RENEWABLE ENERGY RESOURCES
FIELD TESTING

TECHNOLOGY REVIEW FOR FIELD TEST #7
PHOTOVOLTAIC POWERED LIGHTING AND WATER PUMPING
AT BAHARIA OASIS

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[redacted]

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FOREWORD
TECHNOLOGY REVIEW

The Egyptian Electricity Authority (EEA), the United States Agency for International Development (USAID/Cairo), and a group of U.S. consultants, form a team responsible for conducting field test demonstration projects for eleven renewable energy applications in Egypt. These demonstration projects include the use of photovoltaic, wind and solar thermal systems for water pumping, ice making, desalination, industrial process heat and grid connected electricity generation. The specific objectives of the four-year program are: (1) to demonstrate the viability of renewable energy technologies in Egypt, (2) to comprehensively strengthen Egyptian technical and institutional capabilities in the full spectrum of renewable energy planning and decision making, and (3) to establish the infrastructure necessary to ensure that renewable energy technologies, which have proven successful, are available for widespread use in Egypt.

Each field test contains seven generic tasks: Technology Review, Application Review, Conceptual Design, Preparation of a Statement-of-Work for a Tender Document, Proposal Evaluation, Supervision of Hardware Installation and Performance Evaluation. The Technology Review for one of these field tests, Photovoltaic Powered Lighting and Water Pumping, is presented in this document.

This Technology Review assesses the component and system technologies of this field test and provides a representative selection of manufacturers and system integrating contractors, hardware system specifications and examples of field experience with other PV powered lighting and water pumping system applications.

This document is subtask 3.7.2 to the field test requirements under Contract AID 263-123C-00-4069-00, Task Area 3.

PV/DIESEL POWERED ICE MAKING PLANT
TECHNOLOGY REVIEW
TASK 3.7.2
FIELD TEST #7

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1.0 EXECUTIVE SUMMARY

1.1 Project Objectives

The primary objective of this field test is to provide EEA with practical working experience in the design, operation and evaluation of photovoltaic energy systems. This field test will accomplish this objective by the demonstration and evaluation of three photovoltaic village electrification applications: water pumping, decentralized lighting systems, and a centralized village power system. The field test will also provide information on the technical, institutional and financial performance of these systems for assessing the viability of similar power systems for other applications throughout Egypt.

1.2 Intent of the Technology Review

There are a number of key factors that provide the context for Technology Reviews and support the evaluation of the desirability to proceed with a particular field test. The first factor is the degree to which the field test contributes to the objectives of the overall REFT Project. The Project has broad objectives to investigate selected renewable energy options:

1. Comprehensively strengthen Egyptian technical and institutional capabilities in the full spectrum of renewable energy planning and decision-making for technologies and applications;

2. Develop and sustain an Egyptian renewable energy infrastructure through establishment of data bases, information systems and organizations that effectively serve both the public and private sectors;

3. Design, realize and evaluate the performance of a series of field tests which utilize commercially available technologies in applications having potential for widespread use in Egypt.

4. Complete formal managerial and technical training, both on-the-job and specialized, and an intensive information dissemination program.

An assessment of the contribution of this specific field test to the REFT project objectives must consider the criteria necessary for a successful demonstration of a PV village electrification system. The Technology Review is

primarily concerned with the evaluation of commercially available hardware and systems required for the successful design, installation and operation of the power system and the relevant end-use technologies. The criteria used to evaluate technologies are listed below, although not necessarily in the order of importance.

1. Commercial availability of hardware systems
2. Hardware performance/system reliability
3. Capital cost and cost of energy
4. Operation and maintenance costs
5. Potential for widespread development in Egypt.

A review of the component and system technologies involved with this field test has been performed to support a decision of whether or not to proceed with this demonstration. A representative selection of manufacturers system integrating contractors, and hardware specifications has been provided. Finally, available design and application experience with PV village electrification systems are included.

1.3 Technology Perspective

Field Test #7 involves three distinct applications of PV technology: water pumping, decentralized village lighting, and centralized village power. Different considerations are involved in integrating PV technology with the specific end use technologies associated with each application.

PV water pumping technology has reached a significant level of commercialization; there are estimated to be over two thousand systems installed worldwide. Packaged systems including both the PV power system and the pumping hardware are available from a variety of manufacturers. Development efforts are currently focusing on (1) making the systems more cost-effective, and (2) improving their reliability.

Design refinements center around making PV pumping systems simpler, and with fewer components. Especially important is the use of DC (Direct Current) pump motors, which eliminate the need for expensive and unreliable DC-to-AC inverters. Many designs also eliminate the use of costly battery storage, and instead directly connect the pumps to the PV array.

The choice of pump type, either jack pump, submersible turbine, or surface mounted centrifugal, depends on the water flow and head characteristics at the well. Accurate hydrologic information is vital to the design of a successful PV pumping system. This success also depends to a great degree on careful matching of the available solar resource, the PV power production equipment, controls, the pump and motor, with the actual hydrologic conditions.

Decentralized village lighting technology has also reached a significant level of commercial success, with many more than 1000 systems currently in operation. A large number of manufacturers and system integrators offer packages that include both the PV power system and the lighting system.

Most PV village lighting systems are use small PV arrays (30-50 watts), batteries, charge controllers, and one or two highly efficient gas vapor lamps (fluorescent, sodium, or halogen) that operate on DC current.

Technical factors that are critical to the implementation of successful projects include (1) reliable charge controllers, and (2) availability of and distribution system for spare parts.

Centralized PV village power technology has achieved a substantially lower level of commercialization than either water pumping or decentralized lighting. This is primarily due to the current high cost of PV modules. The individual components of PV village power systems have proved themselves technically in several demonstration projects around the world, and, as the cost per watt of PV power decreases, the use of such systems can be expected to increase dramatically in unelectrified villages in remote areas of the developing world.

One of the key technical factors affecting the successful implementation of a centralized PV village power system is the reliability of the power conditioning equipment. All of these systems require battery storage and charge controllers to allow electricity consumption during non-daylight hours, but AC systems need additional hardware in the form of a DC-to-AC inverter. Large DC-to-AC inverters are currently somewhat unreliable. If customer loads permit it, a DC power system should be deployed, since it avoids the use of an inverter. An additional technical requirement unique to this application is the need for metering of power consumption by individual households.

1.4 Manufacturers and Hardware Systems

A selection of manufacturers, integrating contractors and hardware system specifications are provided in Sections 7 and 8 of this document. It is possible that no single company will have the broad capabilities needed to respond to he tender document. Therefore, it is probable that an integrating contractor, who may or may not be a PV system manufacturer, will coordinate the design, equipment selection, testing, procurement, shipping, installing, start-up, and training among a bidding team of companies.

1.5 Conclusions and Recommendation

The findings in this Technology Review support the recommendation to proceed with Field Test #7 from the point of view of the potential for widespread use of the technology in Egypt, and based on the growing commercial availability of proven hardware.

This review indicates that there should be no insurmountable technical problems associated with this demonstration project. This review supports the following conclusions:

1. Packaged PV water pumping system and decentralized PV lighting system technologies applicable for this field test are proven, reliable and commercially available.

2. The individual subsystem component technologies for a centralized PV village electrification system are also proven, reliable and commercially available.

3. The most important design trade-offs in this field test center on the choice between flexible, but somewhat unreliable AC systems, and more limited, but more reliable DC systems.

4. Many of the factors that will determine the success of these PV applications are not strictly techncial; consideration of adequate user training, the local availability of spare parts, and the degree of local interest in maintaining and operating the systems are other crucial items.

5. Lessons drawn from this field test will be applicable to a wide set of potential users of PV technology facing similar conditions in unelectrified rural villages throughout Egypt.

2.0 FIELD TEST OBJECTIVES AND DESCRIPTION

2.1 Project Objectives

The primary objectives of this field test are to provide EEA with practical working experience with photovoltaic energy systems, and to provide system design and operational training for Egyptian engineers for the purpose of assessing and implementing similar projects throughout Egypt. Specifically this field test will evaluate the performance of photovoltaic (PV) energy systems used in three village electrification applications: Water pumping, decentralized lighting systems and centralized village power systems.

The application of PV power systems for lighting and water pumping at the Baharia Oasis will serve as a demonstration of the technical & financial capability of PV technology to meet power demands in remote locations. This field test will also provide valuable data on the levels of maintenance and operational support that are required to support increasing numbers of similar applications in remote locations in Egypt. This Technology Review provides a detailed review of the specific equipment and technologies to be employed in this field test, i.e. PV power systems, water pumping and lighting systems.

The document is supplemented by the technical information provided in the PV System Technology Reference Notebook which was published in September 1985. Recommendations are provided pertaining to the commercial availability of equipment and the capabilities of contractors.

