*ETTERSBERG RD*ARCO*16-2000(252547)*07/24/85*11:11:03*
:10040000C500BD1EBC32B041AB4EA4599C6297667C
:10041000916A896E826F7B7072716B7163715C71AE
:1004200056721A7416741574147513741274117448
:100430001075FFF2674247421741F741D741C74BE
* 28.7 * 33 * 4.8 * 67.5 * 24 * 25.2 *
CAROL AND LES SCHER*ETTERSBERG RD*ARCO*16-2000(252547)*07/24/85*11:14:03*
:10040000C600C110C01EBA29B733B43BB142AE49D1
:10041000AB4FA855A65AA05F9C649768916C8A6EF2
:1004200085708072797373736C7466745E755875B9
:1004300051754C75467640763B77367632762E7619
:100440002E7628762577227720761E771D771777EB
:1004500016771476137712771176FFF1177FFF67
* 29 * 33 * 4.8 * 67.8 * 25.8 * 25.8 *
CAROL AND LES SCHER*ETTERSBERG RD*ARCO*16-2000(252535)*07/24/85*11:21:53*INITIAL
TEMP= 24.0
:10040000C600C211BE1EBB29B833B53BB242AF49CC
:10041000AC4FA955A65BA2609E649A68946C337732
:100420003077167715771478137712771177FFF7E
* 30 * 33 * 4.8 * 67.1 * 24 * 25.2 *
CAROL AND LES SCHER*ETTERSBERG RD*ARCO*16-2000(252487)*07/24/85*11:29:13*MANY PC
INTS MISSING WILL DO SECOND RUN
:10040000C600BE1FB833B241AC4EA6599F639A686E
:10041000956B8F6F867180732477187816771577B0
:100420001477137712781178FFF12771177FFF97
* 30.1 * 33 * 4.8 * 68 * 24 * 25.2 *
CAROL AND LES SCHER*ETTERSBERG RD*ARCO*16-2000(252487)*07/24/85*11:32:15*NOT MUC
H BETTER BUT WE'RE USING IT
:10040000C900C31EBE33B942B44FAC5AA45D9F5F4E
:100410009A6194638F658A668568806A7B6B766C67
:10042000706D6C6E677062705D71597254734F734A
:100430004A74457441743C753876347630762D763E
:100440002A7627762476227620761E761C771B77EE
:100450001A771A7719771677157714771377127733
:100460001177FFF30C030C030C030C030C030C066
* 31 * 33 * 4.8 * 68 * 24 * 26 *
CAROL AND LES SCHER*ETTERSBERG RD*ARCO*16-2000(252730)*07/24/85*11:39:49*ONE CEL
L IS CRACKED
:10040000C600C208BD10B918B61EB224AF29AC2E62
:10041000A932A636A43AA13E9F419C459A48984BE2
:10042000964E935191538F558D588A5B885D8660A7
:10043000846281647E667C677969766B736C6F6EAB
:100440006C6E687063715E725A7354744F74497441
:1004500044743F753A75367632762D752A7627764E
:10046000247622761F761E761C761B761A761676F2
:1004700015761476137612761176FFF30C030C0F1
* 32 * 33 * 4.8 * 67.9 * 24 * 26.4 *
CAROL AND LES SCHER*ETTERSBERG RD*ARCO*16-2000(252485)*07/24/85*11:47:45*BAD PAN
EL

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:10040000C300BD1EB733B242AD4FA85AA0649D676A
:100410009B69986A956D916E8D70887283737C73F9
:1004200075746E7567756076597652764C77467638
:1004300041773B77377733772E772B772777257779
:10044000227720771E771D771C771B771A7817770E
:10045000157714771377137712771177FFFF2776C5
* 33 * 33 * 4.8 * 67.6 * 24 * 26 *

CAROL AND LES SCHER*ETTERSBERG RD*ARCO*16-2000(252334)*07/24/85*11:53:43*

:10040000D300CB35C451BD67B578B085A2889A8B2F
:10041000958C8E8D888D808D7A8D738E6C8E668E88
:10042000618E5C8E288E208E1D8E1C8E1B8E1A8EE9
:10043000198E188E178EFFFF30C030C030C030C00C
* 34 * 44 * 1 * 69.3 * 24 * 25.4 *

FRED BAUER*CROOKED PRAIRIE*KYOCERA*PSA100H-361H*07/24/85*14:03:19*MISSED SOME P
INTS

:10040000D300CD21C936C546C253BE5EBB69B772A3
:10041000E27AAD80A687A08A988C8F8E888F818FC4
:100420007A8F738F6C90688F618F5C8F578F538F2B
:100430004F904B8F47904490408F3D903A9038902A
:100440003590339031902F902E902C902A902990B7
:10045000289027902690259024901F901E901C9005
:100460001B901A91199018901790FFFF30C030C060
* 35 * 44 * 0.25 * 69.2 * 24 * 26.6 *

FRED BAUER*CROOKED PRAIRIE*KYOCERA*PSA100H-361H*07/24/85*14:17:22*

:100400000000FFFF30C0F0E030C010E010C030C08E
 * 36 * 33 * 6 * 66.9 * 50 * 50 *
 STEVEN REE*CROOKED PRAIRIE*ARCO*16-2000 (238254)*08/05/85*10:55:38*PANEL IS BROK
 EN AND GAVE NO OUTPUT. THE LEADS HAD BEEN WIRED WITH VERY STIFF WIRE AND BROKEN.
 :100400000D761B7623762B7637763F764D755575B0
 :100410005D7569746F73797285728D7197709F6E57
 :10042000AA6AAF62A958B958BD48C240C828CC12C0
 :10043000FFFFFFF308030C030C0B0C070C030D090
 * 37 * 33 * 6 * 67.9 * 24.6 * 25.6 *
 STEVEN REE*CROOKED PRAIRIE*ARCO*16-2000 (238004)*08/05/85*11:07:44*A LITTLE BROW
 N CORROSION
 :10040000807511751F7427742F733B7345724F727B
 :10041000597165706B6F776D7F6C86698F689764B3
 :100420009F61A75AAF54B34DB941BF2EC31EC71029
 :10043000CB02CA02FFFF30C030C0B0C070C030D0A5
 * 38 * 33 * 6 * 70.2 * 24.6 * 25.2 *
 STEVEN REE*CROOKED PRAIRIE*ARCO*16-2000 (237915)*08/05/85*11:14:07*A BIT OF BROW
 N CORROSION
 :100400000000FFFF1F7427742F733B7345724F72F8
 * 39 * 33 * 6 * 70 * 24.6 * 25.2 *
 STEVEN REE*CROOKED PRAIRIE*ARCO*16-2000 (238332)*08/05/85*11:21:54*SEEMS LIKE TH
 ERE WERE TOO FEW POINTS; WE'LL DO IT OVER
 :100400000000FFFF1F7427742F733B7345724F72F8
 * 39.1 * 33 * 6 * 70.2 * 24.6 * 24.6 *
 STEVEN REE*CROOKED PRAIRIE*ARCO*16-2000 (238332)*08/05/85*11:29:17*PANEL AHS ONE
 BADLY CORRODED CELL AND SOME GENERAL BROWN CORROSION. SEEMS TO BE SHOT.
 :100400000F7A177A1F792F7937793F794D78557898
 :100410005D786A77727779767F748D7395709F6C4B
 :10042000A668AF60B458B94EC136C624CA13FFFFE0
 * 40 * 33 * 6 * 70.2 * 24.6 * 25.2 *
 STEVEN REE*CROOKED PRAIRIE*ARCO*16-2000 (237760)*08/05/85*11:35:20*SOME BROWN CO
 RRSION ONE A FEW CELLS
 :10040000D27B137B1D7B277B337B3D7A4A7A527AE2
 :100410005B7A677A6F7A777983788B7793769B7438
 :10042000A770AD6CB660BB58BF4DC53CC92BCD1A8B
 :10043000D106FFFFFFF30C030C0B0C070C030D069
 * 41 * 33 * 6 * 69.9 * 24.6 * 25.2 *
 STEVEN REE*CROOKED PRAIRIE*ARCO*16-2000 (237973)*08/05/85*11:42:18*FAIRLY BAD CO
 RRSION ON SOME CELLS
 :100400000000FFFF1D7B277B337B3D7A4A7A527ABF
 * 42 * 33 * 6 * 70 * 35 * 35 *
 STEVEN REE*CROOKED PRAIRIE*ARCO*16-2000 (238022)*08/05/85*11:44:30*PANEL TERMINA
 L IS BROKEN. PANEL IS
 INOPERABLE.
 :100400000B7617761F76297537753F754B755374C4
 :100410005F7467736F717B70836C8D66935C9B54A4
 :100420009F46A53CAB28B016B406FFFF9953983001
 * 43.1 * 33 * 6 * 70.8 * 65.2 * 65.2 *
 LARRY AND DANA HEALD*CROOKED PRAIRIE*ARCO*16-2000 (237361)*08/05/85*13:16:07*
 :100400000B77197622762F76377645754D765975A6
 :100410005F75697475737D70876C8F6897609D5682
 :10042000A248A740AE2AB316B706FFFF99539830EB
 * 43.2 * 33 * 6 * 71 * 60.4 * 60.4 *
 LARRY AND DANA HEALD*CROOKED PRAIRIE*ARCO*16-2000 (237361)*08/05/85*13:18:06*
 :100400000F751D75257532753A7443744F745774A2
 :1004100063736B7373727F7287729271996FA36B40
 :10042000AA66AF5CB754BC44C13CC727CB14CF0508
 :10043000FFFF8C0D860D820B80277F3384558962E8
 * 43.3 * 33 * 6 * 71.3 * 24.6 * 25.6 *
 LARRY AND DANA HEALD*CROOKED PRAIRIE*ARCO*16-2000 (237361)*08/05/85*13:23:31*LIT
 TLE BIT OF BROWN CORROSION.

:100400000D7B177B1F7B2D7A377A43794B79577891
 :100410005F78697775767D7489738F709B6DA1693C
 :10042000A761B15AB54DEB44BF3CC526C914CD0325
 :10043000FFFF8COD860D820B80277F3384558962E8
 * 44 * 33 * 6 * 71.5 * 24.6 * 25.6 *
 LARRY AND DANA HEALD*CROOKED PRAIRIE*ARCO*16-2000 (237236)*08/05/85*13:31:38*BR
 WN CORROSION ON THREE CELLS.
 :100400000D7715771F762B7633763F7649765176C2
 :100410005E766675627572757A747F748D72957189
 :100420009F6DA66AAD62E55ABA4DBF44C33AC9269C
 :10043000CD14FFFF860D820B80277F3384558962A0
 * 45 * 33 * 6 * 71.6 * 24.6 * 25.6 *
 LARRY AND DANA HEALD*CROOKED PRAIRIE*ARCO*16-2000 (237130)*08/05/85*13:39:29*DO
 NG AGAIN (LOW OUTPUT).
 :100400000B7719771F772A7737773F7647765577B7
 :100410005D7669766F75797485738C71976D9D695A
 :10042000A360AC58B150B640BB2ABF1DC30EFFFFF3E
 * 45.9 * 33 * 6 * 71.7 * 38.8 * 38.8 *
 LARRY AND DANA HEALD*CROOKED PRAIRIE*ARCO*16-2000 (237130)*08/05/85*13:45:11*RE
 PEAT PANEL COLD (CALL IT .8)
 :100400000D761A7723762F7637763F764D765576AA
 :100410005F76697571757D7485748F7297709F6C46
 :10042000A967AF61B755BB4CBF408334C334C82202
 :10043000CC11FFFF860D820B80277F3384558962A4
 * 45.8 * 33 * 6 * 71.8 * 24.6 * 25.4 *
 LARRY AND DANA HEALD*CROOKED PRAIRIE*ARCO*16-2000 (237130)*08/05/85*13:48:55*WE
 LL TAKE IT
 :100400000B7E157E237D2B7D357D3F7C4B7C577C81
 :100410005F7B697A757A7D7989778F759772A36C1E
 :10042000A968AF5CB754BB4ABF3BC332C720CB11EE
 :10043000FFFFFFFF860D820B80277F338455896283
 * 46 * 33 * 6 * 71.9 * 24.6 * 25.8 *
 LARRY AND DANA HEALD*CROOKED PRAIRIE*ARCO*16-2000 (237246)*08/05/85*13:55:27*
 :10040000097D177D1F7D2A7D377C3F7C4D7B567B88
 :100410005F7B6B7A737A7B7887778F759B72A16E1F
 :10042000A76AB160B658BB48BF40C334C722CB12DD
 :10043000FFFFFFFF860D820B80277F338455896283
 * 47 * 33 * 6 * 72 * 24.6 * 25.2 *
 LARRY AND DANA HEALD*CROOKED PRAIRIE*ARCO*16-2000 (237199)*08/05/85*14:01:07*
 :100400000B7D157D237C2B7C3A7B3F7B4F7A577984
 :100410005F786B7673747B72866C8D68935D9B548A
 :100420009F4CFFFA53CAA28AE1CB20FFFFFCB12CA
 * 48.1 * 33 * 6 * 71.8 * 64.4 * 64.4 *
 LARRY AND DANA HEALD*CROOKED PRAIRIE*ARCO*16-2000 (237291)*08/05/85*14:07:20*DI
 N'T GO ALL THE WAY
 :100400000F7D1D7D257C337C3B7C457A517950796D
 :100410005A7967786E7676747F70876B8F66975A95
 :100420009B529F44A53AAB26B014B403FFFFCB12F6
 * 48.1 * 33 * 6 * 71.8 * 65.4 * 65.4 *
 LARRY AND DANA HEALD*CROOKED PRAIRIE*ARCO*16-2000 (237291)*08/05/85*14:09:42*LO
 KS OK,BUT RATED OUTPUT SEEMS TOO LOW.
 :100400000B77E137E1B7D257D337C3B7C437B4F7BFE
 :10041000597A5F796D7775767D71876D8F68976092
 :100420009D56A14DA740AC29B11DB50CFFFCB12C5
 * 48.2 * 33 * 6 * 72 * 61.8 * 61.8 *
 LARRY AND DANA HEALD*CROOKED PRAIRIE*ARCO*16-2000 (237291)*08/05/85*14:11:51*ONI
 HIGH POINT.
 :100400000F7D177C267D2F7C377B457B4D7B557A76
 :10041000627A6A7972787F7786768D7499719F6D2A
 :10042000A66AAF61B559B950BF42C530C920CD0DDC
 :10043000FFFFFFFF860D820B80277F338455896283
 * 48.3 * 33 * 6 * 71.8 * 24.6 * 25.4 *