2.2 Description of the Field Test

The sites chosen for this field test demonstration of PV powered lighting and water pumping are located within the Baharia Oasis, an area some 380 kilometers southwest of Cairo (see Exhibit 2-1). The population of the oasis is estimated to be 20,000 - 30,000 people.[1] The oasis consists of a center area or

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1 Arab Republic of Egypt, Ministry of Development, Regional Development Plan for New Valley, prepared by EURO CONSULT & PACER Consultants, Cairo, Egypt, June 1983 pp. 12.

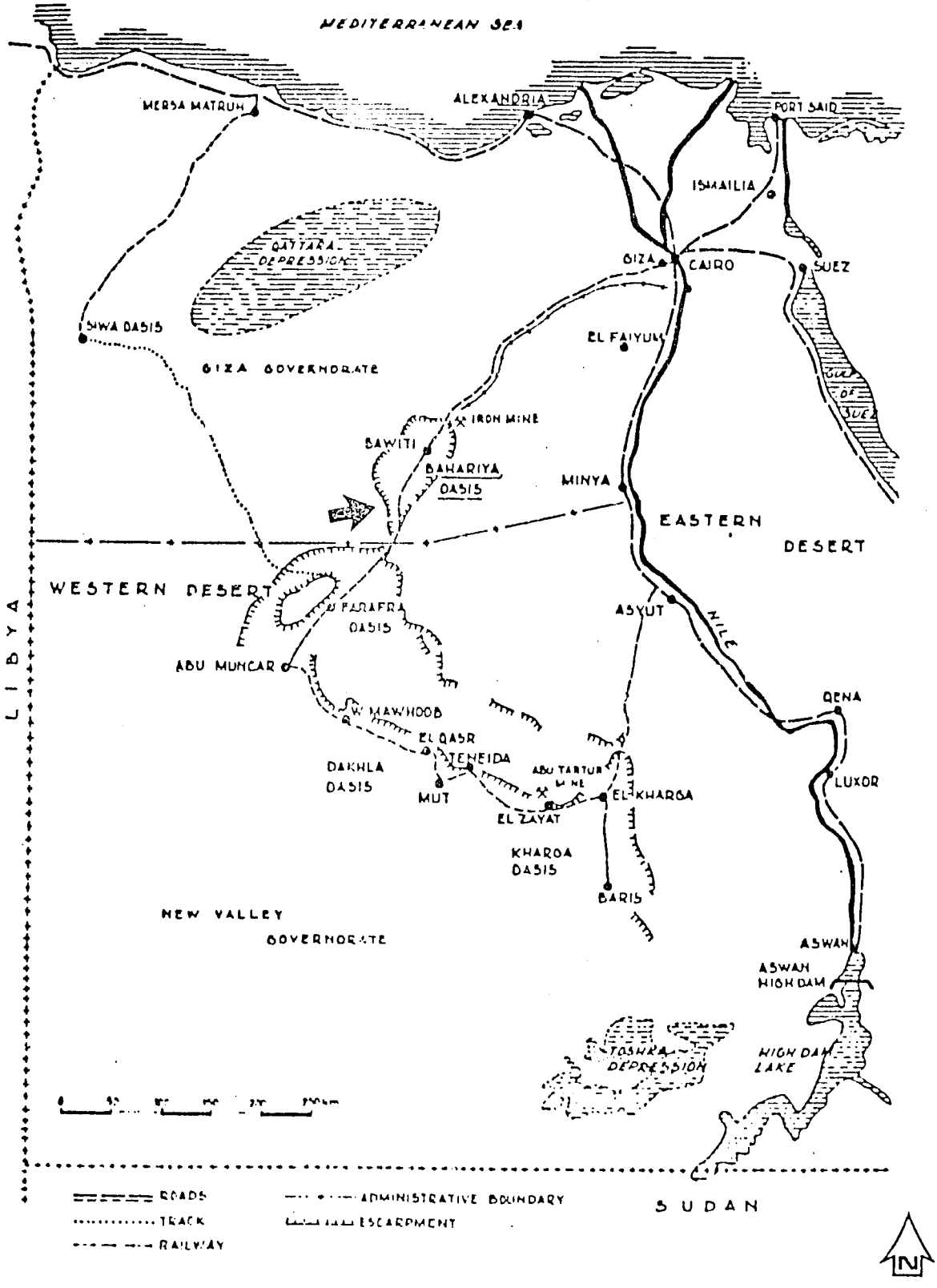

Exhibit 2-1 LOCATION OF THE STUDY AREA

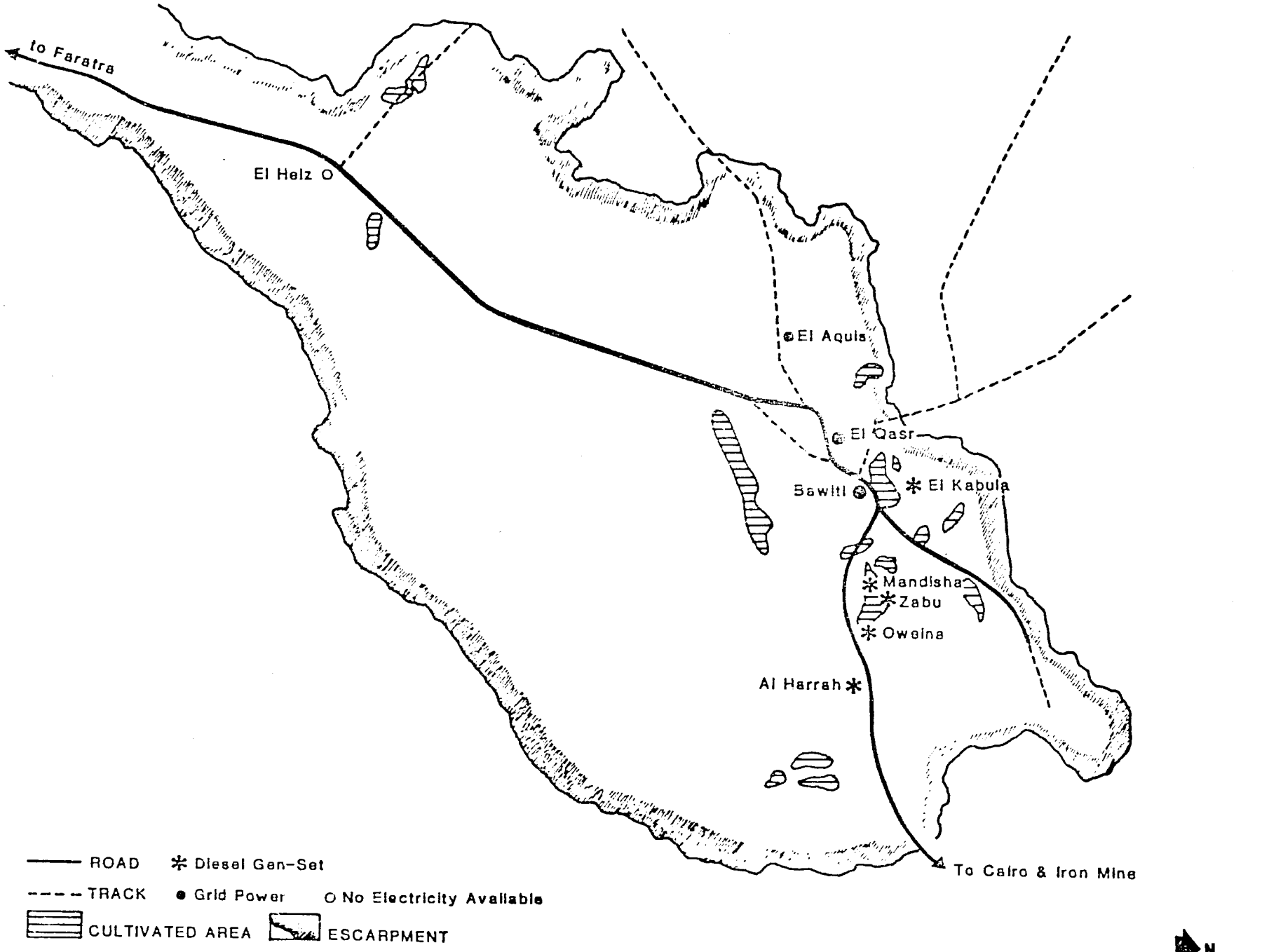

Exhibit 2-2: BAHARIA OASIS MAP

capital city, called Bawiti, surrounded by several village areas within a radius of 50 kilometers of Bawiti (See Exhibit 2-2).

The electrical energy supply for the oasis comes through a 132 kV transmission line from the Aswan Dam. Power is stepped down to 33 kV and 6.6 kV for distribution in the village areas of El Kasr and El Aquis, two of six major village areas within the Baharia Oasis. A principal energy user in the oasis is a government owned and operated iron ore mine with major facilities at the northeastern border of the oasis. Outside of El Kasr and El Aquis, several villages have been supplied with remote diesel engine-generator sets (See Exhibit 2-2). The remaining villages are not electrified. According to government officials in Bawiti, there are no current plans to extend the electric grid or to provide diesel generators to the El Haiz village area, because of its remoteness from Bawiti, and because of capacity constraints on the transmission line.

Photovoltaic power systems are being considered to supply water and/or irrigation pumping and basic lighting needs for several villages. Two potential village areas recently visited were in the El Haiz village area: Ain Gomaa and Ries. For Ain Gomaa, a decentralized approach is being investigated, in which small PV systems are installed on individual houses to provide energy for lighting. Approximately fifteen independent, small lighting systems (30-50 watts of PV per system) would be installed, each consisting of a roof-mounted photovoltaic module, a simple controller, a battery, and one or more fluorescent lighting fixtures.

For Ries, a more centralized approach is being considered, in which a single large PV array will serve about 30 households. Included would be the PV system, possibly with a DC-to-AC inverter, local distribution wiring, house-by-house metering, fluorescent light fixtures and possibly other end-use equipment such as small battery chargers or connectors for radios and television sets.

A third village, named Ain Gdid, located in the El Harrah village area, is being considered as a site for the water pumping component of Field Test #7. This village currently has a water supply and distribution system powered by a diesel pump located at the edge of the village. The pump draws water from a shallow well and pumps it directly into the distribution system; there is no water storage. The system serves about 2000 people.

Under initial plans the diesel pumping system would be replaced with a PV powered water pumping system and elevated water storage. The proposed system would provide roughly 40 m^3/day of water, at 20 meters total head, to an elevated storage tank with capacity for three days of use by the village residents. The PV array size would be on the order of 1kW, and it would directly drive a DC pumping system, without need for batteries or power conditioning. It would tie into the existing water distribution system and would draw water from the existing well.

Details of the preliminary system configurations, sizes and costs will be contained in the Application Review/Conceptual Design Document for this field test. This Technology Review contains an evaluation of the equipment components applicable for use on Field Test #7.

3.0 HISTORICAL PERSPECTIVE ON COMPONENT TECHNOLOGIES

Field Test #7 will evaluate photovoltaics, technology applications for three distinct village electrification applications; centralized and decentralized village electrification and water pumping. During this field test each system and hardware component will be tested on a technical, institutional and economic basis. The integrated performance of the power system components and the end use equipment will also be evaluated.

A perspective on the past and current performance of each technology is provided in this section to identify possible areas of concern for this field test.

3.1 Pumps

Electrically driven water pumping is a mature technology that has been in widespread use since the invention of the electric motor. Numerous reputable companies worldwide, including Egyptian firms, regularly design, manufacture, assemble, install and maintain water pumping systems. A development occuring within the last 5 years that is particularly relevant to this project is the widespread commercializaiton of DC motor driven pumps, designed specifically for use with PV power sources. They are available in a limited range of small sizes, and require no DC-to-AC inverter; they may be directly connected to the PV array.

3.2 Lights

Electric lighting is likewise a mature technology that has been continuously improved and refined over the past century, with the emphasis in the past decade on energy efficiency improvements. Fluorescents are among the most energy efficient lighting types, and have gained widespread acceptance as being particularly compatible with PV and other remote power sources. At the present time, a number of packaged PV/fluorescent lighting systems are commercially available worldwide, as are a variety of portable, DC battery powered fluorescent lighting systems.

3.3 Batteries

Lead-acid and nickel-cadmium storage batteries, best suited for photovoltaic power system applications, are proven technologies. Lead-acid storage batteries have been produced on a commercial scale for over 75 years. Nickel-cadmium batteries, first developed around 1900, did not come into common use until after 1945. Both lead-acid and nickel-cadmium batteries are available worldwide.

Development in battery technology is directed at lowering cost, increasing life, reducing maintenance requirements and increasing efficiency. Progress toward these objectives is expected to occur slowly but steadily.

An important development in battery storage technology for PV systems is the commercial availability of deep cycle, sealed lead-acid batteries that use recombination battery technology. Recombination battery technology significantly reduces water consumption by designing the battery cells to recombine any generated hydrogen and oxygen into water. This permits the battery to be sealed and results in a relatively maintenance free battery. Although the cost of these batteries is higher than "vented" lead-acid batteries, which require higher maintenance levels, their use in photovoltaic systems is expected to steadily increase. The effect of high temperature battery operation, as can be expected in Egypt, is an important consideration in the selection of a specific type of battery.

3.4 Photovoltaics

The development and growth of terrestrial photovoltaics has been impressive over the past 20 years. The cost of photovolatic equipment has dropped dramatically while performance has steadily increased. The reliability of today's photovoltaic modules is virtually 100% according to reports from NASA-Lewis Research Center based on their extensive PV application and evaluation experience. Related application experience worldwide supports this view. The

productive life of photovoltaic modules is currently expected to be approximately 20 to 30 years. Ten year performance warrantees from manufacturers are now available.

4.0 PV PUMPING SYSTEM TECHNOLOGY

4.1 Pump Options

Several types of pumps are available for well pumping applications, including positive displacement "jack" pumps, submerged rotary turbine pumps, and surface mounted rotary centrifugal or turbine pumps. Each is suitable for a specific class of applications, and has unique operating constraints. Exhibit 4-1 summarizes this information graphically.

Positive displacement or "jack" pumps are best suited for low flow rates or deep wells. The motor and controls are located on the ground at the well head. They operate with a reciprocating piston action to draw water efficiently from a well. However, because their reciprocating action imposes a fluctuating energy load on the power system, they are not compatible with directly connected photovoltaic power sources. Two means employed to "match" the jack pump loads with PV arrays are to use (1) a battery buffer or (2) a control system and flywheel to accomodate the steady supply of energy from the PV array to the cycling energy demand of the pump. Field experience with such systems has proven their designs.

Submersible rotary turbine pumps are suitable for moderate to high-flow applications, especially those with high head requirements such as are found in deep wells. Most submersible motors are AC (alternating current), which requires the power output from the PV array must be converted from DC (direct current) to AC before it can be used to drive a pump. Submersible pumps function quite well connected directly through an inverter to the PV array. DC motor submersible pump units are available today up to power levels exceeding 1 HP. Field experience is very positive and several companies offer DC "submersible" systems. The tradeoff with DC comes from using brushed vs. brushless motors. Brushed DC motors must be pulled out of the well every 2-5 years to change the brushes. Brushless AC motors use an electronic commutator. The benefit of DC submersible pumps vs. AC units comes chiefly from the ability to eliminate the DC-to-AC converter.

Surface mounted centrifugal pumps are most useful in low-lift applications such as providing water for irrigation from canals and shallow tube wells. They cannot muster the suction head required to draw water from deep wells. They provide the most efficient matching to a PV array of the pump/motor technologies.

The water pumping application for Field Test #7 has been tentatively sited at Ain Gdid, located in the El Harrah village area. At Ain Gdid and most other places within the Baharia Oasis, water is obtained from artesian wells that carry ground water to the surface under natural pressure. The pressure head requirement for pumping this water is therefore minimal. Surface mounted centrifugal pumps are ideally suited for application under this condition.

The system configuration that is proposed for this field test is the use of a surface mounted centrifugal pump feeding an elevated storage tank that will allow distribution of the water under gravity pressure throughout the day.

The Regional Development Plan for New Valley[2] projects that increased water usage will not cause significant draw down of the wells until after the year 2000. This exceeds the expected equipment lifetime of the initial pumping system, although it is still within the expected lifetime of the PV array. However, drawdown information specific to the field test site should be collected prior to specifying a pump. If the dynamic suction head is less than 5 meters, then a surface mounted centrifagal pump would be a good choice. If it is greater than 5 meters, submersibles should be considered.

In the long run (ca. 100 years), falling piezometric pressures will require that formerly free-flowing wells be pumped. By the year 2086, the pumping depth of the water can be expected to increase to approximately 50 meters below the surface, according to the Regional Development Plan (See Exhibit 4-2). When these conditions prevail, the type of replacement pumping system specified will have to match the changed conditions.