LARRY AND DANA HEALD*CROOKED PRAIRIE*ARCO*16-2000 (237291)*08/05/85*14:17:34*
:10040000B87C157C1F7C2D7B357B437B4B7A537AE4
:100410005F7867776F767B72837089689362995A89
:100420009F4CA342AA2CAE1DB210FFFFC920CDODD8
* 49.1 * 33 * 6 * 71.8 * 63.2 * 63.2 *
LARRY AND DANA HEALD*CROOKED PRAIRIE*ARCO*16-2000 (237204)*08/05/85*14:22:05*COM
PLETLY CRAKED CELL AND BROWN CORROSION ON 2 CELLS ON LAST PANEL.
:10040000B07C167C1F7C077C277C357B3F7B4B7B3D
:10041000537A5B7967786F76777583708A6C8F68AB
:10042000995C9F54A34AA73CAB34AF21B315B703E3
:10043000FFFFFFFFF860D820B80277F338455896283
* 49.2 * 33 * 6 * 71.8 * 61.8 * 61.8 *
LARRY AND DANA HEALD*CROOKED PRAIRIE*ARCO*16-2000 (237204)*08/05/85*14:23:56*ONE
HIGH POINT, AGAIN!
:100400000B7B157B237B2B7A357A3F7A4B7A577996
:100410005F79677873777B7783758F7397719D6E3C
:10042000A768AD62A15AB35AB94CBD44C42DC918CE
:10043000CD06FFFFF860D820B80277F3384558962AE
* 49.3 * 33 * 6 * 71.6 * 24.6 * 25.6 *
LARRY AND DANA HEALD*CROOKED PRAIRIE*ARCO*16-2000 (237204)*08/05/85*14:29:22*ONE
BAD CORROSION SPOT AT TERMINAL SITE.
:100400000F7B197B277B2F7A3E7B477A537A5B7968
:1004100063786F7877767F76877493719B6CA56825
:10042000AB63B358B750BB44BF38C330C71DCBOAOA
:10043000FFFFFFFFF860D820B80277F338455896283
* 49.4 * 33 * 6 * 71.6 * 24.6 * 25.8 *
LARRY AND DANA HEALD*CROOKED PRAIRIE*ARCO*16-2000 (237204)*08/05/85*14:31:34*
:100400000A7A177A1F7A2E79377A3F794B7953789F
:100410005D7869776F77777685748B7393719E6C4F
:10042000A568AB64B358B750BB48BF39C330C720C9
:10043000CB0DFFFFF860D820B80277F3384558962A9
* 49.5 * 33 * 6 * 71.1 * 24.6 * 25.4 *
LARRY AND DANA HEALD*CROOKED PRAIRIE*ARCO*16-2000 (237204)*08/05/85*14:35:17*
:10040000127A1B7A277A2F7A397A47794F79FD
:1004100057785F776B7775767F7587748F719B6E72
:10042000A16BAB64B15DB655BC48C235C722CB12D7
:10043000FFFFFFFFF860D820B80277F338455896283
* 49.6 * 33 * 6 * 71 * 24.6 * 25.8 *
LARRY AND DANA HEALD*CROOKED PRAIRIE*ARCO*16-2000 (237204)*08/05/85*14:38:47*
:100400000F7A177A1F7A2F7937793F79477955799B
:100410005E776B7773767B7587748E7299709F6D3C
:10042000A768AD60B558BA50BF42C339C825CC14CF
:10043000FFFFFFFFF860D820B80277F338455896283
* 49.7 * 33 * 6 * 71 * 24.6 * 25.4 *
LARRY AND DANA HEALD*CROOKED PRAIRIE*ARCO*16-2000 (237204)*08/05/85*14:41:50*
:100400000D7A1B7A037923792B7935783F784B78ED
:1004100057775F7667766F757B7483728E70956D94
:100420009B6AA364AB5EB152B749BB40C22CC718EC
:10043000CB08C802CC02FFFFF80277F338455896236
* 50 * 33 * 6 * 70 * 24.6 * 25.6 *
LARRY AND DANA HEALD*CROOKED PRAIRIE*ARCO*16-2000 (237198)*08/05/85*14:48:18*BRC
WN CORROSION ON FIVE CELLS.
:100400000A7617751F7527752F753D7546745275D9
:100410005A7462746A7477737E7389728F7197707D
:100420009F6CA968AF62B758BC50C336C72DCB1CB0
:10043000CF0BFFFFFCC02FFFFF80277F3384558962FB
* 51 * 33 * 6 * 69.6 * 24.6 * 25.2 *
LARRY AND DANA HEALD*CROOKED PRAIRIE*ARCO*16-2000 (237116)*08/05/85*14:55:11*4 (C
ELLS WITH BROWN CORROSION.
:10040000D87917791F792F7937783F7847775577DB
:100410005D776977717679757F748D7294719F6E4F
:10042000A56AAB66A25CB25CBA54BE4AC33CC72A9A

:10043000CB1ACFOAFFFFFFFFF80277F3384558962E5

* 52 * 33 * 6 * 69 * 24.6 * 25.4 *

LARRY AND DANA HEALD*CROOKED PRAIRIE*ARCO*16-2000 (237165)*08/05/85*15:00:36*ALL
CELLS HAVE CORROSION ON RIGHT EDGE.

:100400000977177723762D7635753F754A755775B9
:100410005F74677473747B7387738F709B6EA5684A
:10042000AB62AF54B748BD30C11CC509FFFF70COF7
* 53.1 * 33 * 6 * 65.6 * 24.6 * 25.2 *
ANN AND ROBERT*BLACK FOREST*ARCO*16-2000 (262046)*08/06/85*10:47:18*
:100400000D78167823782B7835773F774A775777AA
:100410005F76677573757B7587748F7396719F6E42
:10042000A764B15CB54ABB40C124C50CFFF70COD6
* 54 * 33 * 6 * 64.6 * 24.6 * 25.2 *
ANN AND ROBERT*BLACK FOREST*ARCO*16-2000 (260617)*08/06/85*10:52:58*
:10040000C5740F74197327732F733B7343734F7342
:1004100057725F726C7175707F6F876D936B9965A2
:10042000A360A755AF4CB344B735BC26C012C40572
:10043000FFFF90C0308030C030C0B0C030C030D07E
* 55.1 * 33 * 6 * 64.8 * 41 * 41.2 *
ANN AND ROBERT*BLACK FOREST*ARCO*16-2000 (138083)*08/06/85*11:01:06*
:10040000C475007513751B7523752F7539753F7489
:100410004F74577363736B7277727F718B6E916DCC
:100420009968A363A758AF50B340B938BD24C1162B
:10043000C506FFFF308030C030C0B0C030C030D003
* 55.2 * 33 * 6 * 65.2 * 41 * 41.2 *
ANN AND ROBERT*BLACK FOREST*ARCO*16-2000 (138083)*08/06/85*11:06:26*
:10040000D07513751D7408742A7433743F74477360
:100410004F735B7363726F7277727F708B70936DC3
:100420009D6CA569AE63A25CB35CB950BF46C3388E
:10043000C826CC12D003FFFF30C0B0C030C030D0CF
* 55.3 * 33 * 6 * 65.5 * 24.6 * 25.2 *
ANN AND ROBERT*BLACK FOREST*ARCO*16-2000 (138083)*08/06/85*11:11:17*7 CELLS WITH
BROWN CORROSION
:100400000B7B157B237B2B7B397B3F7A4B7A577A8F
:100410005F7A6D7975787E768A74916E9C68A26039
:10042000A952AD48B138B530B91CBD0BFFFC33878
* 56.1 * 33 * 6 * 68.3 * 55.2 * 55.4 *
ANN AND ROBERT*BLACK FOREST*ARCO*16-2000 (138114)*08/06/85*11:14:09*
:100400000F7B177B257B2E7B377A457A4D7A5B7A7B
:10041000637A6B7977787F768B7493709A68A36030
:10042000A856AF45B52CB920BD0CFFFFFC33860
* 56.2 * 33 * 6 * 67.6 * 55.4 * 55.4 *
ANN AND ROBERT*BLACK FOREST*ARCO*16-2000 (138114)*08/06/85*11:15:48*
:10040000D07B157B1F7B0B7A2B7A357A3E7A4B7A21
:10041000537A5F7A697971787E78877893769A755E
:100420009F73AB6DB367B859BF50C344C734CB2378
:10043000CF10FFFFD003FFFF30C0B0C030C030D0BE
* 56.3 * 33 * 6 * 68.2 * 24.6 * 25.2 *
ANN AND ROBERT*BLACK FOREST*ARCO*16-2000 (138114)*08/06/85*11:24:23*5 CELLS WITH
BROWN CORROSION.
:10040000C07E127E1F7D2A7D377E3F7D4F7D477DDA
:10041000577D5F7D6D7C757C7D7C8A7B927A9A7836
:10042000A573AB6DB264B951BD44C328C712FFFFB9
* 57 * 33 * 6 * 68.7 * 24.6 * 25.2 *
ANN AND ROBERT*BLACK FOREST*ARCO*16-2000 (261877)*08/06/85*11:30:48*
:10040000C87C127C1B7C277B317B3B7B477B4F7AF4
:10041000577A65796E7976797F788B77827692765E
:100420009E73A570AB68B358B74EBB42BF30C416BD
:10043000FFFFFDD003FFFF30C0B0C030C030D09F
* 58 * 33 * 6 * 69.2 * 24.6 * 25.4 *
ANN AND ROBERT*BLACK FOREST, CROOKED PRAIRIE*ARCO*16-2000 (260440)*08/06/85*11:37
:29*
:10040000D08015801F7F277F357E3F7E477E557DBC
:100410005D7D667C737B7B7A83788F7696729D7028
:10042000A768AD60B35ABA4CC13CC530C924CD15DC

:10043000D106FFFFD003FFFF30C0B0C030C030D0C6
* 59.1 * 33 * 6 * 69.5 * 37.6 * 38 *
ANN AND ROBERT*BLACK FOREST, CROOKED PRAIRIE*ARCO*NO MODEL # (L-0801286)*08/06/85
*11:45:51*NEW DEFECTED SOLAREX WITH RED PAINT ON FRONT.
:1004000007640F641B6422642D6435643B64436499
:100410004D6455645F6465636D6377637D63836377
:100420008E6293619A609F5BA958A954A954A954FC
:1004300030C090C0308030C030C0B0C070C030C05C
:1004400030C090C030C030C0B0C030C030C030C04C
:10045000B0C070C0A954A954A954A954AE54B54B06
:10046000B945BD40C135C62ACA1ECE12D206FFFF0D
* 60 * 33 * 2 * 71.1 * 24.6 * 25.2 *
**SOLAREX*4330EG*08/06/85*12:38:42*
:1004000013CB1FCB37CB47CA5DC86BC777C687C036
:1004100097B8A3AAAF8AB674BB60BF40C330C714F5
:10042000FFFF93619A609F5BA958A954A954A954EE
* 61 * 33 * 2 * 71.8 * 24.6 * 24.8 *
PAUL AND JUDY*BLACK FOREST, CROOKED PRAIRIE*SOLAREX*SAME AS #60*08/06/85*12:56:5
7*

:10040000806613661B6622662D6635663B66476608
:100410004D6555655F6566656F6577657E65876463
:100420008F6495639F60A45EAA5AB152B64CBA45D8
:10043000BF38C32AC71CCB0EFFFFB0C030C030C0CE
* 63 * 33 * 7 * 63 * 24.6 * 25.2 *
RANDY DRESSNER*CROOKED PRAIRIE*ARCO*16-2000 (238734)*08/06/85*14:55:37*3 CELLS W
ITH BROWN CORROSION.
:100400000D76057617761F752D7635753F7649750D
:1004100051755A7567756E747B757F758A7495749E
:100420009D72A370AB69B562B959BF48C340C92872
:10043000CD10FFFFC71CCB0EFFFFB0C030C030COD7
* 64 * 33 * 7 * 66.9 * 24.6 * 25.2 *
RANDY DRESSNER*CROOKED PRAIRIE*ARCO*16-2000 (238800)*08/06/85*15:04:38*1 CELL WI
TH BROWN CORROSION.
:10040000D46D126D1A6C226C2E6C356B3D6B496B82
:100410004F6A576A636A6A6971697D6983688E6821
:1004200095689B67A264AB62B15DB754BE4AC434A1
:10043000C82AFFFFC71CCB0EFFFFB0C030C030COC2
* 65 * 33 * 7 * 66.3 * 24.6 * 25 *
RANDY DRESSNER*CROOKED PRAIRIE*ARCO*16-2000 (238748)*08/06/85*15:11:20*6 CELLS W
ITH BROWN CORROSION.
:10040000097717771F77277735773D764B765376C1
:100410005B7563756F7477737F70896D8F68976094
:100420009F56A34CA740AC34B022B411B804FFFFD0
* 66.1 * 33 * 7 * 65.1 * 60.6 * 60.8 *
RANDY DRESSNER*CROOKED PRAIRIE*ARCO*16-2000 (137847)*08/06/85*15:14:10*
:100400000B7913791D792B7933793D7849785178E7
:100410005B7767776F76777583748B71926A9B646D
:10042000A15DA750AD44B32CB720BB0CFFFFFFF6D
* 66.2 * 33 * 7 * 65.2 * 58.4 * 57.4 *
RANDY DRESSNER*CROOKED PRAIRIE*ARCO*16-2000 (137847)*08/06/85*15:17:29*TOO COOL
OF TEMP,DO AGAIN.
:100400000B7813781D782B7833783B770377477711
:100410004F775976407566756D7576737F72897002
:100420008F699A629F5AA44CAA42A838AD38B32467
:10043000B712FFFFC71CCB0EFFFFB0C030C030COEB
* 66.9 * 33 * 7 * 64.5 * 60.4 * 60.4 *
RANDY DRESSNER*CROOKED PRAIRIE*ARCO*16-2000 (137847)*08/06/85*15:19:37*REPEAT RU
N TO MATCH DUSTY TEMP.
:100400000F77197727762F76377545764D755575A1
:100410005F7467746F74777485738B7293709F6F5A
:10042000A66CAD68B560BB58BF4DC340C734CB2088
:10043000CF0EFFFFC71CCB0EFFFFB0C030C030COD7
* 66.3 * 33 * 7 * 64.4 * 24.6 * 25.2 *
RANDY DRESSNER*CROOKED PRAIRIE*ARCO*16-2000 (137847)*08/06/85*15:24:05*6 CELLS W
ITH BROWN CORROSION.
:100400000FB225B12FB03FB04BAE5DAD69AD75AB4E
:1004100087A993A791A49DA4AB9CB590BC80C3640D
:10042000C950CF34D315FFFFBF4DC340C734CB20D5
* 67 * 55 * 2 * 64.9 * 24.6 * 25.2 *
RANDY DRESSNER*CROOKED PRAIRIE*PHOTOWATT*NO MODEL#*08/06/85*15:31:44*