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2 Ibid. pg. 60

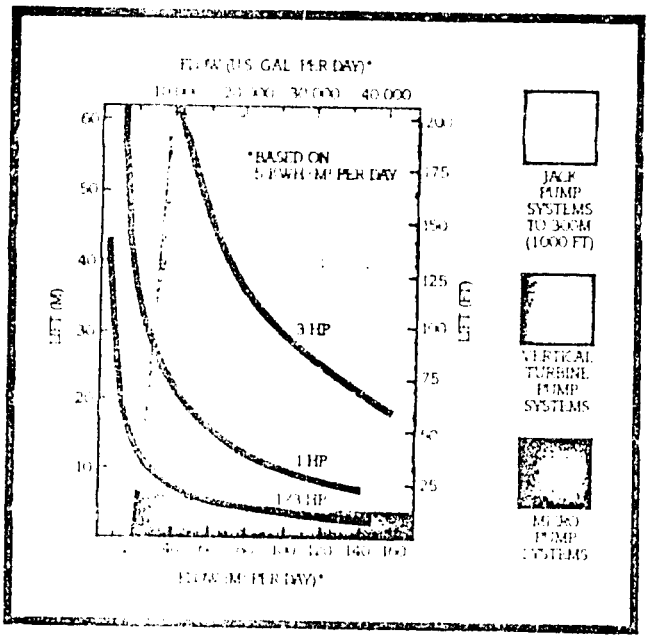

Exhibit 4-1 PUMP SELECTION CHART

Source: Tri-Solar Corporation

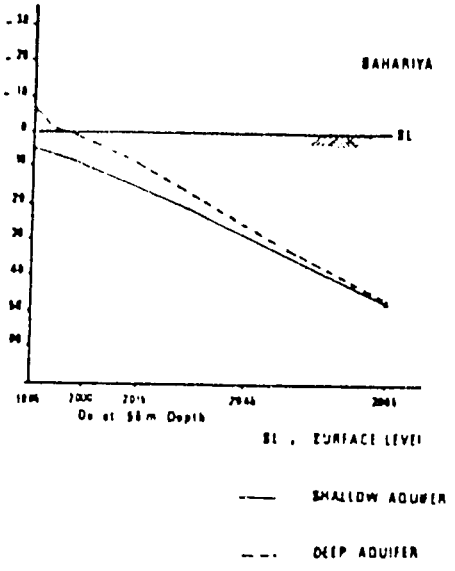

Exhibit 4-2 SIMULATED FUTURE WATER LEVELS AFTER DEVELOPMENT

SOURCE: Regional Development Plan for New Valley , 1983

4.2 Power System Options

The photovoltaic power system that drives the water pump at Ain Gdid can be configured in several different ways. The most important system options include direct connection of PV with a DC motor, AC direct connection of the array through a DC-to-AC inverter to an AC motor, and the incorporation of battery storage.

A DC direct connection power system configuration requires the use of a pump with a DC motor. DC motor driven pumps are limited to a range of small sizes (generally less than 1 kW). In the absence of battery storage or diesel backup, the pump will function whenever there is adequate sunshine to provide power. The mechanical characteristics of the pump generally allow it to operate at part load when only partial power is available, in the early morning and late afternoon, for example. Because the direct current (DC) produced by the PV array is utilized without intermediate conditioning, this is an extremely energy-efficient configuration. By having the pump feed a large storage tank, the timing of the water use does not have to match that of the pump operation.

The second configuration examined here is an AC system that is connected to the PV array through a DC-to-AC inverter. In this design, the DC output of the PV array is converted to AC power with approximately 10% power losses. This AC power is then used to directly drive a pump with an AC motor. Since most motors for all sizes and pump types are AC, this system configuration offers more flexibility in pump selection than the DC configuration described above. However, DC-to-AC inverters consistently have been shown to be the most unreliable part of a PV system, and their use significantly decreases the expected reliability of the power system.[3] Like the DC direct-connect system

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3 Eskanazi, Kerner & Slominski, Evaluation of International Photovoltaic Projects, prepared for Sandia National Laboratories by Meridian Corporation, Falls Church, VA, June 1986, pg. 3-11.

above, this configuration would allow part-load operation and would work best when feeding an elevated water storage tank.

The third possible power system configuration is one that incorporates battery storage. Battery storage could be coupled with either a DC or an AC system. It would store energy to allow the pump to operate somewhat independent of the PV array. Specific advantages would include (1) the possibility of operating the pump during non-sunlight hours, (2) providing a buffer to allow operation of an irregular or cyclical energy load such as that imposed by a reciprocating pump, (3) multi-use service for example, pumping and lighting needs and (4) higher operating efficiency resulting from constant pumping at full load. The disadvantages of battery storage include high cost and increased maintenance requirements. The use of water storage makes many aspects of battery storage redundant.

A DC direct-connect system without battery storage should be used for Field Test #7.

4.3 Technology Maturity of PV Pumping Systems

Over two thousand PV powered water pumping systems are estimated to have been installed worldwide, most of them during the last decade.[4] A variety of systems large and small, DC and AC, with and without battery storage, have been installed in Egypt over the last few years.

Primarily because of the expense of the PV arrays, the most popular and cost-effective PV pumping systems have been low power, low flow/head, DC direct-connect systems. According to the Meridian report footnoted above, they are currently estimated to be the least cost alternative (compared to diesel powered pumps) for most remote applications requiring less than $25m^3$/day at 25 m head. They are also reported to be economic for specific applications

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4 Ibid, pg. 3-2

requiring less than 550 m^3/day at 25 m head, but may not be financially viable for applications larger than that.

Spare parts availability is crucial for the success of any pumping system. It is particularly important for a PV pumping system because the lifetimes of the pump and motor (ca. 6 years) are so much shorter than that of the PV array (ca. 20 years). Thus, in order to get the full benefit from the investment in PV, replacement pump parts must be readly available.

PV pumping technology has been shown to have extremely high reliability compared to diesel pumps, which are the most common alternative system. The success of the PV pumping system depends to a great degree on careful matching of the available solar resource, the PV power production equipment, controls, the pump and motor, and the actual hydrologic conditions. The availability and proper use of credible data on solar resource and well yield characteristics has avoided significant under- and over-sizing of systems. It has further been shown that effective training in the use and maintenance of the system is important to correct misconceived user expectations and to reduce system downtime.

5.0 DECENTRALIZED LIGHTING SYSTEM TECHNOLOGY

5.1 Lighting system Options

Photovoltaic power for area lighting and home power systems is emerging as a significant technology in the developing world. For example, in French Polynesia, more than 1,000 home power systems were installed over a three-year period.[5] This application includes one-to-two-module systems used in individual households as well as systems used to provide area lighting. The small household systems have been primarily dedicated to lighting, but they can also be used to power radios, televisions, refrigerators and/or water pumps. Area lighting systems have been used for community, street and security lighting purposes.

The demand for lighting in rural areas of developing countries has typically been supplied by kerosene, candles or primary batteries. Lighting from these sources is often expensive and of poor quality. For example, a kerosene pressure lamp provides about 12 lux of light, while a 20-watt fluorescent tube with reflectors will provide 100 lux. Lighting is used for evening activities such as cooking, reading, simple work and social activities. During the night, a lamp is often kept lit for security and safety reasons.

A light consists of three major components: a luminaire (or bulb or tube), a ballast (for fluorescents) and a fixture. PV powered lighting applications identified for developing countries use gas vapor lamps (e.g., fluorescent, low-pressure sodium, mercury vapor and metal halide). These lamps require a high-voltage electric charge to excite the gas molecules, thus producing light. Once initiated, lighting can be maintained with lower voltages. The charge is sparked and the operating frequency is regulated by a ballast--a high frequency

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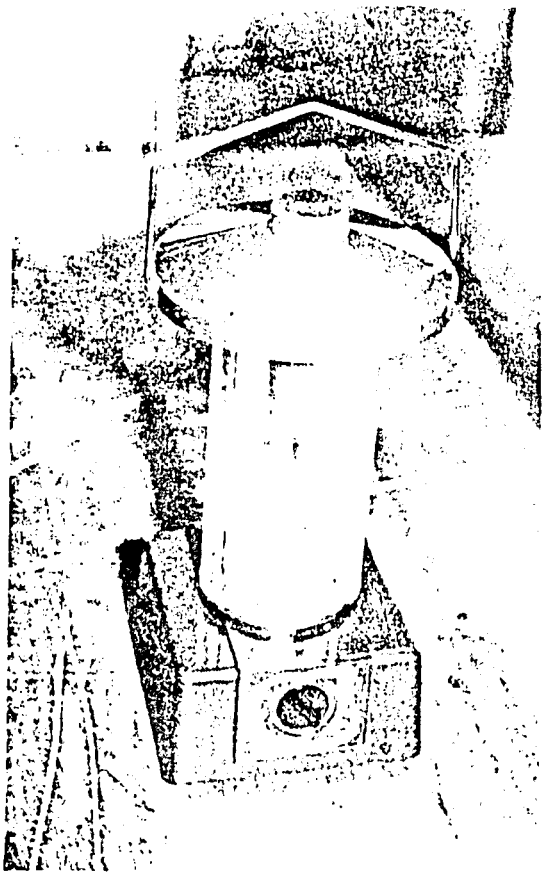
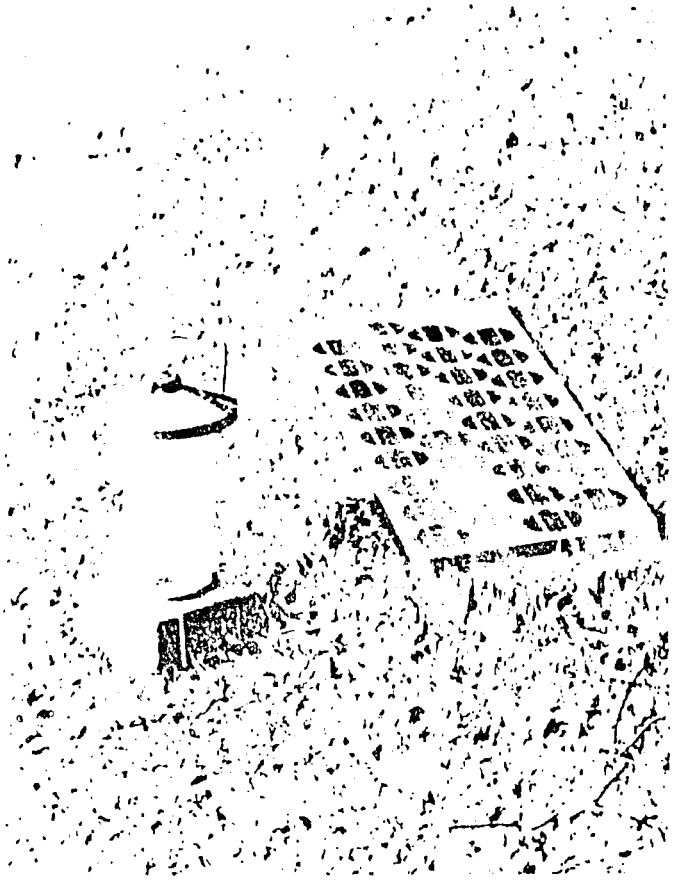
5 Ibid, pg. 6-1

Exhibit 5-1
PORTABLE PV-POWERED LANTERN





inverter and transformer that controls the current flow into the lamp. The ballast and lamp are mounted in a fixture. The only difference between an AC and DC fluorescent light is the ballast design.

Conventional lighting practices observed in Baharia usually involve the use of kerosene-fueled lamps. A typical household may have one or more hurricane lamps or lanterns (wick lamps with a capacity of 0.5 to 1 liter of kerosene), and sometimes a pressurized lamp (e.g., the Coleman variety). Electrical loads, such as radios, are powered by automotive batteries that are recharged by engine generators. Primary batteries (e.g., throw-away batteries) have also been used to power electrical loads.

In rural areas of developing countries, kerosene-fueled lamps are used both indoors and outdoors. Therefore, an important design aspect of small lighting systems can be portability. In Papua New Guinea, this issue has been addressed by using PV to charge nickel-cadmium batteries for fluorescent lanterns (Exhibit 5-1). These systems have been developed and tested to compete with kerosene-fueled lanterns.

5.2 Power System Options

Exhibit 5-2 depicts a typical area lighting system. These systems consist of one or two PV modules, battery storage, a simple charge controller, timing controls and a light. Several companies offer self-contained units (the type depicted in Exhibit 5-2) equipped with light poles and weatherproof containers for battery storage and electronics. Area lighting systems represent a relatively new remote lighting application in the developing world, made possible through the advent of photovoltaics.

Home power systems are typically one-to-two-module systems operating two-to-four- fluorescent lights (10 to 40 watts each) in a private household. this type of lighting is usually combined with other end-use devices (such as

EXHIBIT 5-2. Area Lighting System

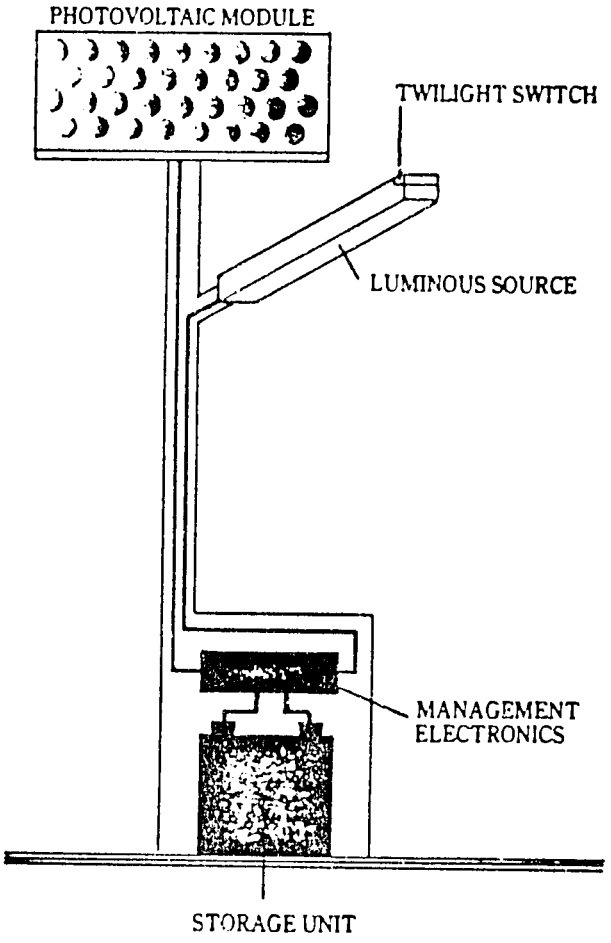
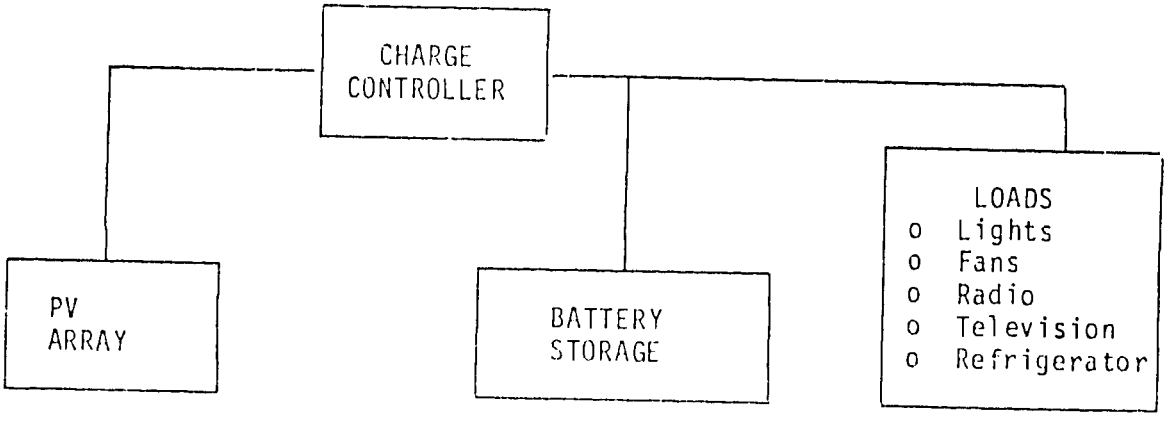


EXHIBIT 5-3. Configuration of a Home Power System



refrigerators, radios, televisions, fans, etc.) operated from the same PV power system. The basic configuration of such a system is outlined in Exhibit 5-3.

5.3 Technology Maturity of PV Lighting Systems

Meridian's previously referenced review of 1,260 PV-powered lighting and home power systems in 14 developing countries, found that successful PV-powered lighting and home power systems used both reliable charge controllers and DC ballasts and/or ensured adequate availability of spare parts and technical support. PVpowered lighting and home power systems were shown to be technically reliable. Many users also found such PV-powered systems to be cost-competitive with kerosene-fueled lamps, the predominant technology currently employed.

Based on the review of past projects, certain factors emerged as being critical to the implementation of successful projects. These factors are:

- Reliable charge controllers
- Available spare parts and distribution system
- Customer financing policy.

A range of experience has been encountered with charge controllers. In early systems, charge controllers were often a weak link in system performance. However, as product development has progressed, increased precaution has been taken by the manufacturers to protect components from environmental conditions. As a result, improved performance has been experienced.

While the charge controller is often the least costly part of a system and improved products are available, care should be taken to select a reliable, field-proven component. Successful implementation of large numbers of systems has also been made possible through the availability of replacement charge controllers.