:100400000F77177725772D7735773E760A764B76F7
:1004100053765B7667766F76777583768B75937593
:100420009F74A572AD6CB664BB5CBF4CC540C92857
:10043000CD1CD106FFF30C030C0B0C070C030D07E
* 68 * 45 * 1 * 52.9 * 24.8 * 25.2 *
ROOS KOEN*PERRY MEADOW RD*KYOCERA**05/15/88*09:53:42*MODEL #LA361J45AV, SERIAL #
531911, PANEL CONNECTIONS LOOK CORRODED
:100400000B7513751F75297532753B7547754F75DB
:10041000577563746B7573757F7487748F719A7079
:100420009F6CA762AF59B450BC34C219FFFFC928F2
* 69.1 * 45 * 1 * 54.7 * 42 * 42 *
ROOS KOEN*PERRY MEADOW RD*KYOCERA*LA361J45AV, 521330*05/15/88*09:57:10*
:100400000F76177625762D76367643764B765376AD
:100410005F7667756F767B7683758B7493729E6E4D
:10042000A56AAB60B354B940BD30C120C50AFFFFF17
* 69.2 * 45 * 1 * 54.4 * 41.8 * 42 *
ROOS KOEN*PERRY MEADOW RD*KYOCERA*LA361J45AV, 521330*05/15/88*10:05:06*
:10040000807E1D7E277E2F7D3F7E477E4F7E5F7ED6
:10041000677E6F7D7D7D857C8E7899749F6CA75CEF
:10042000AE50B532B921BD10FFFF96709B6C9F682E
* 70.1 * 45 * 1 * 58.6 * 50 * 50.2 *
ROSS KOEN*PERRY MEADOW RD*KYOCERA*LA361J45AV, 531912*05/15/88*10:24:03*HOT AND I
USTY
:100400000F7F17841F842B843B8443844D845B843B
:1004100063846D847B8383828D80997A9F74A66ABE
:10042000AB58B24AB82EBC20C009FFFF9B6C9F6836
* 70.2 * 45 * 1 * 60 * 49.2 * 49.2 *
ROSS KOEN*PERRY MEADOW RD*KYOCERA*LA361J45AV, 531912*05/15/88*10:27:53*HOT AND C
LEAN
:1004000013891E892D8837883F884A8857885F87D7
:100410006B8779877F878B8693859F82A980AF744E
:10042000BA68BF5AC3CCA2ECE15FFFF9B6C9F689B
* 70.3 * 45 * 1 * 62.5 * 25 * 25.6 *
ROSS KOEN*PERRY MEADOW RD*KYOCERA*SAME*05/15/88*10:36:22*
:10040000D08B178B238B2D8B378A468B4F8A598A3B
:10041000678A6F8A7B8A838992899B88A386AB804F
:10042000B776BD6AC254C744CB38D01AFF9F6865
* 71 * 45 * 1 * 65 * 24.6 * 25 *
ROSS KOEN*PERRY MEADOW RD*KYOCERA*LA361J45AV, 531907*05/15/88*10:45:03*
:1004000009620F62176223622A6231623C624362B0
:1004100049624F615B615F6167616F6079607F60B6
:10042000855E8F5C945A99569F50A64AAA44B2346E
:10043000B628BB1CBF0CFFFCB1EC91ACD1AD10CAE
* 73.1 * 32 * 5 * 68.8 * 50.2 * 50.2 *
ROSS KOEN*PERRY MEADOW RD*SOLAREX*4330EG*05/15/88*11:06:48*HOT AND DUSTY
:100400000A651165196524642B6533653A65456491
:100410004B6453645D6463646B6371637B6382628A
:100420008960925E975B9D58A350A94AAD43B1394C
:10043000B532B926BD1AC10DFFFC91ACD1AD10CAC
* 73.2 * 32 * 5 * 69.5 * 48.2 * 48.2 *
ROSS KOEN*PERRY MEADOW RD*SOLAREX*4330EG*05/15/88*11:12:12*HOT AND CLEAN
:10040000D066126619661F66276633663B663F65CF
:10041000496553655B655F656765736479657F648E
:100420008764916397629D61A35EAD5AB155B74CE5
:10043000BD46C338C9:10044000FFFF90C030C030C030C030C03E
* 73.3 * 32 * 5 * 69.5 * 24.8 * 25 *
ROSS KOEN*PERRY MEADOW RD*SOLAREX*4330EG*05/15/88*11:25:43*LOOKS SCREWY
:100400000A6715671D6625672F6737663E6746666C
:100410004F6657665E6665656F6577657D65856461
:100420008F6495649B61A560AB5CAF58B550BB48C9
:10043000BF41C33BC92ACD18D10CFFFC91AD10C47

* 73.4 * 32 * 5 * 70.7 * 24.8 * 25 *
ROSS KOEN*PERRY MEADOW RD*SOLAREX*4330EG*05/15/88*11:29:02*LOOKS GOOD
:10040000096811681D6824672B6733673F67456774
:100410004D6753675F6765666D6673667E66856563
:100420008B6592649C63A261A05CA95CB158B653D1
:10043000BA4DBE42C33AC92DCD20D110FFFFD10C19
* 73.5 * 32 * 5 * 70.7 * 24.8 * 24.8 *
ROSS KOEN*PERRY MEADOW RD*SOLAREX*4330EG*05/15/88*11:31:34*
:100400000B6813681E6825682D6835673F68476765
:100410004D6755675F6767676E6679677F66866653
:100420008D6597659D63A362AA5EB359B754BD4AB3
:10043000C344C935CE25D216D607FFFFFFD10C26
* 73.6 * 32 * 5 * 71.1 * 24.8 * 24.8 *
ROSS KOEN*PERRY MEADOW RD*SOLAREX*4330EG*05/15/88*11:34:01*
:100400000B6717681F672767336839683F67476757
:1004100053675A675F666766736679667F658B6543
:10042000916597649F62A760AD5CB354BA4EBE48B5
:100430008240C240C930CD23D114D505FFFFD10C75
* 73.7 * 32 * 5 * 71.2 * 24.8 * 25 *
ROSS KOEN*PERRY MEADOW RD*SOLAREX*4330EG*05/15/88*11:37:27*
:100400000B6513651F6426652D6435643F6446647F
:100410004D6353635F6365636B6373627D62836285
:1004200089618F60995E9F5CA559AA54B14EB64808
:10043000BD39C133C628CA1CCE10D202FFFFD10C71
* 74 * 32 * 5 * 71.6 * 24.8 * 25 *
ROSS KOEN*PERRY MEADOW RD*SOLAREX*4330EG*05/15/88*11:47:27*
:100400000B6813681B6827672E6735673D6747666B
:100410004F6655655D6567656E6575657B6386636B
:100420008C6293629960A360A75DAE59B351BA4BD9
:10043000BE44C434C82ECC22D015D408FFFFD10C42
* 75.1 * 32 * 5 * 71.6 * 25 * 25 *
ROSS KOEN*PERRY MEADOW RD*SOLAREX*4330EG*05/15/88*11:54:27*

:100400000F7917781F782F7837783F784D775577A1

:100410005D776A7772777B7787768F769775A27329

:10042000A970AF6BB960BD55C14AC539CA26CE1097

:10043000FFFFD106FFFF30C030C0B0C070C030D069

* 69.3 * 45 * 1 * 55.8 * 24.8 * 25.2 *

ROSS KOEN*PERRY MEADOW RD*KYOCERA*

*05/15/86*10:15:00*

:10040000806413641A6422642D6433643B64426321
:100410004D6353635A635F636B63726279637F6298
:1004200089628F6196609C5DA559AA56AF52B44A05
:10043000BA44BE40C330C72ACB1EC91ACD1AD10C4C
:10044000FFFF90C030C030C0B0C030C030C030C03E
* 72 * 32 * 5 * 66.3 * 24.8 * 25.0 *

ROSS KOEN*PERRY MEADOW RD*SOLAREX*

*05/15/86*10:55:00*

:100400000B7817781F78297833783F7747784F77BC
:100410005D7765776D7679757F7487728F6C996675
:100420009E60A350A944AF2EB421B813BC03FFFFB4
* 76.1 * 33 * 4 * 65 * 41.6 * 41.8 *
MARK*DAVID KATZ'S LAND PARTNER*ARCO*16-2000, 256293*01/01/00*01:26:56*
:1004000012821B822A8233823D814B8153805B8022
:100410006980727F7B7E837C8F7896729D66A55AF9
:10042000A950AD40B134B525B918BD08FFFFFFF95
* 76.2 * 33 * 4 * 70.5 * 40 * 40 *
MARK*DAVID KATZ'S LAND PARTNER*ARCO*16-2000, 256293*01/01/00*01:29:57*HOT AND CI
EAN
:100400000F831A8323822D823B8245824D825B8239
:1004100063816D8175807F808B7E937A9F75A570D7
:10042000AB64AF50B644BB30BF28C316C706FFFF4E
* 76.3 * 33 * 4 * 71.3 * 24.6 * 25 *
MARK*DAVID KATZ'S LAND PARTNER*ARCO*16-2000, 256293*01/01/00*01:33:07*
:100400000F7F17811F812F8139813F814F80578056
:100410005F806B80777F7F7E877D8F7A9B76A370EE
:10042000A960B154B549BB30BF22C312C703FFFF57
* 76.4 * 33 * 4 * 70.8 * 24.6 * 25 *
MARK*DAVID KATZ'S LAND PARTNER*ARCO*16-2000, 256293*01/01/00*01:34:50*
:100400000F81198123812D813B8043804D805A804B
:1004100063806B7F737E7F7D897C91789D74A36CF4
:10042000A964AE52B548BB30BF21C311FFFFFFF27
* 76.5 * 33 * 4 * 70.6 * 24.6 * 25 *
MARK*DAVID KATZ'S LAND PARTNER*ARCO*16-2000, 256293*01/01/00*01:36:25*
:100400000B8117811F812B8035803F804B8053806B
:100410005D7F6B7F737E7B7D877C8F7B97789F6E04
:10042000A964AE5AB250B640BB34BF22C314FFFF1A
* 76.6 * 33 * 4 * 70.4 * 24.8 * 25.2 *
MARK*DAVID KATZ'S LAND PARTNER*ARCO*16-2000, 256293*01/01/00*01:37:35*
:10040000C78113811D80278035803D8046804F7FC6
:100410005D7F657E6E7F777E837D8B7C93789F7218
:10042000A56AAB61AF50B644BB32C020C40EFFFF1B
* 76.7 * 33 * 4 * 70.3 * 24.6 * 25 *
MARK*DAVID KATZ'S LAND PARTNER*ARCO*16-2000, 256293*01/01/00*01:38:52*
:100400000F811E8127812F80398047814F8057803F
:100410005F7F6F7F777F7F7E8D7D957B9D79A371D9
:10042000AD68B360B751BB40BF32C418C805FFFF09
* 77 * 33 * 4 * 69.6 * 24.6 * 25 *
MARK*DAVID KATZ'S LAND PARTNER*ARCO*16-2000, 256057*01/01/00*01:43:27*
:100400000F7C1B7C277B2F7B397B437B4F7B577B70
:100410005F7A677A75797D7985778F7597709E6831
:100420008258A358AB4CB138B620BA09FFFFFFF82
* 78.1 * 33 * 4 * 69.1 * 43.8 * 43.8 *
MARK*DAVID KATZ'S LAND PARTNER*ARCO*16-2000, 256057*01/01/00*01:47:35*SERIAL #2
2553
:100400000B7C177B1F7B2A7B337B3F7A477A4F7AA3
:10041000597967796F79777883778B779274996C4C
:10042000A364A75AAC50B432B918BD05FFFFFFF53
* 78.2 * 33 * 4 * 68.8 * 40 * 40 *
MARK*DAVID KATZ'S LAND PARTNER*ARCO*16-2000, 262553*01/01/00*01:50:54*HOT AND CI
EAN
:10040000C77A117A1B7923792B7939793F79497920
:1004100053785F78477767776F7777783768B76D0
:1004200093759F72A56DAB66AF56B74ABD34C120B8
:10043000C50AFFFFB414B806FFFFB0C030C030C01B
* 78.3 * 33 * 4 * 68.2 * 24.8 * 25.2 *
MARK*DAVID KATZ'S LAND PARTNER*ARCO*16-2000, 262553*01/01/00*01:53:43*THESE PANF
LS AND ALL THE PRECEEDING PANELS OF MARK'S AR
E ONLY 4 YEARS OLD

:10040000807A137A1B792379317939783F784B7860
:1004100057775F7767766F757B7583748B7492718E
:100420009D6FA36CAB64B35DB755BC4CC434C82698
:10043000CC14FFFFB414B806FFFFB0C030C030C00A
* 79.1 * 33 * 6 * 68.3 * 24.8 * 25.2 *
MARK *ELK RIDGE RD*ARCO*16-2300, 138200*01/01/00*01:59:25*
:10040000C87A137A1D7925792E793B7943784B7810
:1004100055785F7769776F77797685768D75937480
:100420009B70A66CAC65B15CB64CBB40C128C515D1
:10043000FFFFFFFFB414B806FFFFB0C030C030C0EC
* 80 * 33 * 4 * 67 * 24.8 * 25.2 *
MARK *ELK RIDGE RD*ARCO*16-2000, 262547*01/01/00*02:03:48*
:100400000F79197922792E7937793F78497855779F
:100410005D7765776E777B767F75897591739D7053
:10042000A36DA968AF5AB650BA44BF2AC31CC70609
:10043000FFFFFFFFB414B806FFFFB0C030C030C0EC
* 81 * 33 * 4 * 66.4 * 24.8 * 25.4 *
MARK *ELK RIDGE RD*ARCO*16-2000, 262538*01/01/00*02:07:45*
:100400000D3F15781F782E7833783D7745765176F8
:10041000597662756E7575747D7485738F71976D7D
:100420009D68A35AAB50B13AB724B01DB81DBC0AA1
:10043000FFFFFFFFB414B806FFFFB0C030C030C0EC
* 82.1 * 33 * 4 * 66 * 41.6 * 41.8 *
MARK *ELK RIDGE RD*ARCO*16-2000, 262525*01/01/00*02:10:47*HOT AND DUSTY
:100400000E78067817781F782D7835773D77467700
:1004100053765B7663756B7577757E7485738D70B7
:10042000976D9F68A460A950AF45B52CB91EBDOA51
:10043000FFFFFFFFB414B806FFFFB0C030C030C0EC
* 82.2 * 33 * 4 * 66 * 41.4 * 41.4 *
MARK *ELK RIDGE RD*ARCO*16-2000, 262525*01/01/00*02:13:10*
:100400000A7713771B7623762F7639753F754975F2
:1004100055745D7465746D7379737F7287719371B0
:100420009B70A16CA764B15AB550B945BF2CC320CD
:10043000C708FFFFFFFFB414B806FFFFB0C030C030C01B
* 82.3 * 33 * 4 * 65.3 * 24.8 * 25.2 *
MARK *ELK RIDGE RD*ARCO*16-2000, 262525*01/01/00*02:15:27*
:100400000F7517751F742D7435743D7445735273D1
:1004100059735F72697275717D7185718F70977094
:100420009E70A56DAF6AB666BB60BF50C644FFFFF45
* 82.4 * 33 * 4 * 64 * 5.8 * 6.6 *
MARK *ELK RIDGE RD*ARCO*16-2000, 262525*01/01/00*02:19:00*SCREWING AROUND TO SEE
HOW LOW WE COULD GET THE TEMP

:10040000095E0F5E1B5E225E275E335E395E3F5ED5
:100410004A5E4F5E575D5F5D675D6D5C775C7D5CDE
:10042000865B8B5A91599A569F54A350AB48B13A68
:10043000B530B920BE11FFFF30C0B0C070C030D0A1
* 83 * 33 * 4 * 53.45 * 24.8 * 25 *

MARK*DAVID KATZ'S LAND PARTNER*ARCO*16-2000,256302*05/29/88*09:32:06*

:1004000007611361196125612B6132613D604360B1
:10041000496053605A605F5F6B5F6F5F775F7F5EBD
:10042000875E8D5D965C9B59A352A84DAC48B23C4B
:10043000B72DBB20BF11FFFF30C0B0C070C030D09F
* 84 * 33 * 4 * 54.9 * 24.8 * 25.2 *

MARK*DAVID KATZ'S LAND PARTNER*ARCO*16-2000,256243*05/29/88*09:39:05*BROWN CORR
SION SHOWS AT THE TOP OF THE PANEL, ABOVE THE
WAFERS

:100400000B6311631D6223622B6235623B624362A0
:100410004A6153615B6065606B6072607B5F835FA4
:100420008C5E925D97589F54A54EAB44B136B52C67
:10043000B921BD14C106FFFF30C0B0C070C030D0BC
* 85 * 33 * 4 * 56.1 * 24.8 * 25.2 *

MARK*DAVID KATZ'S LAND PARTNER*ARCO*16-2000,256285*05/29/88*09:44:47*

:100400000B6416641D6423642F6336633D630563C8
:1004100047634E6255625B6266616D6177607D60C5
:10042000835F8D5E935C9B5AA158A754AE4EB24831
:10043000B643B239BB39BF2CC41DC80EFFFF30D044
* 86 * 33 * 6 * 57 * 24.8 * 25.2 *

MARK*DAVID KATZ'S LAND PARTNER*ARCO*16-2300,138197*05/29/88*09:49:11*FOUR CELLS
SHOW BROWN CORROSION

:100400000E6816681F6829672F673B6743674E674A
:1004100055665B6663666D6674657B6585648B6334
:1004200095619B60A15CA754AE4CB244B738BB2821
:10043000BF15C305FFFFBF2CC41DC80EFFFF30D082
* 87 * 33 * 4 * 58.2 * 24.8 * 25.4 *

MARK*DAVID KATZ'S LAND PARTNER*ARCO*16-2000,256346*05/29/88*09:55:07*

:10040000C469116919691F69276933693B684368C1
:100410004E6855685D6867676E67646675667F6677
:1004200087668F6497619D5EA356AA50AE48B63228
:10043000BA21BE12FFFFBF2CC41DC80EFFFF30D073
* 88 * 33 * 4 * 58.9 * 24.8 * 25.2 *

MARK*DAVID KATZ'S LAND PARTNER*ARCO*16-2000,256253*05/29/88*09:59:37*

:10040000010A050A09090D091109150819081D082D
:1004100018081D082107200724072007280734058E
:1004200087668F6497619D5EA356AA50AE48B63228
:10043000BA21BE12FFFFBF2CC41DC80EFFFF30D073
* 89 * 33 * 4 * 61.4 * 24.8 * 25.6 *

MARK*DAVID KATZ'S LAND PARTNER*ARCO*16-2000,256326*05/29/88*10:16:54*TERMINAL CC
NNECTION IS LOOSE. WHEN WE FIRST RAN, IT WAS

AN OPEN. DURING THIS RUN, THE TERMINAL CONNECTED DURING THE RUN.

:10040000031507150B150F14151419151D152215B5
:1004100027142C15311536153B15401445144A1573
:100420004F14531457145B145F14651469146E143D
:10043000721376137B137F13831387138B138F121F
:10044000931297119B119F10A310A70FAB0EAF0D26
:10045000B30CB70ABB08BF07C305C703FFFF30C013
* 90 * 5 * 0 * 64.1 * 24 * 26.2 *

ALT. ENERGY ENG*GARBERVILLE*ARCO*G100*05/29/88*11:45:56*AMORPHOUS PANEL

:100400000E8B178B278C318B3B8B4B8B538B5E8AE0
:100410006D8B768A7F8A8D8A96889F84AB80B27630
:10042000B964BF54C348C92ACD14FFFF69146E14C0
* 91.1 * 45 * 0 * 66 * 24.8 * 25.6 *

ALT ENERGY ENGR*GARBERVILLE*KYOCERA*LA361J45*05/29/88*11:56:44*THIS IS A NEW PAN
EL. WE ARE NOT DOING A HOT AND DIRTY, JUST FI

VE COLDS RUNS.

:100400000F8B1B8A2B8A358B3F8B4D8A578A5F8ACD
:10041000698A778A7F8A8B8997889F85A780B3743A
:10042000B968BE5CC245C638CA20CEODFFFF6E1447
* 91.2 * 45 * 0 * 66.1 * 24.6 * 25.2 *
ALT ENERGY ENGR*GARBERVILLE*KYOCERA*LA361J45*05/29/88*11:58:18*
:100400000E8A178B278A328A3B8A4B8A538A5D8AE7
:10041000678A7E8A878A8F889E85A581AD7452
:10042000B768BB5CBF46C539C922CDODFFFF6E144E
* 91.3 * 45 * 0 * 66 * 24.6 * 25.4 *
ALT ENERGY ENGR*GARBERVILLE*KYOCERA*LA361J45*05/29/88*12:01:35*FINAL TEMP IS 25.
4
:100400000B8B1B8B258A2F8A3F8A478A538A5F8AEB
:100410006A8A738A7F8A8B8993879F84A980AF7841
:10042000B968BE58C24AC82CCC15FFFFFFF6E1436
* 91.4 * 45 * 0 * 66.1 * 24.6 * 25.2 *
ALT ENERGY ENGR*GARBERVILLE*KYOCERA*LA361J45*05/29/88*12:03:30*
:10040000C08B198B238B2D8B3D8B478B4F8B5A8A3F
:10041000678A718A7B8A898992899B85A780AF794F
:10042000B568BD59C14CC538CA25CE0BFFFF6E1447
* 91.5 * 45 * 0 * 66.1 * 24.6 * 25.2 *
ALT ENERGY ENGR*GARBERVILLE*KYOCERA*LA361J45*05/29/88*12:07:28*THIS TEST WAS A F
OLYCRYSTALINE PANEL. ITS SERIAL NUMBER IS 5Z2
335
:10040000808B158B1F8B2F8B378B3F8A4F8A5B8A94
:10041000638A6D8A7B8985898E889B88A384AB7A61
:10042000B670BB64BF55C340C734CB20CFOCFFFB1
* 92 * 45 * 0 * 66.1 * 24.6 * 25.2 *
ALT ENERGY ENGR*GARBERVILLE*KYOCERA*LA361J45, 5Z2335*05/29/88*12:12:38*
:100400000F8B198B238A338B3D8B478B558B5F8BDF
:10041000678A778A7F8A898997889F86A782B96A3F
:10042000BE60C348C73ACB22CFOEFFFFCFOCFFFO1
* 93.1 * 45 * 0 * 65.7 * 24.8 * 25.2 *
ALT ENERGY ENGR*GARBERVILLE*KYOCERA*LA361J45, 5Z2336*05/29/88*12:17:05*WE DID NC
T DO FIVE REPLICATE RUNS ON THIS PANEL.
:10040000138B1E8B2D8B378B3F8B4B8B598B638BB9
:100410006D8A7B8B858A8E899B88A385AB80B3741C
:10042000BD68C159C544CA38CF1AD303FFFFFFF3C
* 94 * 45 * 0 * 65.9 * 24.6 * 25.2 *
ALT ENERGY ENGR*GARBERVILLE*KYOCERA*LA361J45, 5Z2337*05/29/88*12:20:13*
:10040000808C158C258C2F8B398B478B4F8B5B8A7F
:10041000698B738A7B8A858993869B80A16CAA608D
:10042000B136B520B907FFFFCF1AD303FFFFFFF97
* 95 * 40 * 0 * 65.9 * 24.6 * 25 *
ALT ENERGY ENGR*GARBERVILLE*KYOCERA*LA321J40, 610611*05/29/88*12:23:56*PANEL HAS
FEWER CELLS FOR A SMALLER OPEN CIRCUIT VOLTA
GE
:10040000C59317931F932B933B9246924F925B9108
:10041000699173917D918B8F958D9D88A57CAF702F
:10042000B560B948BD38C118FFFFD303FFFFFFF18
* 96.1 * 45 * 0 * 65.9 * 24.5 * 25.2 *
ALT ENERGY ENGR*GARBERVILLE*ARCO*N75, SNO05748*05/29/88*12:30:21*WE ARE ONLY DOI
NG FIVE REPLICATES; THIS IS A NEW PANEL
:100400000D931D93279232923D924B9156915F919D
:100410006F9179917F908D8E9B8AA384AA76B36821
:10042000B758BB48C126C50BFFFFD303FFFFFFF33
* 96.2 * 45 * 0 * 65.8 * 24.6 * 25.2 *
ALT ENERGY ENGR*GARBERVILLE*ARCO*N75, SNO05748*05/29/88*12:32:04*THIS PANEL IS F
ATED AT 47 WATTS
:100400000D921792279233923D92479157915F91A7
:100410006B917A9183908D8F968AA384AA7CAF6822
:10042000B754BB44BF26C318FFFFD303FFFFFFF32

* 96.3 * 47 * 0 * 65.6 * 24.6 * 25.2 *
 ALT ENERGY ENGR*GARBERVILLE*ARCO*N75, SNO05748*05/29/88*12:35:00*
 :10040000C59317931F922B92379247924F925B910D
 :100410006A9173917D91878F958C9D88A67AAF6C38
 :10042000B560B944BD35C116FFFFD303FFFFFFFFF21
 * 96.4 * 47 * 0 * 65.6 * 24.6 * 25.2 *
 ALT ENERGY ENGR*GARBERVILLE*ARCO*N75, SNO05748*05/29/88*12:36:31*
 :10040000D931793299233923E92479257915F91A1
 :100410006B917B9185908E8E9788A382AB78B1602B
 :10042000B750BD34801BC01BFFFFD303FFFFFFFFF8E
 * 96.5 * 47 * 0 * 65.7 * 24.6 * 25.2 *
 ALT ENERGY ENGR*GARBERVILLE*ARCO*N75, SNO05748*05/29/88*12:38:47*
 :10040000E7517751F752B7433743D7449744F73D3
 :1004100057725F716B70736D7B6885648A5E8F58ED
 :1004200095509B489F44A33AA735AB31AF26B323E1
 :10043000B719BB12BF0BC304FFFFF87138B138F12B7
 * 97 * 33 * 4 * 65.5 * 24.6 * 25.2 *
 LES SCHER*GARBERVILLE*ARCO*16-2000, 252483*05/29/88*12:43:41*THIS PANEL SHOWED A
 HIGH SERIES RESISTANCE. IT STILL DOES!
 :10040000A7413741F7427742F73377345724D71F8
 :10041000556E5F6C67696D65735D7B587F52864969
 :100420008D44933C97359B32A12BA624AA1EAE1A6D
 :10043000B314B70FBBOABF04FFFFF87138B138F12D0
 * 97.2 * 33 * 4 * 65.3 * 24.6 * 25.6 *
 LES SCHER*GARBERVILLE*ARCO*16-2000, 252483*05/29/88*12:47:28*WE REPEATED THE TES
 T. IT STILL SHOWS HIGH R
 :10040000E74177423732B7333733B7247724F71DF
 :10041000576F5F6B69686F63765A7E548350874964
 :100420008B41913C95389C2EA128A621AC19AB108C
 :10043000AF17B314B70FBBO9BF05FFFF8B138F12A4
 * 97.3 * 33 * 4 * 65.4 * 24.6 * 25.8 *
 LES SCHER*GARBERVILLE*ARCO*16-2000, 252483*05/29/88*12:49:32*ANOTHER REPEAT TEST
 . STILL SHOWS HIGH SERIES R.
 :1004000007400B380F3016321B30212B26292A23A8
 :100410002F1C331B37173D164117451249134D1139
 :1004200051115511590F58115C11600E640E680C72
 :100430006C0C700B740978087C07800684058804AE
 :100440008C049004940398039C02FFFFAB0EAF0D45
 * 97.4 * 33 * 4 * 65.3 * 44 * 45.8 *
 LES SCHER*GARBERVILLE*ARCO*16-2000, 252483*05/29/88*12:54:41*HEAVY WEIRDNESS
 :1004000009400F3215301930212D27292D1F331C9B
 :10041000371A3B173F17431647144C12501154110B
 :10042000590F5D0C610B650A69096D097108FFFFC1
 * 97.5 * 33 * 4 * 65.2 * 51 * 51.4 *
 LES SCHER*GARBERVILLE*ARCO*16-2000, 252483*05/29/88*12:56:35*ALMOST NO ALMOST
 :100400000A7517741F74277435743D7445744D73E1
 :1004100059735F72697275717B70836E8A6A9466B4
 :100420009A619F5CA553AC4CB43DB938BE2DC32432
 :10043000C819CD10D106FFF7C078006840588040B
 * 97.6 * 33 * 4 * 64.9 * 3.2 * 4.8 *
 LES SCHER*GARBERVILLE*ARCO*16-2000, 252483*05/29/88*13:02:36*
 :1015721E722B71313635323130393022
 :100410003E29432847244D21511F561D5A1B5E1A61
 :10042000621867176B166F147312770F7B0D7F0CB2
 :10043000830A87098B088F07930697059B049F0300
 :10044000A302FFFF940398039C02FFFFAB0EAF0DC6
 * 97.14 * 33 * 4 * 64 * 42 * 43.8 *
 LES SCHER*GARBERVILLE*ARCO*16-2000, 252483*05/29/88*13:18:02*
 :10040000B0400B400F3C133917361D32232E2A27DC
 :100410002E21331C371A3B183F17431748164D152A
 :100420005113551359115D0F610F650C690B6D0A5E
 :100430007109750879077D068105850589048D0395

:1004400091029502FFFF98039C02FFFFAB0EAFODD8

* 97.15 * 33 * 4 * 63.9 * 48 * 49.4 *

LES SCHER*GARBERVILLE*ARCO*16-2000, 252483*05/29/88*13:20:10*

:1004000017A92BA937A83FA84FA65FA56BA477A370

:1004100087A28FA09B9EA598B390BB84BF72C6583D

:10042000CB44CF25D30DFFFF610F650C690B6D0A1F

* 98 * 55 * 4 * 62.4 * 24.6 * 25.2 *

ALT ENERGY ENGR*GARBERVILLE*PHOTOWATT*7010, 1371*05/29/88*13:27:25*

:100400000FA81DA827A835A747A753A65EA669A5CC

:100410007BA485A38FA19B9EAA99B390BB80C36840

:10042000C754CD30D116D010FFFF650C690B6D0A93

* 99 * 55 * 4 * 63.6 * 24.6 * 25 *

ALT ENERGY ENGR*GARBERVILLE*PHOTOWATT*ML1070, 1432*05/29/88*13:31:57*

:100400001BD12BD13FD04FCC5BC0628067506B1C9F

:10041000FFFF85A38FA19B9EAA99B390BB80C36861

* 100.1 * 33 * 4 * 62.9 * 24.6 * 25 *

AIT ENERGY ENGR*GARBERVILLE*SOLAR POWER CORP*G12-361, 28002*05/29/88*13:41:02*TF

IS IS 6V PANEL. WE DID NOT DO A HOT AND DIRT

Y BECAUSE THE PANEL WAS NEW (EVEN THOUGH ITS BEEN IN THE BOX FOR 4 YEARS)

:10040000173F26D135D03FCE57C05FA065706B280F

:10041000FFFF85A38FA19B9EAA99B390BB80C36861

* 100.2 * 33 * 4 * 62.4 * 24.8 * 25 *

ALT ENERGY ENGR*GARBERVILLE*SOLAR POWER CORP*G12-361, 28002*05/29/88*13:43:53*WE

'RE DONE!

:100400000F70177023702B70336F3F6E476F4F6EF6
:100410005B6E626D696C756C7B6C836A8D699468C8
:100420009B63A35EA958AF49B340B729BB1CBF0B60
:10043000FFF90C0308030C030C0B0C070C030D03E
* 101 * 33 * 6 * 65.2 * 24.6 * 25.2 *

GIL CIKORA*DOOTY RIDGE RD*ARCO*16-2000, 260116*06/12/88*09:38:16*

:100400000A70176F1F6F276E336F3B6E426E4A6E16
:10041000556D5D6D656D6F6C776C7E6B896A8F68ED
:1004200096649F60A55AA952AE44B33AB725BB194A
:10043000BF04FFFF308030C030C0B0C070C030D0CB
* 102 * 33 * 6 * 64 * 24.6 * 25.2 *

GIL CIKORA*DOOTY RIDGE RD*ARCO*16-2000, 259635*06/12/88*09:47:54*ALL THESE FOUR RUNS (101-104) ARE FOR PANELS WHICH ARE SIX YEARS OLD BUT HAVE BEEN INSTALLED FOR ONLY FOUR YEARS

:100400000B7413741D742974317439743F734E73F3
:1004100056735E726A727172797185708B6F936DAB
:100420009668A361A75AAD4CB340B72DBB1BB81751
:10043000BC17C004FFFF30C030C0B0C070C030D0A7
* 103 * 33 * 6 * 67.7 * 24.6 * 25.3 *

GIL CIKORA*DOOTY RIDGE RD*ARCO*16-2000, 259650*06/12/88*09:55:45*ONE CELL HAS IR REGULAR EXTRA WIRES SILKSCREENED ONTO IT.