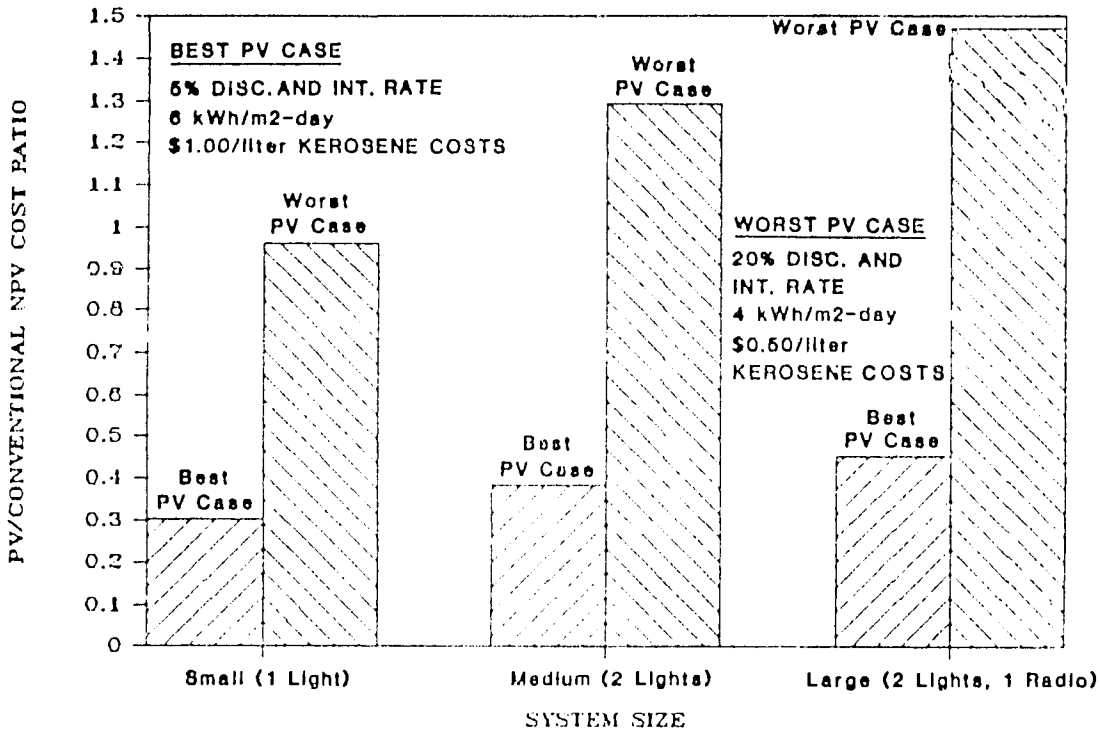
Essential to the successful implementation of PV-powered lighting systems is ensuring an adequate supply of spare lamps (Lifetime of 6 months) and ballasts (Lifetime of 3 years). An infrastructure of this type is necessary for the widespread application of any technology. Maintenance on the systems are restricted to the batteries and loads. If the batteries are vented, then

distilled water must be added on a regular basis. Fluorescent tubes should be replaced as they burn out.

In 1980, according to the Meridian report, PV-powered lighting was determined to be cost-competitive with kerosene in Papua New Guinea. As a result of government policies, conditions for the viability of PV-powered lighting exist in many other countries as well. At least two governments, French Polynesia and Spain, have established policies that subsidize the use of PV for rural electrification in remote areas. French Polynesia and Spain have successfully encouraged the implementation of thousands of PV-powered home power systems in the last few years.

For the typical small systems examined in the Sandia/Meridian report (a single light), PV-powered systems are financially attractive, even under "worst-case" conditions for PV, (See Exhibit 5-4 for details). For medium (two lights) and large (two lights, one radio) configurations, PV-powered systems may be financially attractive, depending on specific technical and financial project parameters. The conventional power system costs are dominated by fuel costs, followed by maintenance expenses. The PV-powered systems are dominated by debt service (repayment of initial capital cost plus interest).

Exhibit 5-4
SENSITIVITY OF LIGHTING AND HOME POWER COSTS TO BEST AND WORST CONDITIONS



Source: Evaluation of International PV Projects, Sandia/Meridian, 1986

Analysis assumes $8/Wp PV array costs.

6.0 CENTRALIZED PV POWER SYSTEM TECHNOLOGY

6.1 System Options

Centrally powered multi-use systems are considered an important application for PV because of the large number of unelectrified villages in remote locations of the developing world. Traditionally, needs for power in developing countries have been met through conventional means such as diesel- and gasoline-fueled engines, kerosene-fueled refrigerators and lights, and batteries.

A multi-use system or mini-utility system consists of a centralized generator that provides service to an entire community through a distribution network. (See Exhibit 6-1). Such systems, using diesel generators, are in place at several villages in the Baharia Oasis.

PV-powered multi-use systems can be designed to produce AC or DC power. Mini-utilities are traditionally AC since AC is a more efficient means of distributing power over large distance, but both AC and DC systems have been designed. Applications experts have agreed[6] that systems should be designed to be DC whenever possible. The basis for this consensus is the fact that using an inverter increases system complexity and hence the risk of system failure. Load availability is the critical factor in determining the viability of designing a DC system, as DC loads are currently available only for speciality markets. Items such as lights, fans, refrigerators and some audio-visual equipment are available in DC. However, for multi-use systems with a mixture of appliances, such as stereos, televisions, small hand tools, and complex medical equipment, AC power systtems are the only real option.

Mini-utilities have traditionally been powered by engine generator sets (gen-sets) that produce AC electricity as shown in Exhibit 6-2. Back-up power

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[6] Ibid, pg. 7-4.

EXHIBIT 6-1. Schematic of a PV-Powered Mini-Utility System

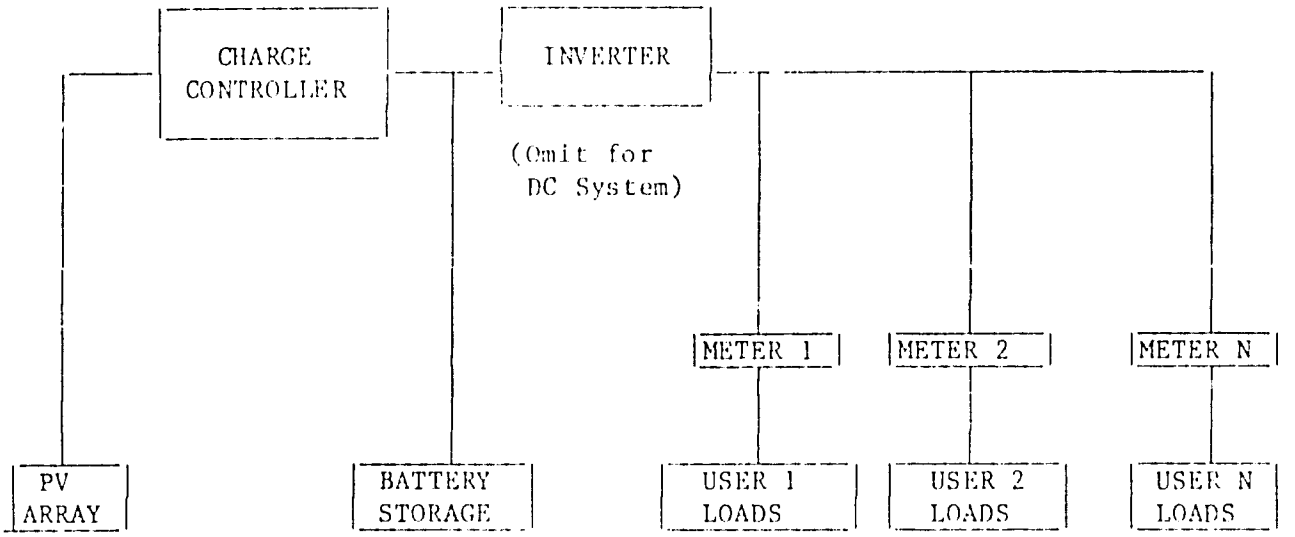
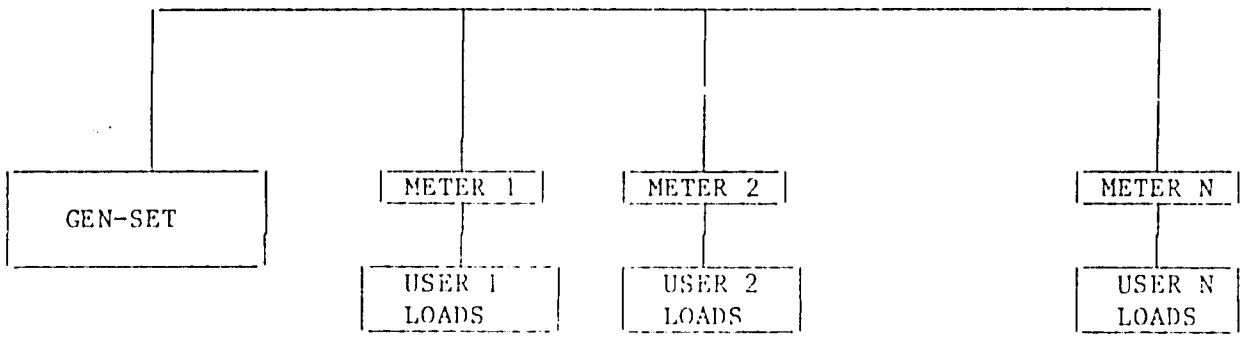


EXHIBIT 6-2. Schematic of an Engine-Powered Mini-Utility System



for these systems has generally been in the form of another engine generator (i.e., a dual-engine system). Diesel gen-sets are only available above 3 kW. If the loads require engines below that size and a diesel gen-set is desired, a 3-kW diesel engine operating at a lower load factor must be used. Maintenance must be regularly performed on conventional-powered multi-use systems.