:100400000C07613761D7625762D753B7643754B7534
:1004100057755F7467746F737B727F7289729170A6
:100420009B6CA268A75CAF52B348B740BC26C01310
:10043000FFF0D78177825782D78357843774B773F
* 104 * 33 * 6 * 65.5 * 24.6 * 25 *

GIL CIKORA*DOOTY RIDGE RD*ARCO*16-2000, 262668*06/12/88*10:08:47*CONNECTIONS MADE THROUGH ABOUT ONE FOOT OF CONNECTING WIRE RATHER THAN AT THE TERMINALS.

POSITIVE FOIL HAS ARCING EVIDENT.

:100400000D6D136E1B6D236D2B6D376D3F6D476D3D
:100410004E6C596C5F6C676C6F6C766B7F6987682C
:100420008D64935C9B549F48A340A725AB14FFFFAA
* 105 * 33 * 2 * 64.7 * 24.6 * 25.1 *

MARY LEE BY THE RIVER*BY THE RIVER*ARCO*REJECTED MODULE, NO #*01/28/00*23:42:54* THESE PANELS WERE OBTAINED FROM ARCO BY MARY LEE'S FATHER. THEY ARE ALL SECONDS AND DO NOT HAVE SERIAL NUMBERS

:100400000D6D156D1F6D276D2F6D376C3F6C4B6C2F
:10041000526B596B5F6A6769726879677F66856539
:100420008B60945899509F3CA524A90BFFFFF8
* 106 * 33 * 2 * 65.9 * 24.6 * 25.2 *

MARY LEE BY THE RIVER*BY THE RIVER*ARCO*REJECTED MODULE, NO #*01/28/00*23:47:48*

:100400000F701B7023702B70336F3B6F476F4F6EF5
:10041000556E5D6D646B6F6A76687C668364896017
:10042000925C97549B4C9F44A52AA917AD03FFFFEC
* 107 * 33 * 2 * 65.9 * 24.6 * 25.2 *

MARY LEE BY THE RIVER*BY THE RIVER*ARCO*REJECTED MODULE, NO #*01/28/00*23:54:04*

:100400000B6D136C1F6C276C2E6C356B3D6B476B43
:100410004F6B576B5E6A696A6F6977687D67836443
:100420008D60935D97589D50A144A63AAA28AE13BB
:10043000FFF90C0308030C030C0B0C030C030C08E
* 108 * 33 * 2 * 67.4 * 24.6 * 25.3 *

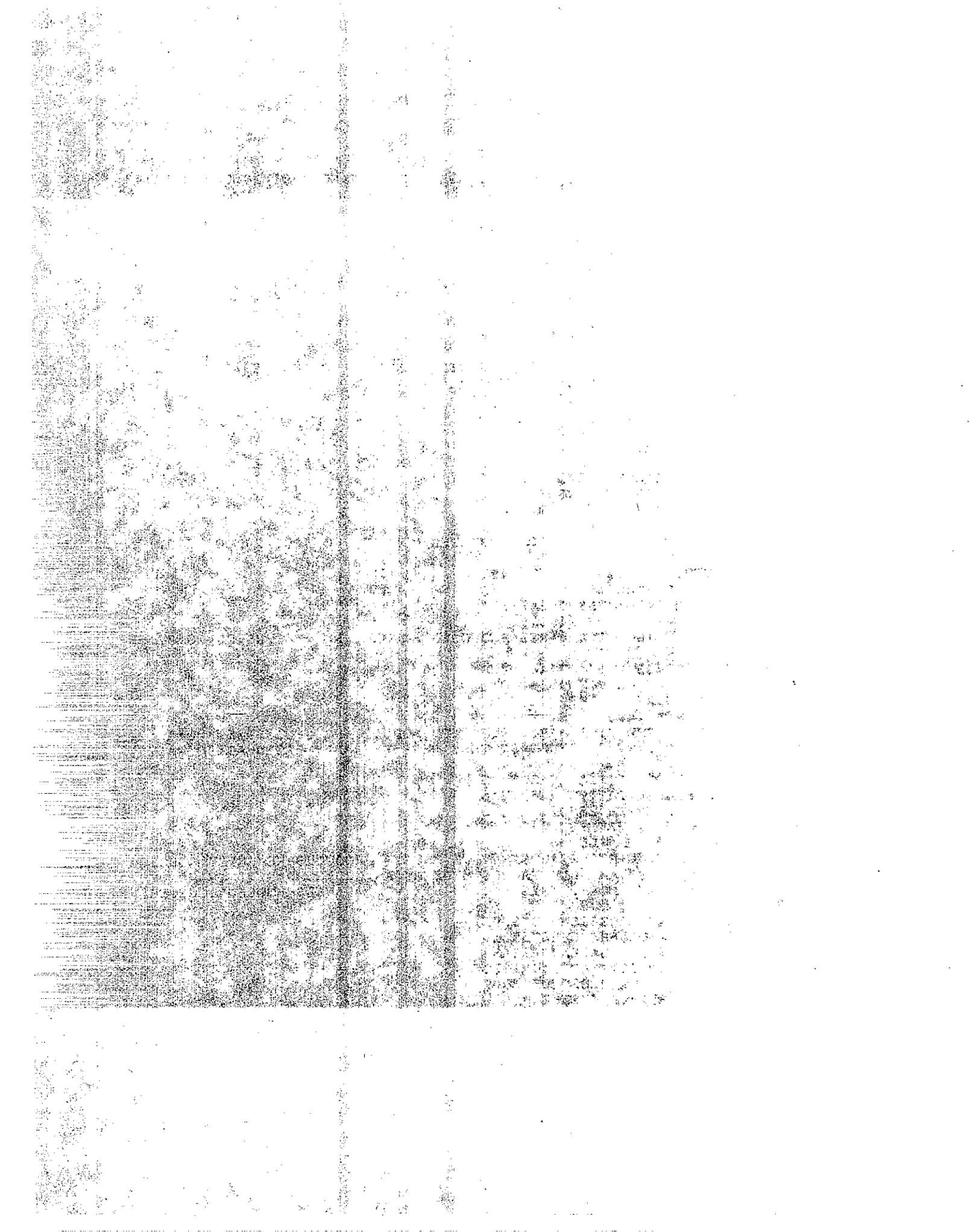
MARY LEE BY THE RIVER*BY THE RIVER*ARCO*REJECTED MODULE, NO #*01/29/00*00:01:58*

:10040000080700F70176F1F6F2D6F356E3B6F436ECF
:100410004B6E576F5D6E656C6B6C73687D62825C52
:1004200087548B4992309716FFFA63AAA28AE133D
* 109.1 * 33 * 2 * 67.9 * 63 * 63.1 *

MARY LEE BY THE RIVER*BY THE RIVER*ARCO*REJECTED MODULE, NO #*01/29/00*00:07:07* HOT AND DIRTY

:10040000080730F73197225722D7235723D724971A6
:100410004F7157705F70676E736B79687F62855537

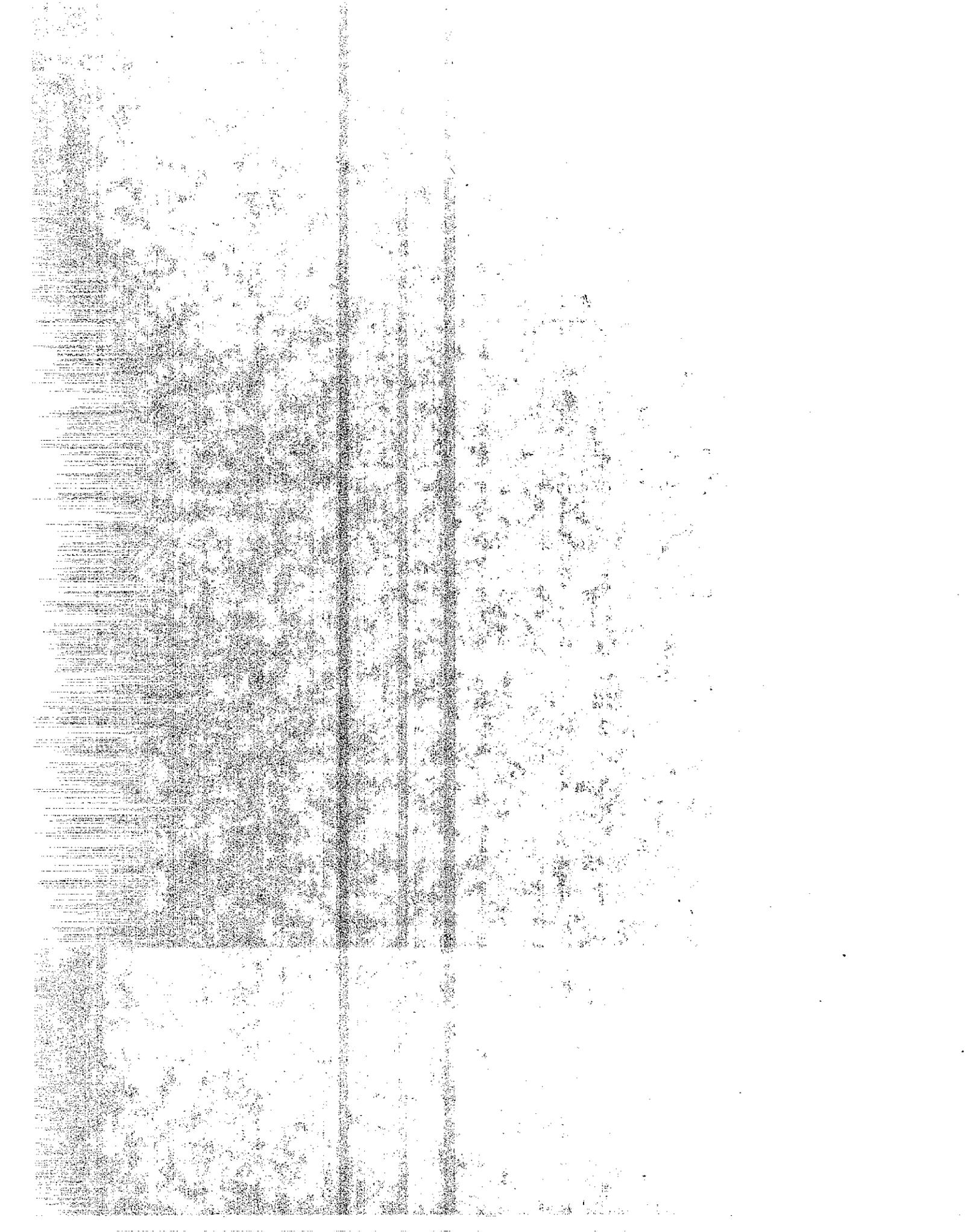
:100420008B4A8F40932A97189B029A02FFFFAE13C4
 * 109.2 * 33 * 2 * 68.2 * 63 * 63.1 *
 MARY LEE BY THE RIVER*BY THE RIVER*ARCO*REJECTED MODULE, NO #*01/29/00*00:12:48*
 HOT AND CLEAN
 :100400000D7115711D712571317039703F70477014
 :100410004F705B6F636F6B6F736F7D6E856C8B6AF4
 :100420009166975C9F52A348A82BAC1BB002AF0209
 :10043000A002B002FFFF30C030C0B0C030C030C03A
 * 109.3 * 33 * 2 * 68.4 * 24.6 * 25.2 *
 MARY LEE BY THE RIVER*BY THE RIVER*ARCO*REJECTED MODULE, NO #*01/29/00*00:16:21*
 :10040000077215721D7225722D723A713F71497112
 :100410004F705D7063716B70637073707B6E856C11
 :100420008B68916397569E4CA436A820ACOCFFFB6
 * 110 * 33 * 2 * 68.9 * 24.6 * 25.2 *
 MARY LEE BY THE RIVER*BY THE RIVER*ARCO*REJECTED MODULE, NO #*01/29/00*00:23:30*
 :100400000B62156214611C6123602A60355F3B60DA
 :100410003F5F475F4E5E575E5E5E645E6B5D745C21
 :100420007A5B7F5B855B8B5A945899519D48A330CA
 :10043000A720AB09FFFF30C030C0B0C030C030C013
 * 111 * 33 * 2 * 69.1 * 24.6 * 25.2 *
 MARY LEE BY THE RIVER*BY THE RIVER*ARCO*REJECTED MODULE, NO #*01/29/00*00:28:25*
 :100400000D7415741E742B7333733A7243724E71EC
 :1004100055705D6E636B6B6673627A5C7F56834862
 :1004200089408E2C921A9607FFFF99519D48A33060
 * 112.1 * 33 * 2 * 69.5 * 64.5 * 64.6 *
 MARY LEE BY THE RIVER*BY THE RIVER*ARCO*REJECTED MODULE, NO #*01/29/00*00:33:06*
 HOT AND DIRTY
 :100400000907715771D7725762D76257535753F7490
 :1004100049744F735970636D6B6A7166775E7F566E
 :10042000844D8B348F2C93189705FFFF9D48A33084
 * 112.2 * 33 * 2 * 69.7 * 64.5 * 64.6 *
 MARY LEE BY THE RIVER*BY THE RIVER*ARCO*REJECTED MODULE, NO #*01/29/00*00:37:58*
 HOT AND CLEAN
 :100400000E751B7523752B7433743B7447744F73CF
 :1004100057725F716A70716E776C7F6889648F60E4
 :10042000945A99529D44A33CA729AB18FFFA330CF
 * 112.3 * 33 * 2 * 69.9 * 24.6 * 25.2 *
 MARY LEE BY THE RIVER*BY THE RIVER*ARCO*REJECTED MODULE, NO #*01/29/00*00:42:24*
 ALL OF MARY LEE'S PANELS HAVE 30 CELLS SO THEY WERE PROBABLY RATED AT 30 WATTS F
 ATER YHAN 33.
 :100400000B6413631D6223602A5F315C3B5A3F58C3
 :1004100046564B535451594E5E4C634967446D42A6
 :100420007140753C79387E35832F89288D26921E40
 :10043000961A9B149F0DA309A702FFFF30C030C07E
 * 113 * 33 * 8 * 69.5 * 67.8 * 68 *
 MARY LEE BY THE RIVER*BY THE RIVER*ALTERNATIVE ENERGY PRODUCTS*REJECTED MODULE,
 NO #*01/29/00*00:51:00*THESE ARE OLD PANELS MADE BY AN OLD COMPANY IN VAN NUYS.
 THEY ARE NOT IN BUSINESS ANY MORE. THIS IS TWO SIX VOLT PANELS HOOKED TOGETHER I
 N SERIES.
 :100400000D6613661B6522642D6333623A613F5F9C
 :100410004B5E4F5C575C5CA63586B566F54755219
 :100420007B507F4D874A8B488F4693419A40A13A33
 :10043000A733AB30B12BB624BA20BFLAC314C710F0
 :10044000CB0ACF03FFFF30C0B0C030C030C030C0D7
 * 113.3 * 33 * 8 * 69.1 * 24.8 * 25.2 *
 MARY LEE BY THE RIVER*BY THE RIVER*ALTERNATIVE ENERGY PRODUCTS*REJECTED MODULE,
 NO #*01/29/00*01:01:58*THE PANEL HAS TWO GLASS PLATES



APPENDIX III

Design Meteorological Year (DMY) Data Sets

Charles E. Chamberlin and Peter Lehman



DESIGN METEOROLOGICAL YEAR (DMY) DATA SETS

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Peter Lehman

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June 2, 1987

PVFORM6 and PVINTER require meteorological data in order to simulate the response of photovoltaic panels to local insolation and temperature conditions. Total horizontal and direct normal insolation and air temperature are required by PVINTER; PVFORM6 requires these variables as well as wind velocity.

Based on data tapes supplied by the Solar Energy Research Institute (SERI) and the Solar Insolation Monitoring Program of PG&E (SIMP), design meteorological year (DMY) data sets have been prepared and formatted for 46 locations in California for use with PVINTER. The available DMY data sets are listed in Table 1 and the locations are shown in Figure 1 and Figure 2.

The original SERI data sets contained air temperature, total horizontal insolation, and in some cases direct normal insolation recorded at 15 minute intervals for 1 to 5 years of record. The SIMP data sets contained air temperature and total horizontal insolation recorded at 30 minute intervals for 1.5 years of record. For each site, the January 1 to December 31 period with the fewest missing values was selected as the DMY. Where two or more years of record had essentially identical amounts of missing values, the year with the lowest total insolation was selected as the DMY. The original data sets were converted to 365 days of 24 hourly observations. The hourly values averaged four observations for the SERI data sets and two observations for the SIMP data sets.

Missing values were treated in several ways: If the missing values were isolated so that some observations were available for the hour containing the missing value, the hourly average was simply calculated by omitting the missing value. If all the values in the hour were missing but values in adjacent hours were available, linear interpolation was used to estimate the missing value. If several hours were missing, values from corresponding hours in the day before were used to estimate the

missing value. If seven or more days in a row were missing, the DMY was not used and another year of record was examined. If none of the years of record met the above criterion, the site was omitted.

In many cases, total horizontal insolation data were available but direct normal insolation data were not. For those sites, the direct normal component was estimated based on the latitude, longitude, day-of-year, and total horizontal insolation using an empirical relationship developed by Liu and Jordan(1960, Solar Energy, 4:1-19).

The DMY files are structured as fixed format, direct access files containing 9,135 lines with a record length of 15 characters in the format shown below.

Lines 1 through 10: header material - site name
SERI or SIMP
period-of-record
DMY year
latitude
longitude
elevation
DN or estimated DN
2 comment lines

365 repetitions of a 25 line sequence:

line 1: day-of-year number (1 though 365)

line 2: DN, H, TEMP for 0:00 time

line 3: DN, H, TEMP for 1:00 time

.

.

line 25: DN, H, TEMP for 23:00 time

-FORMAT(I4,I5,F6.1)

where: DN=direct
normal
H=total
horizontal
TEMP=air

temperature

TABLE 1
Design Meteorological Year (DMY) Data Sets

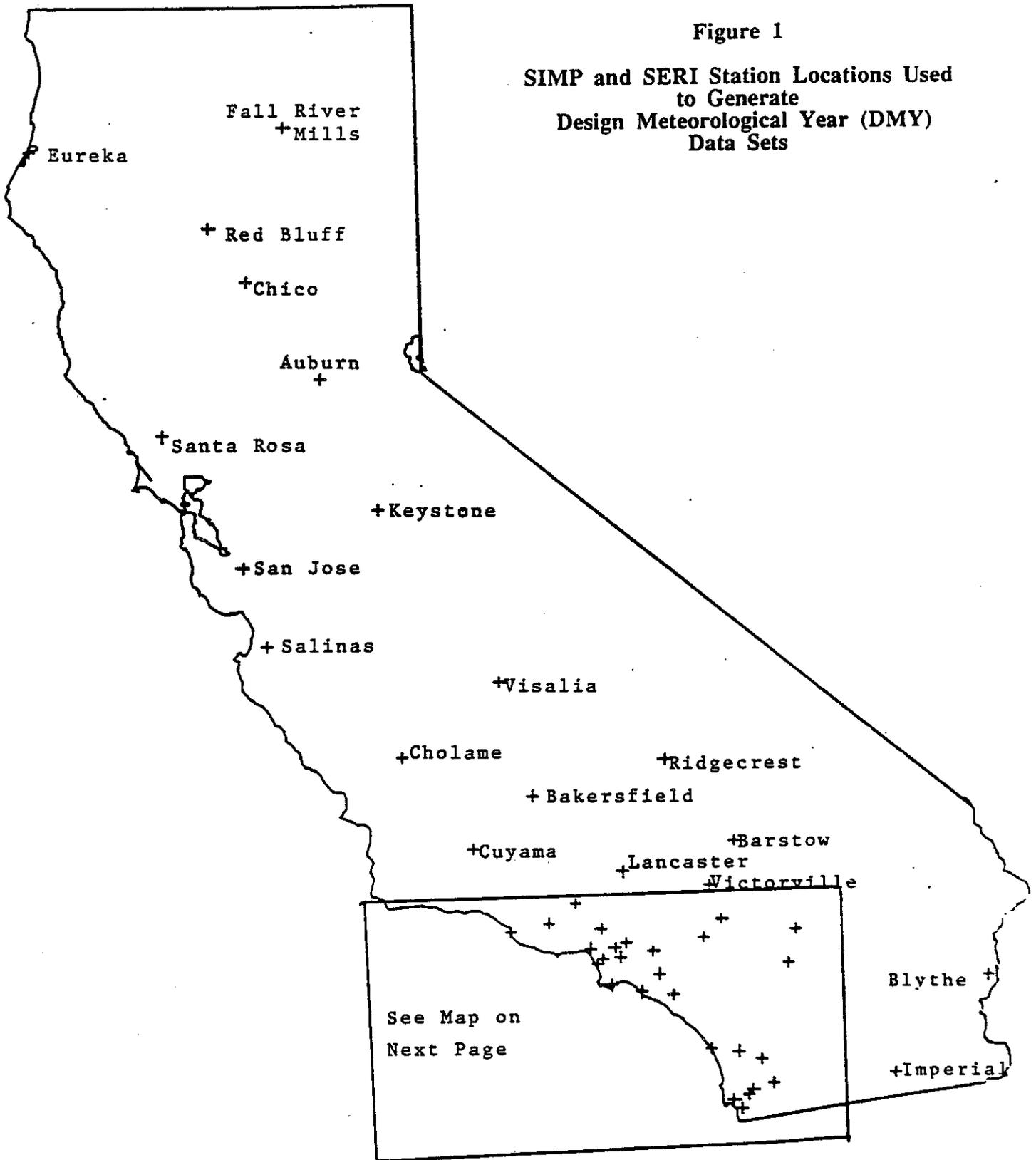
Station	Lat.	Long.	Elev. (M)	Period of Record	DMY	Direct Normal
----- Solar Energy Research Institute (SERI) Data Sets -----						
Alhambra	34.08	118.15	143	1978-80	1980	measured
Alpine	32.85	116.10	625	1978-80	1979	estimated
Arrowhead	34.28	117.22	1542	1977-80	1978	estimated
Barstow	34.88	117.00	664	1976-80	1978	measured
Blythe	33.60	114.60	81	1976,78-80	1976	measured
Carlsbad	33.13	117.33	23	1978-80	1979	estimated
Chula Vista	32.67	117.03	20	1978-80	1978	estimated
El Cajon	32.78	116.67	140	1978-80	1979	estimated
El Segundo	33.90	118.42	12	1976-80	1977	estimated
El Toro	33.63	117.70	110	1977-80	1978	estimated
Escondido	33.13	117.98	216	1978-80	1978	measured
Huntington Beach	33.65	117.98	6	1976-80	1978	estimated
Imperial	32.82	115.38	-6	1977-80	1979	estimated
Inglewood	33.95	118.38	30	1979-80	1980	measured
Laguna Bell	33.97	118.15	41	1976-80	1976	estimated
Lancaster	34.70	118.15	715	1976-80	1978	measured
Los Angeles	34.07	118.23	88	1978-80	1979	measured
Mandalay	34.20	119.25	6	1976-80	1978	estimated
Moorpark	34.28	118.90	140	1977-80	1978	estimated
Palm Spring	33.78	116.47	93	1977-80	1979	measured
Pardee	34.45	118.58	315	1976-80	1978	estimated
Ramona	33.00	116.75	527	1978-80	1979	estimated
Rialto	34.10	117.35	369	1977-80	1980	estimated
Ridgecrest	35.62	117.67	696	1976,78-80	1976	measured
San Diego	32.72	117.17	18	1979-80	1980	estimated
San Pedro	33.75	118.28	12	1979-80	1980	measured
Spring Valley	32.73	116.92	216	1978-79	1978	estimated
Sun Valley	34.25	118.38	277	1978-80	1980	measured
Victorville	34.55	117.28	870	1976-80	1978	measured
Villa Park	33.82	117.85	78	1977-80	1980	estimated
Visalia	36.33	119.28	102	1977-80	1978	estimated
Walnut	34.00	117.97	107	1976-80	1976	estimated
West Los Angeles	34.07	118.45	122	1978-80	1979	measured
Yucca Valley	34.12	116.42	1024	1976,78-80	1976	measured

TABLE 1 (continued)

Station	Lat.	Long.	Elev. (M)	Period of Record	DMY	Direct Normal
Solar Isolation Monitoring Program (SIMP) Data Sets						
Auburn	38.90	121.07	394	1984-85	1985	estimated
Bakersfield	35.37	119.05	124	1984-85	1985	estimated
Chico	39.70	121.78	62	1984-85	1985	estimated
Cholame	35.70	120.32	351	1984-85	1985	estimated
Cuyama	34.95	119.70	689	1984-85	1985	estimated
Eureka	40.80	124.17	13	1984-85	1985	estimated
Fall River Mills	41.02	121.50	1003	1984-85	1985	estimated
Keystone	37.83	120.50	274	1984-85	1985	estimated
Red Bluff	40.15	122.25	104	1984-85	1985	estimated
Salinas	36.67	121.60	23	1984-85	1985	estimated
San Jose	37.72	121.88	27	1984-85	1985	estimated
Santa Rosa	38.40	122.77	51	1984-85	1985	estimated

Figure 1

SIMP and SERI Station Locations Used
to Generate
Design Meteorological Year (DMY)
Data Sets



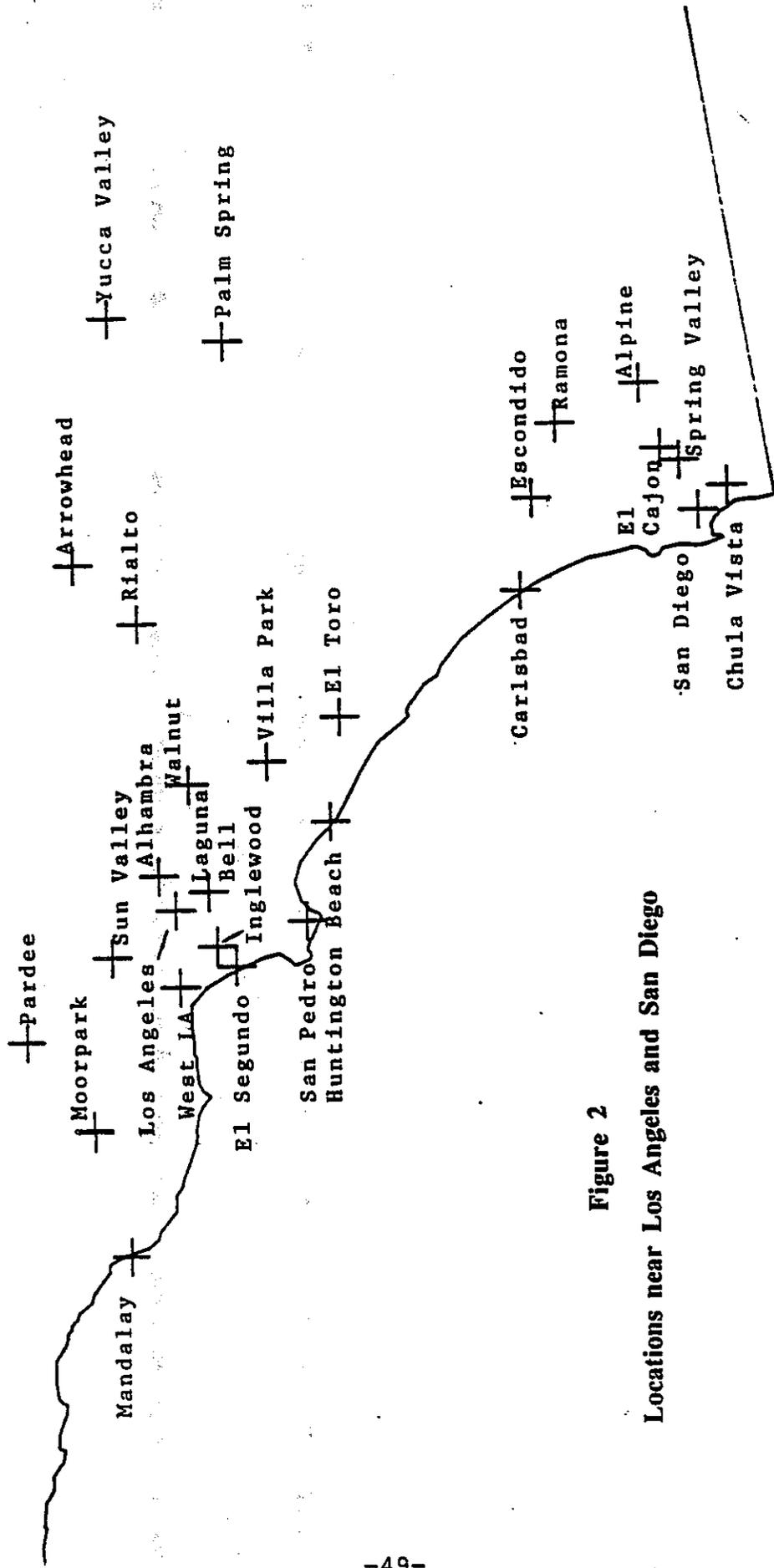
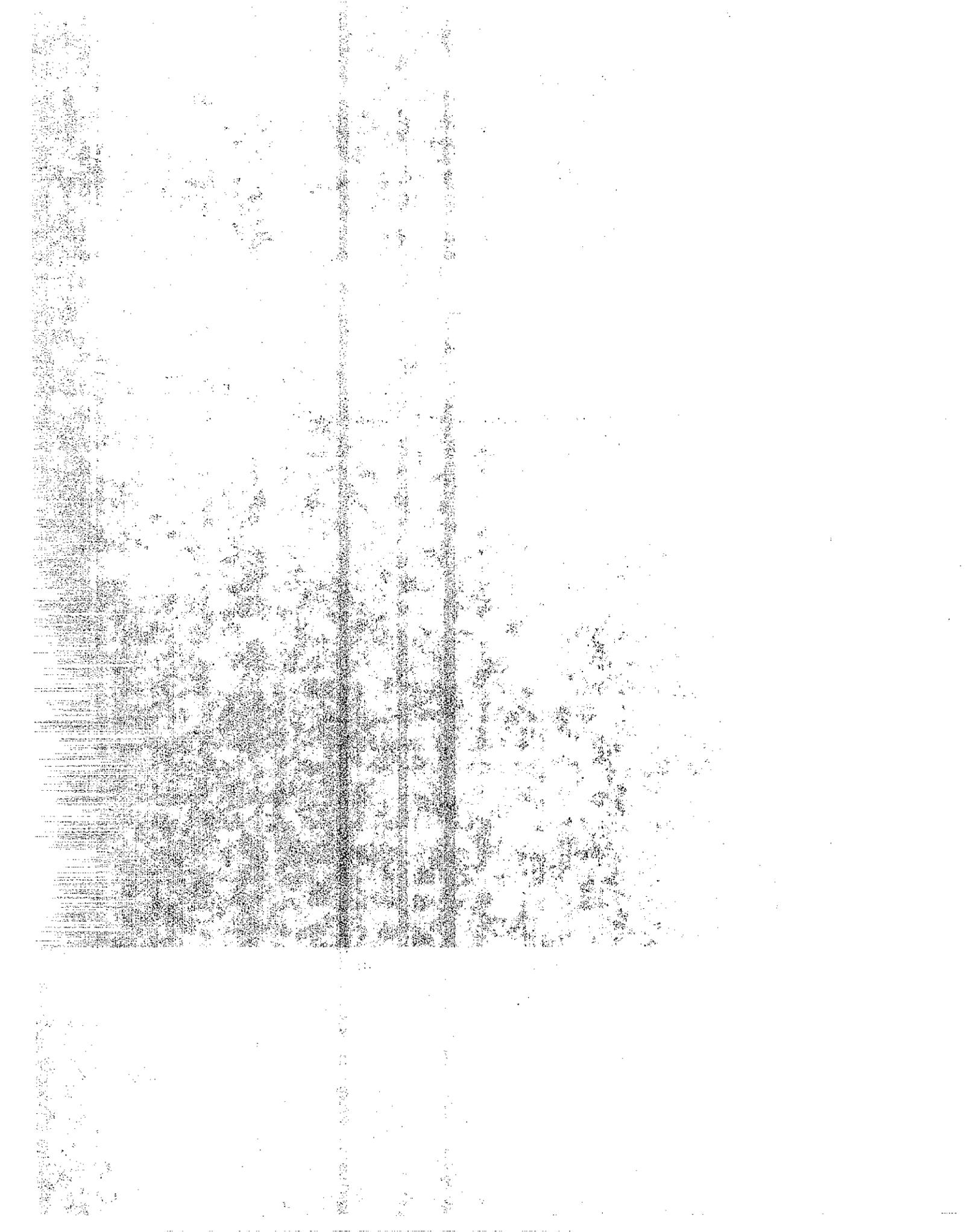