6.3 Technology Maturity of PV Power System

For the Meridian report the experience associated with a variety of systems was reviewed. Projects of particular interest include those managed by NASA-Lewis: the grain mill project in Tangaye, Bourkina Fasso (formerly Upper Volta), five medical clinics in four developing countries and mini-utility systems in Tunisia, Arizona, and Indonesia.

Key factors in the implementation of PV-powered multi-use system were determined to be:

- o Reliability and complexity of power conditioning equipment
- o Infrastructure for system management
- o Rural electrification policy.

Since multi-use systems have a combination of various end-uses, the key factors affecting the system implementation of the individual applications should also be taken into account.

6.3.1 Reliability and Complexity of Power Conditioning Equipment

Field experience has shown that the reliability of power conditioning equipment is critical to successful systems. While both inverters and charge controllers have been identified as potentially weak links in the PV-powered systems, charge controllers are considered further along in the product development process. Some system problems have been related to quality control and most likely would have been discovered had "burn-in" testing been performed. Other problems have been related to environmental factors (e.g., heat and humidity) or user

operating errors. Only proven equipment should be selected for all inverters and controllers. Factory testing should be included as part of the purchase specifications.

At a Round Table Meeting held in November 1985[7], applications experts agreed that low power inverters present a weak link in a multi-use system (both in terms of reliability and efficiency losses). Inverter problems have driven system designers to install DC systems whenever possible.

Complex operating procedures and over-sophistication of equipment and documentation have caused system implementation problems in developing countries. For example, in the grain mill and water pumping system in Tangaye, Bourkina Fasso, it was observed that the complexity of the orginial control system intimidated the technical support staffs of the in-country participating institutions. Although state-of-the-art equipment is moving to simpler designs, thate is still room for improvement. For these reasons, it is recommended that the centralized PV power system specified for Field Test #7 be a DC system.

6.3.2 Infrastructure for System Management

The most important factor impacting the success of a multi-use system is the effectiveness of local management in operating the system. A sense of "ownership" results in a commitment to system success, ensuring an adequate supply of spare parts and availability of technical support.

As the systems get larger in size and/or consist of a larger variety of loads, effective management becomes more critical since the interests of a larger number of people must be integrated.

6.3.3 Rural Electrification Policy

The decision to procure one centralized system as opposed to many dispersed

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7 Ibid, pg. 7-11.

systems is a key policy issue. Traditionally, centralized systems have been preferred by funding organizations since their performance is more easily monitored, and maintenance and control functions seem easier to administer. However, some governments, such as Papua New Guinea and French Polynesia, have made commitments to promote small individual systems.

Individual household power supplies do not require a distribution system throughout the village or metering systems. Also system failures impact a smaller sector of the population (e.g., sometimes only one household) than would be the case for a large centralized system. The PV modules can be mounted on roofs rather than dedicating valuable land to a large array. The management of power is much more complex in a centralized system since the interests of the entire community must be integrated and administrative support must also be available to coordinate a billing system. Field Test #7 will permit comparative analysis of centralized and dispersed systems under real-life conditions, and will provide valuable insights regarding the relative suitability of each configuration for further replication within Egypt.

7.0 REVIEW OF ADDITIONAL FIELD TEST HARDWARE

A discussion of the technology of photovoltaic modules, structures, batteries and controllers is provided in Chapter 3 the PV Technology Reference Notebook published in September 1985. This section summarizes that discussion and describes the specific equipment component technologies to be used in this field test that have not been covered in previous chapters.

7.1 Photovoltaics

Photovoltaic modules are available worldwide. They have been proven in numerous applications and under harsh conditions. Most field experience exists with single crystalline, poly-crystalline, and ribbon technology flat plate photovoltaic modules. The term "flat plate" refers to the direct use of the sun's energy (i.e., there is no enhancement or concentration of the sun's energy). Although concentrating photovoltaic modules are available, they have limited operating experience in developing countries. In addition to crystalline silicon PV technology, the technology of amorphous silicon has received much attention over the past few years and projections are that it will someday replace all other photovoltaic technologies as the least cost option. However, for the most part, amorphous silicon is being utilized on very small applications (square centimeters in size) such as calculators and watches. All photovoltaic technologies are highly reliable, virtually 100 percent based on NASA-Lewis Research Center extensive worldwide installation experience.

7.2 Structures

Common to all photovoltaic power plants is the desire to maximize the amount of incident solar energy on the array and at the same time minimize the cost and operating complexity of the system. There are three possible array structure designs which influence the amount of insolation incident on the array; fixed, single-axis tracking, and two-axis tracking. Project experience

with two axis tracking systems, which orient the PV array surface normal to the sun at all times, has shown that the increased cost and complexity is not justified by the increased insolation compared to a single-axis tracking design. A single-axis tracker permits the array to follow the path of sun, east to west by rotating the array about a single-axis. Single-axis tracking is approximately 20% more productive than a fixed array structure design. However, in order to maximize reliability and maintainability, the single-axis tracking option will be eliminated because of its many moving parts. A fixed array structure, as the name states, is a stationary array structure usually inclined approximately to the latitude of the site.

Fixed and adjustable tilt array mounting structures are commercially available. Fixed structures are constructed of galvanized pipe, aluminum or galvanized steel angle, and wood and concrete. Adjustable tilt structures permit manual adjustment of the tilt of panels (groups of modules) or sub-arrays. Adjustable tilt structures can be designed using the same basic materials and configuration as a fixed structure. Consideration needs to be given for the operation and maintenance requirement for tilting and for wind loading specifications.

7.3 Batteries

Performance characteristics of batteries, such as capacity, efficiency and discharge rate capability improve as temperature goes up (cold weather is considered a more hostile environment for batteries). However, the increased performance is at the expense of lifetime. Most battery manufacturers caution against extended operation at elevated temperatures above 32°C (it should be noted that in addition to the environment, battery temperatures rise during rapid charging and discharging cycles).

The most dominant maintenance item connected with battery banks is the periodic addition of water to the electrolyte. For this reason the physical

arrangement of the battery bank should be carefully considered so that this water addition can be done in a safe manner without unduly exposing maintenance workers to high currents or high voltages.

The enclosure for the batteries must be vented so that any hydrogen which is generated will not accummulate and cause an explosive hazard.

One comparatively recent innovation to reduce maintenance is the sealed battery which is especially designed for deep cycle operation. The hydrogen and oxygen is recombined before it leaves the battery to form water. In this way water from the outside does not have to be added.

The two most common batteries used for PV applications are lead-acid and nickel cadmium. Lead-acid batteries are the preferred choice over nickel-cadmium primarily because of lower cost. Lead-acid batteries are sometimes referred to by the type of electrode used; for example, lead-antimony, pure lead, or lead-calcium. Lead-acid batteries are manufactured in sealed and vented configurations. For remote applications and sandy areas, sealed batteries are often preferred over vented batteries because the loss of electrolyte and potential for contamination is greatly reduced. Sealed batteries are however more expensive than vented batteries. Vented batteries can be fitted with "recombination caps" which greatly reduce the loss of electrolyte due to overcharging and evaporation. The decision parameters for selecting a battery system should be life cycle cost, maintenance, and reliability. It is recommended that lead acid, sealed or vented batteries be selected for this application. Vented batteries must contain provisions for minimizing electrolyte and water loss.

7.4 Power System Controller

The power system controller (PSC) is defined as the equipment components which determine the source of power and its level relative to the load demand.

The power sources in this application are the PV array and; except for the pumping systems, the battery. The loads are predominantly the pumping or lighting equipment, however, the battery can behave as a power source or as a load. The PSC may also contain a PV array maximum power tracker, voltage regulators and other power regulation equipment, however, our definition is limited to considering the PSC by its primary function of power source management and regulation. The PSC may provide for the following functions depending on the sophistication level of the design.

1. Efficient management of PV array, and battery power.
2. Regulation of charge and discharge rates of the battery system.
3. Protection of battery system against low and high states of charge.

7.5 Inverters/Rectifiers

The use of an inverter in this application would be to convert DC power from the PV/battery side of the power system to AC power compatable with the load.

The performance record of stand-alone inverters in developing countries has been poor. In addition, there are efficiency penalties and added costs for their use. There are a number of suppliers of commercial inverters and rectifiers.

7.6 System Monitoring and Instrumentation

There are two levels of instrumentation required for this field test: Monitoring and Troubleshooting/Repair. The purposes of each level of instrumentation are as follows:

Level	Purpose
Monitoring	To provide system and component performance information for evaluating long term technical, financial and institution performance.
Troubleshooting/ Repair	To determine system and component performance on site, over short intervals, in sufficient detail to identify faults, make repairs or perform modifications.