Figure 2
Locations near Los Angeles and San Diego

APPENDIX IV

Computer Code for the Program SIMPGEN



```

PROGRAM SIMPGEN

CHARACTER*15 FILE2
REAL KT, LAT, LONG, OMSR, OM1, OM2, OM, IO
INTEGER H, DN, TSR, TSS, DNMAX
DATA IO/1354./BETA/-0.14/EPS/0.1/

HAVE=0.
TAVE=0.
MDN=0
MH=0
MTEMP=0

1 PRINT*, 'STATION NUMBER:'
  READ(*,*)STN1
  IF(STN1.LT.901.OR.STN1.GT.914)THEN
    PRINT*, 'STATION NUMBER OUT OF RANGE (901-914)'
    PRINT*, 'PLEASE TRY AGAIN'
    GOTO 1
  ENDIF
  PRINT*, 'DESTINATION FILE NAME'
  READ(*,100)FILE2
100 FORMAT(A15)
  OPEN(1, FILE='SIMP', RECL=88)
  REWIND 1
  OPEN(2, FILE=FILE2, RECL=15)

  PI=ACOS(-1.)
  RADDEG=2.*PI/360.
  PRINT*, ' INPUT LATITUDE AND LONGITUDE'
  READ*, LAT, LONG
  LAT=LAT*RADDEG
  A11=12.+(LONG-120.)/15.
  A21=RADDEG*23.45
  A22=RADDEG*360./370.
  A23=80.
  A31=15.*RADDEG.
  DO 90 I=1,10
    WRITE(2,104)I
104 FORMAT(I4)
90 CONTINUE
  JLDATE=0

2 READ(1,101,END=99)STN, DAY
101 FORMAT(11X,2F11:0,47(/))
  IF(STN1.NE.STN)GOTO 2
  IF(DAY.LT.367)GOTO 2
  DO 21 I=1,48
  BACKSPACE 1
21 CONTINUE
  PRINT*, STN, DAY

3 JLDATE=JLDATE+1

  DAY=JLDATE
  WRITE(2,201)JLDATE
201 FORMAT(I5)

  IF(DAY.LT.100)THEN
    TO=A11+5./60.+9/60.*SIN(2.*RADDEG*(DAY-1.))
  ELSE IF(DAY.GE.100.AND.DAY.LE.242)THEN
    TO=A11+1./60.-5./60.*SIN(RADDEG*(DAY-100)/0.395)

```

```

ELSE
  TO=A11+2.5/60.-18.6/60.*SIN(RADDEG*(DAY-242)/0.685)
ENDIF

DECL=A21*SIN(A22*(DAY-A23))
OMSR=-ACOS(-TAN(LAT)*TAN(DECL))
TSR=INT(OMSR/A31+TO)
TSS=INT(2.*TO-TSR)+1
A41=12.*1353./PI*(1.+0.033*COS(RADDEG*360./365.*DAY))
A42=COS(LAT)*COS(DECL)
A43=SIN(LAT)*SIN(DECL)

DO 80 IHR=1,24

102 READ(1,102,END=88)STN, DAY, HOR, TEMP, DIRN
  FORMAT(11X,2F11.0,11X,3F11.0)
  IF(STN.NE.STN1)THEN
    PRINT*,STN, DAY, JLDATE
    JLDATE=JLDATE-1
    GOTO 2
  ENDIF
  IDAY=DAY-366.
  IF(IDAY.NE.JLDATE)THEN
    PRINT*,STN, DAY, JLDATE, IHR
    JLDATE=IDAY-1
    BACKSPACE 1
    GOTO 3
  ENDIF
1021 READ(1,1021)HOR1, TEMP1, DIRN1
  FORMAT(44X,3F11.0)
  IF(HOR.EQ.-99999)THEN
    IF(HOR1.EQ.-99999)THEN
      H=-999
      MH=MH+1
    ELSE IF(HOR1.LT.0)THEN
      H=0
    ELSE
      H=HOR1
    ENDIF
  ELSE IF(HOR.LT.0)THEN
    IF(HOR1.LE.0)THEN
      H=0
    ELSE
      H=0.5*HOR1
    ENDIF
  ELSE
    IF(HOR1.EQ.-99999)THEN
      H=HOR
    ELSE IF(HOR1.LT.0)THEN
      H=0.5*HOR
    ELSE
      H=0.5*(HOR+HOR1)
    ENDIF
  ENDIF
  IF(DIRN.EQ.-99999)THEN
    IF(DIRN1.EQ.-99999)THEN
      DN=-999
      MDN=MDN+1
    ELSE IF(DIRN1.LT.0)THEN
      DN=0
    ELSE

```

103

```

        DN=DIRN1
    ENDIF
ELSE IF(DIRN.LT.0)THEN
    IF(DIRN1.LE.0)THEN
        DN=0
    ELSE
        DN=0.5*DIRN1
    ENDIF
ELSE
    IF(DIRN1.EQ.-99999)THEN
        DN=DIRN
    ELSE IF(DIRN1.LT.0)THEN
        DN=0.5*DIRN
    ELSE
        DN=0.5*(DIRN+DIRN1)
    ENDIF
ENDIF

IF(TEMP.EQ.-99999)THEN
    IF(TEMP1.EQ.-99999)THEN
        TEMP=-999.
        MTEMP=MTEMP+1
    ELSE
        TEMP=TEMP1
    ENDIF
ELSE
    IF(TEMP1.EQ.-99999)THEN
        TEMP=TEMP
    ELSE
        TEMP=0.5*(TEMP+TEMP1)
    ENDIF
ENDIF

IF(IHR.LE.TSR.OR.IHR.GT.TSS.OR.H.EQ.0)THEN
    H=0
    DN=0
    IF(TEMP.NE.-999)TAVE=TAVE+TEMP
    WRITE(2,103)DN,H,TEMP
    FORMAT(2(I4,1X),F5.1)
ELSE IF(DN.EQ.-999.AND.H.NE.-999)THEN
    OM1=(REAL(IHR-1)-TO)*A31
    OM2=(REAL(IHR)-TO)*A31
    OM=(REAL(IHR)-0.5-TO)*A31
    HO=A41*(A42*(SIN(OM2)-SIN(OM1))+A43*(OM2-OM1))
    KT=REAL(H)/HO
    IF(KT.LE.0.0)THEN
        HD=H
    ELSE IF(KT.LE.0.22)THEN
        HD=(1.-0.09*KT)*H
    ELSE IF(KT.LE.0.8)THEN
        HD=0.9511-0.1604*KT+4.388*KT*KT-16.638*KT**3
        HD=(HD+12.336*KT**4)*H
    ELSE
        HD=0.165*H
    ENDIF
    HB=REAL(H)-HD
    AM=A42*COS(OM)+A43
    IF(ABS(AM).LT.EPS)THEN
        AM=10.
    ELSE
        AM=ABS(1./AM)
    ENDIF

```

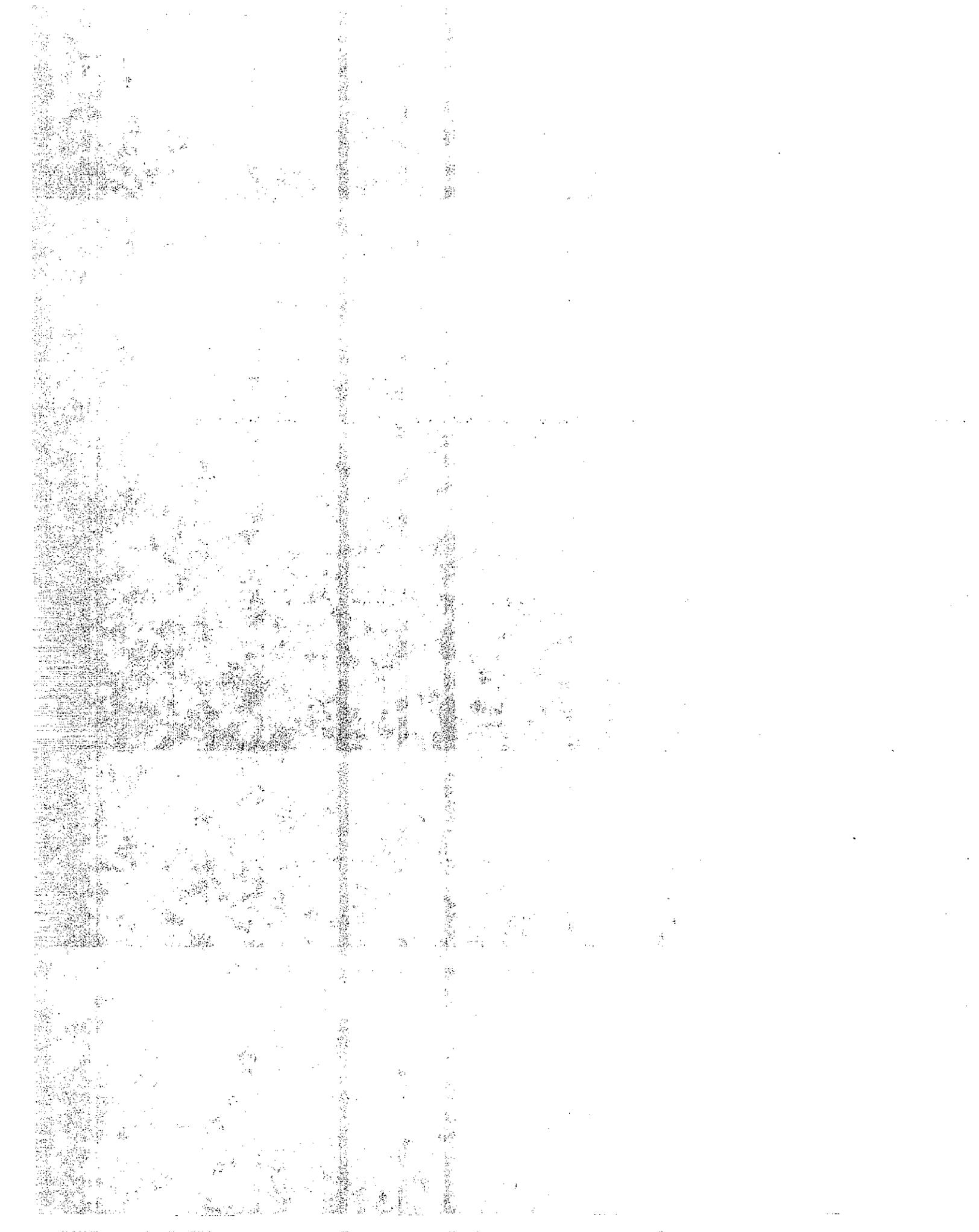
```

DN=HB*AM
DNMAX=IO*EXP(BETA*AM)
IF(DN.GT.DNMAX)DN=DNMAX
IF(DN.LT.0)DN=0
IF(ABS(DN).GT.10*H)WRITE(20,*)JLDATE, IHR, TSR, TSS, DN
HAVE=HAVE+H
IF(TEMP.NE.-999)TAVE=TAVE+TEMP
WRITE(2,103)DN,H,TEMP
PRINT*, '***** ESTD DN *****', JLDATE, IHR
ELSE
WRITE(2,103)DN,H,TEMP
HAVE=HAVE+H
IF(TEMP.NE.-999)TAVE=TAVE+TEMP
ENDIF
80 CONTINUE
IF(JLDATE.EQ.365)THEN
TAVE=TAVE/(8760.-MTEMP)
HAVE=HAVE/(8760.-MH)
PRINT*, 'AVERAGES ---- ', STN1, HAVE, TAVE
PRINT*, ' MISSING VALUES FOR DN, H, TEMP', MDN, MH, MTEMP
STOP
ELSE
GOTO 3
ENDIF
88 PRINT*, 'END-OF-FILE ---- ', STN, DAY, JLDATE
JLDATE=JLDATE-1
99 CONTINUE
CLOSE (1)
OPEN(1, FILE='SIMP2', RECL=88)
REWIND 1
GOTO 2
END

```

APPENDIX V

Contents Summary of Photovoltaic Power Systems and Accessories Guide
Including: Guide's Table of Contents
 Product Listing
 Manufacturer Listing



PHOTOVOLTAIC POWER SYSTEMS AND ACCESSORIES GUIDE

VOLUME 1

Peter A. Lehman

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Department of Environmental Resources Engineering
Humboldt State University
Arcata, CA 95521

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Section 1: Photovoltaic Modules

- Single crystal modules
- Polycrystalline modules
- Amorphous modules
- Concentrator systems
- Self-contained power systems

Section 2: Array Support Structures

- Passive trackers
- Active trackers
- Stationary support structures: Ground and pole mounts
- Mounting hardware
- Tracker installation and operating instructions

Section 3: Batteries

- Deep cycle batteries
- Shallow cycle batteries
- Battery racks and accessories
- Battery installation and operating instructions

Section 4: Inverters

- Power inverters
- Sine wave inverters
- Motor generators
- Inverter installation and operating instructions

SECTION 1: PHOTOVOLTAIC MODULES

<u>Manufacturer</u>	<u>Product Description</u>
Kyocera	Polycrystalline modules: 11,24,38,43,48,59W
Hoxan	Single crystal modules: 10,20,30,35,36,40,45,48W Power Pack self-contained power system: 10,20,30,40W
Solarex	Polycrystalline modules: 18,30,53,56,60W Amorphous modules: 1,2,5,20W
Interatom	Single crystal modules: 130W
Solec	Single crystal modules: 7.5,10,18,20W Solar cells and assemblies Portable self contained power system: 10W
Sovonics	Amorphous modules: 20,32W Portable battery chargers: 10,30W
Chronar	Amorphous modules: 3,4,5,6,8,10,12,15,20,25,30,40,50,60W
Mobil Solar	Single crystal modules: 18,36,220W
Arco Solar	Single crystal modules: 7,10,22,40,42,47,53W Amorphous modules: 1,2.5,5,30W Modules for solar DHW pumping systems
Integrated Power	Single crystal modules: 4.5,9,36,40W Self-contained power system: 9W
Solavolt	Polycrystalline module: 40W
Intersol	Concentrator modules: 88W Concentrator array: 5.4KW
Sun Selector	Self-contained power system: 80W

SECTION 2: ARRAY SUPPORT STRUCTURES

<u>Manufacturer</u>	<u>Product Description</u>
Zomeworks	Passive solar trackers
Heart	Sun tracking controllers
Robbins Engineering	Sun tracking systems
Dinh	PV trackers
Sovonics	R series structural support systems
Solavolt	Array support structures: Ground and pole mount
Solar Electric	Module mounting structures
Arco Solar	Module support structures
Levelog	Solar mounting hardware
Integrated Power	Array support structures: Ground and pole mount

SECTION 3: BATTERIES

<u>Manufacturer</u>	<u>Product Description</u>
GNB Absolyte	Storage batteries Battery racks and cabinets
NIFE Sunica	Ni-Cad batteries
Exide Dynacell	Shallow cycle batteries Deep cycle batteries Battery racks and accessories
Elpower Technacell	Lead acid batteries Ni-Cad batteries Lithium cells
Trojan	Shallow cycle batteries Deep cycle batteries (including L16) Gelled batteries Battery hardware
Surrette	Deep cycle batteries
Delco	Deep cycle batteries
Keystone	Storage batteries
Varta	Deep cycle lead-acid batteries Battery racks
IBE	Deep cycle batteries
Solar Electric	Battery hydrometer

SECTION 4: INVERTERS

<u>Manufacturer</u>	<u>Product Description</u>
Trace	FET inverters, modified sine wave Inverter stacking interface
Vanner	Inverters Circuit accessories
Photoelectric	Inverters
Dytek	Inverters
Abacus Controls	Inverters: Single and three phase, 50 and 60 Hz
Wilmore Electronics	Inverters
Heart	FET inverters
TrippLite	Inverters
Best	Inverters
Dynamote	Inverters: Modified sine wave Inverters: Full sine wave
Omnion	Inverters Standby power systems
Honeywell	Motor generators
Redi-Line	Motor generators
Dinh	Inverters: Square wave Motor generators

PHOTOVOLTAIC POWER SYSTEMS AND ACCESSORIES GUIDE

VOLUME 2

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- Power controllers
- Charge controllers
- Voltage regulators
- Battery regulators: Conditioners, equalizers, and isolators
- Power maximizers

Section 2: Water Pumping Systems

- Submersible, deep and shallow well pumps
- Positive displacement pumps
- Portable pump assemblies
- Irrigation control systems
- Circulating pumps

Section 3: Generators

- Portable generators
- Stationary generators: Gasoline and diesel fueled

Section 4: Miscellaneous Accessories

- DC lighting: Fluorescent, incandescent, and halogen
- Mobile power generators
- Cathodic protection
- Low pressure sodium street lighting
- Security lighting
- Track signalling and power
- Electronic flashers
- Remote site repeaters
- DC ballasts
- Ventilation and air conditioning systems
- Solar refrigeration
- Wire and wiring hardware

Section 5: Miscellaneous Information

- System design
- Research updates
- Technical information: Inverters and batteries
- Maximum power point tracking
- Specification guidelines for remote PV power systems

SECTION 1: CONTROLLERS AND REGULATORS

<u>Manufacturer</u>	<u>Product Description</u>
Heliotrope General	Switch mode controller
Specialty Concepts	Charge and power controllers Sequencing charger Control systems
Integrated Power	PV system regulator
Arco Solar	Battery protectors Charge controllers
Solar Electric	Charge controllers
Solavolt	Voltage regulators
GNB Absolyte	Charge regulators
SunAmp Systems	PV controllers
Vanner	Battery charger/conditioner Battery isolators and equalizers
BOSS	Voltage regulators Charging controllers
Watkinson-Coomer	Power maximizer
ECT	Load matching computers

SECTION 2: WATER PUMPING SYSTEMS

<u>Manufacturer</u>	<u>Product Description</u>
Grundfos	Deep well submersible pumps PV pumping systems
A.Y. McDonald	Shallow and deep well submersible pumps Non-submersible pumps PV pumping systems
Ergo Industries	Positive displacement PV pumping systems
Kyocera	Submersible PV pumping systems
Warns Pumps	Submersible DC pumps
Chronar	Shallow and deep well submersible pumps Jack pumps
Lamb Solar	Deep well PV pumping systems
Windlight Workshop	Deep and shallow well submersible pumps
SunAmp	PV pumping systems
Dinh	PV pumping systems
Solar Electric	PV pumping systems
Solray	PV pumping systems
Heliodinamica	Submersible PV pumping systems
Hoxan	PV pumping systems Irrigation control systems
BOSS	Power converters for DC pumps
SolarJack	Jack pumps
March	Circulating pumps
Hartell	Brushless DC circulating pumps

SECTION 3: GENERATORS

<u>Manufacturer</u>	<u>Product Description</u>
Winco	Slow speed generators: 3000,4000,6000W Mobile power systems Portable generators: various sizes
Onan	GenSets: 2.5,3.0,4.0,5.0,6.5,7.5,10.0, 12.5,15.0KW; gasoline powered GenSets: 6.0,12.0KW; diesel powered Portable generators: various sizes

SECTION 4: MISCELLANEOUS ACCESSORIES

<u>Manufacturer</u>	<u>Product Description</u>
Thin-Lite	12VDC lighting: fluorescent
Sunnyside Solar	12VDC lighting: fluorescent, incandescent, and halogen
Hoxan	Portable PV lantern
Intersol	Mobile PV power generators: 500W to 2.5KW
Integrated Power	Mobile PV power generators: 2.4KW
Chronar	Mobile PV power generators: 300W to 4.0KW
Solavolt	Mobile PV power generators: 720 W
Chronar	PV cathodic protection station
BOSS	Cathodic protection control system
Chronar	PV low pressure sodium street lighting
Solec	PV low pressure sodium street lighting Solar lighted transit shelter
SunAmp	PV security lighting systems
Integrated Power	Track circuit power systems
NIFE PPS	PV track signalling systems
Iota Engineering	DC solid state ballasts
Solar Electric	12VDC inverter ballasts
New Breeze	PV evaporative air cooling systems
Nicro	12VDC ventilation systems
Solar Electric	12VDC ventilation systems
Solavolt	PV refrigeration systems
Polar Products	PV refrigeration systems
SunFrost	PV refrigerators and freezers
National (Solar Elec)	Wire and wiring hardware

SECTION 5: MISCELLANEOUS INFORMATION

<u>Source</u>	<u>Description</u>
PV International	Design of PV diesel generator hybrid system
EPRI	Amorphous silicon technical brief
T.D. Paul	Independent power systems and inverters
Arco Solar	Technical aspects of batteries
Photovoltaics	Maximum power tracking
L.S. Gordon	PV power systems: A user's guide to reliability in sizing and design
Integrated Power	GSA: Authorized federal supply schedule price list Specification guidelines for commercial photovoltaic remote-site power generators

Manufacturers of Solar Products

<u>Name</u>	<u>Address</u>	<u>Phone</u>
A.Y. McDonald MFG. Co.	P.O. Box 508 Dubuque, IO 52001	319-583-7311
Abacus Controls Inc.	P.O. Box 893 Somerville, NJ 08876-0893	201-526-6010
Arco Solar	P.O. Box 2105 Chatsworth, CA 91313	
Best Energy Systems For Tommorrow, Inc.	P.O. Box 280, Route 1 Necedah, Wisconsin 54646	608-565-7200
BOSS	7745 E. Redfield Rd. Scottsdale, AZ 85260	602-948-9809
Chronar	P.O. Box 177 Princeton, NJ 08542	609-587-8000
Chronar TriSolar, Inc.	10 DeAngelo Dr. Bedford, MA 01730	617-275-1200
Delco		
Dinh	P.O. Box 999 Alachua, FL 32615	904-462-3464
Dynamote Corp.	1200 W. Nickerson Seattle, WA 98119	206-282-1000
Dytek Laboratories, Inc.	165 Keyland Ct. Bohemia, NY 11716	516-589-9030

Manufacturers of Solar Products

<u>Name</u>	<u>Address</u>	<u>Phone</u>
Earth Energy Systems Inc.	250 Prairie Center Dr. Eden Prairie, MN 55344	612-830-7200
ECT Marketing, Inc.	5256 Kearny Villa Way San Diego, CA 92123	619-569-1673
Elpower Technacell	2117 S. Anne St. Santa Ana, CA 92704	714-540-6155
EPRI	P.O. Box 10412 Palo Alto, CA 94303	415-855-2000
Ergo Industries Corp.	913 A St. Arcata, CA 95521	
Exide Dynacell	101 Gibraltar Rd. Horsham, PA 19044-2373	215-674-9500
FlowJet Corp.	12 Morgan Irvine, CA 92718	714-859-4945
General Distributing, Inc.	224 W. Evergreen St. Durant, OK 74701	405-920-0025
GNB Incorporated	2010 Cabot Blvd. West, Suite 1 Langhorne, PA 19047	215-750-2600
Grundfos Pumps Corp.	2555 Clovis Ave. Clovis, CA 93612	209-299-9741
Hartell Division	70 Industrial Dr. Ivyland, PA 18974	215-322-0730

Manufacturers of Solar Products

<u>Name</u>	<u>Address</u>	<u>Phone</u>
Heart Interface Corp.	811 1st Ave. S. Kent, WA 98032	206-859-0640
Heliodinamica	P.O. Box 8085 01051 Sao Paulo Brazil	011-493-3888
Heliotrope General	3733 Kenor Dr. Spring Valley, CA 92077	619-460-3930
Honeywell	P.O. Box 106 Rockford, IL 61105	815-966-3600
Hoxan	50 W. 40th St., Suite 215 New York, NY 10018	212-382-1852
IBE Inc.	9121 DeGarmo Ave. Sun Valley, CA 91352	213-875-2840
Integrated Power Corp.	7524 Standish Pl. Rockville, MD 20855	301-294-9133
Interatom	P.O.B. D-5060 Bergisch Gladbach 1 Federal Republic of Germany	(0 22 04)
Intersol	11901 W. Cedar Ave. Lakewood, CO 80228	303-989-8710
Iota Engineering Co.	4700 S. Park Ave., Suite B Tucson, AZ 85714	602-294-3292
Keystone Battery Corp.	35 Holton St. Winchester, MA 01890	617-729-8333

Manufacturers of Solar Products

<u>Name</u>	<u>Address</u>	<u>Phone</u>
Kyocera	8611 Balboa Ave San Diego, CA 92123	619-576-2600
Lamb Solar	P.O. Box 4185 10615 Chandler Blvd. North Hollywood, CA 91601	818-980-6248
Loveleg	8656 Commerce Ave. San Diego, CA 92121	619-271-6240
March Manufacturing Inc.	1819 Pickwick Ave. Glenview, IL 60025	312-729-5300
Mobal Solar	16 Hickory Dr. Waltham, MA 02254	617-890-1180
Omnion Power Engineering Corp.	W. 297 S. 11085 Hwy ES Mukwonago, WI 53149	414-363-4088
Onan Corp.	1400 73rd Ave. N.E. Minneapolis, MN 55432	612-574-5000
Pacific Scientific (Redi-Line)	4301 Kishwaukee St. P.O. Box 106 Rockford, IL 61105	815-226-3030
Photocomm Incorporated	7745 E. Redfield Rd. Scottsdale, AZ 85260	
Photoelectric, Inc.	9191 Towne Centre Dr., Suite 220 San Diego, CA 92122	619-455-5383
Photovoltaics	P.O. Box 3269 Scottsdale, AZ 85257	

Manufacturers of Solar Products

<u>Name</u>	<u>Address</u>	<u>Phone</u>
Polar Products	2808 Oregon Ct., Bldg. K-4 Torrance, CA 90503	213-320-3514
REC Specialties, Inc. (Thin-Lite)	530 Constitution Ave. Camarillo, CA 93010	805-987-5021
Robbins Engineering	751 S. Richmond Rd., Suite F Ridgecrest, CA 93555	619-375-6882
SAB NIFE, Inc.	P.O. Box 100 George Washington Hwy. Lincoln, RI 02865	401-333-1170
Solar Electric Specialties Co.	P.O. Box 537 Willits, CA 95490	707-459-9496
Solarex	1335 Piccard Dr. P.O. Box 6008 Rockville, MD 20850	301-948-0202
SolarJack	102 W. 8th St. Safford, AZ 85546	602-428-1092
Solavolt International	P.O. Box 2934 Phoenix, AZ 85062	602-231-6400
Solec International, Inc.	12533 Chadron Ave. Hawthorne, CA 90250	213-970-0065
Sovonics	6180 Chochron Rd. P.O. Box 39608 Solon, OH 44139	216-349-6852
Specialty Concepts, Inc.	9025 Eton Ave., Suite a Canoga Park, CA 91304	818-998-5238

Manufacturers of Solar Products

<u>Name</u>	<u>Address</u>	<u>Phone</u>
Sun Selector	512 37th St. Parkersburg, W. VA 26101	
SunAmp Systems Inc.	P.O. Box 6346 7702 E. Gray Ed. Scottsdale, AZ 85260	602-951-0699
SunFrost		
Sunnyside Solar	Rd 4, Box 808 Green River Rd. West Brattleboro, VT 05301	802-257-1482
Surette	Box 3027 Salem, MA 01970	617-745-4444
Trace Engineering Co.	5917 195th N.E. Arlington, WA 98223	206-435-8826
TrippLite	500 N.Orleans Chicago, IL 60610	312-329-1777
Trojan	12380 Clark St. Santa Fe Springs, CA 90670	213-946-8381
Vanner Inc.	745 Harrison Dr. Columbus, OH 43204	614-272-6263
Varta Industries Inc.	203 Matzinger Rd. Toledo, OH 43612	419-476-1715
Warns Solar Pumps	P.O. Box 1133 89 W. Piedmont Keyser, W VA 26726	304-788-0142

Manufacturers of Solar Products

<u>Name</u>	<u>Address</u>	<u>Phone</u>
Watkinson - Coomer Laboratories	8 Deborah St. Clontarf Qld. 4019 Australia	07-284-1776
Wilmore Electronics Co, Inc	P.O. Box 1329 Hillsborough, NC 27278	919-732-9351
Windlight Workshop	P.O. Box 548 Santa Cruz, NM 87567	505-753-9699
Zomeworks	P.O. Box 25805 Albuquerque, NM 87125	505-242-5354