It is recommended that monitoring instrumentation be automated for data collection and transmission (by physical or automatic means) and that the troubleshooting/repair level of instrumentation be provided by procuring portable site usable instrumentation. Accessible locations in the system wiring must be part of the design of the system to provide for I-V curve tracing of the array and subarrays and similar levels of testing and evaluation.

Specific instrumentation specifications and a data requirements list were prepared following a sub-contractors meeting held on December 10, 1985, at Meridian Corporation. These data requirements were updated as a result of further meetings on May 14-15, 1986 in Ismailia, Egypt. The list is provided as Appendix D for this field test.

8.0 MANUFACTURER PROFILES

A brief overview of the major manufacturers of PV systems, batteries, inverters, controllers, pumping systems, and lighting systems is provided in this section. Sections 8.1-8.5 are duplicated from the Technology Review for Field Test #6, and are included here for ease of reference. Also provided are a representative selection of integrating contractors that have PV system application experience. PV related product literature from these companies is included in the Technology Reference Notebook (previously submitted under Task 2.1.1). A selection of product specifications are provided in Section 7.

8.1 Photovoltaic Module Manufacturers

ARCO Solar, Inc.
21011 Warner Center Lane
Woodland Hills, CA
800-ARCO-SOL

ARCO is the world's leading volume manufacturer of photovoltaics. ARCO Solar has a world-wide distribution network.

ARCO has built its photovoltaic business by manufacturing single-crystalline modules. Typical efficiencies (using the entire module surface area) are about 10 percent. Recently, ARCO has claimed a significant increase in efficiency, to 12.5% by an improved manufacturing process and a better module packing factor. Cells are made using screen-printed silver metallization. Encapsulant is ethylene vinyl acetate (EVA) with a tough white tedlar backing.

ARCO modules have passed the Jet Propulsion Laboratory (JPL)-sponsored Block V environmental tests and some models have passed the Underwriters Laboratory tests for certification[6]. Standard modules are available in 30, 40, and 43 watt sizes. ARCO is the only company, world-wide, to offer 10 year module performance warranty.

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6 Summary specifications of the JPL tests are provided in Appendix C.

Solarex Corporation
1335 Piccard Drive
Rockville, Maryland 20850
301-948-0202

Solarex is the second largest PV manufacturer (by sales volume) in the world and has modules installed world-wide. Solarex advertises itself as a systems company and unlike ARCO has traditionally bid directly on PV system projects around the world rather than through representative companies.

Solarex uses polycrystalline silicon for their standard modules. This type of silicon is made by a cast process in which the silicon is cast in a near-square shape. Proponents of this type of technology maintain that this process is inherently less expensive and has less waste than single crystal silicon because less silicon is sawed off the ingot. Solarex module efficiencies are typically about 9-10 percent on a module area basis though modules for selected projects have achieved nearly 12 percent. Solarex modules have also passed the JPL-Block V environmental tests. Standard Solarex modules come in 36, 42, 46, and 140 watt sizes. Encapsulant is EVA with a tough white tedlar backing.

Mobil Solar Energy Corporation
16 Hickory Drive
Waltham, Massachusetts 02254
617-890-1180

Mobil Solar is the leading producer of "ribbon" silicon photovoltaic modules in the U.S.

Mobil Solar modules are made from "ribbon" silicon, which refers to the way it is manufactured. Proponents of this process feel that it is a very good approach toward manufacturing low cost silicon solar cells because it avoids the losses associated with sawing silicon made from single crystal or polycrystalline cast silicon ingots. The silicon manufacturing process is being developed to make it more efficient and less costly. Typical module efficiencies are of the order of 8.4 percent.

Modules are manufactured in 40 and 180 watt modules. They have also passed the JPL - Block V environmental tests.

Mobil has made a concentrated effort to develop a market in the Middle East. There are two functioning desalination installations in Jeddah, Saudi Arabia and Doha, Qatar which are powered by Mobil Solar modules. Additionally there is a street lighting project in Riyadh, Saudi Arabia.

Mobil has long maintained the policy to perfect the ribbon technology before going into full volume production. Mobil has however commercially offered modules for several years. Mobil has sufficient field performance experience to support its guarantees for the reliability and performance of its "ribbon" technology.

Solavolt International
P.O. Box 2934
Phoenix, Arizona 85062
Telex 249901

Solavolt modules are polycrystalline silicon. Their prime module for sale is one which produces 40 watts at standard conditions. It has passed the JPL - Block V environmental tests.

Solavolt is a joint venture formed from the former photovoltaics units of Motorola and Shell Oil company. Solavolt is reputed to be working on a proprietary process known as the "ribbon-to-ribbon" technology, which is yet to be introduced commercially. Solavolt currently uses polycrystalline modules for its commercial projects in the near future.

Solavolt has been very active in setting up distributorships world-wide. Solavolt (and its predecessor Motorola) have modules installed in many locations including Gabon, Africa, pumping/irrigation sites in the U.S. southwest, and the Southwest Residential Experiment Station in New Mexico.

8.2 Battery Manufacturers

GNB Batteries Inc.
2010 Cabot Boulevard West
Longhorne, Pennsylvania 19047
215-750-2600

GNB Battery Company is a well established leader in the manufacture of industrial grade, deep cycle batteries. GNB manufacturers the "Absolyte" battery: a sealed, maintenance free, deep cycle lead-acid battery using recombination battery technology. The Absolyte battery has been well received by PV system companies for use in PV power systems in remote harsh environments. Sealed batteries in general are more expensive than vented batteries. The initial capital cost, in dollars per kilowatt-hour of rated capacity, for an Absolyte is approximately fifty percent more than an equivalent rated vented battery.

Exide
101 Gibraltar Road
Horsham, Pennsylvania 19044
215-674-9500

Exide is another reputable manufacturer of lead-acid batteries. They have been used in numerous photovoltaic system applications around the world. The principle battery model used in photovoltaic systems is a vented, deep cycle lead-acid battery. Exide offers gas recombination caps to reduce electrolyte and water loss, minimize contamination and improve operating safety.

Allied C&D Power Systems
3043 Walton Road
Plymouth Meeting, Pennsylvania 19462

C & D is the largest manufacturer of industrial batteries, chargers and associated power equipment in the world, according to their company literature. C & D states that they manufacture fully integrated power systems. C & D provides installation service and maintenance for its energy systems through more than 75 sales and service organizations in the U.S. and Canada.

Chloride Group PLV
P.O. Box 305
North Haven, Connecticut 06473
203-777-0037

Chloride is a leading manufacturer of lead-acid batteries. A London based company, Chloride has distributors around the world. A manufacturing plant is located near Cairo, Egypt.

Chloride makes sealed and vented batteries. The POWERSTORE model battery is a sealed, maintenance free recombination electrolyte battery. Chloride distributor Simpler Solar Systems in Florida indicates that the POWERSTORE is available in cell sizes up to 2 volts and 240 ampere-hours at a 20 hour discharge rate. Larger lead-acid vented batteries are available up to 1000 amp-hours.

8.3 Inverters/Rectifiers

Abacus Controls Inc.
P.O. Box 893
Somerville, NJ 08876
201-526-6010

Abacus is a major supplier of inverters to the photovoltaic industry. Solarex has used Abacus inverters on several stand-alone photovoltaic systems installed in South America and on one relevant project at East Oweinat, Egypt. Abacus makes inverters in a number of sizes capable of being used in this field test (35 kW total capacity).

Helionetics Inc.
17312 Eastman Street
Irvine, California 92714
800-421-7915

Helionetics is a manufacturer of electronic power-conversion equipment and systems for military and commerical use. The DECC division of Helionetics designs and manufacturers power conditioning and conversion equipment (inverters) for the PV industry. Helionetics has been in business since 1970.

Helionetics supplied two 500 kW inverters to ARCO for use in the 1 - MW PV array at Hesperia, California built for Southern California Edison in 1982.

Helionetics makes commercial stand-alone inverters up to 40 kW.

Heart Interface Corporation
1626 S. 341st Place
Federal Way, Washington 98003
800-732-3201

Heart Interface is a manufacturer of small inverters for remote power commerical and private applications. Heart Interface makes stand-alone inverters up to 5 kW capacity.

Best Energy Systems Inc.
P.O. Box 280
Necedah, Wisconsin 54646

Best is another company that manufactures stand-alone inverters. Inverters are commercially offered in sizes up to 10 kW for stand-alone, hybrid power systems and utility interface.

NOVA Electric Manufactering Company
263 Hillside Avenue
Nutley, New Jersey 07110
201-661-3434

NOVA is an electronics company, founded in 1966, which designs and manufactures inverters and rectifiers. NOVA products all feature modular designs with easily replaceable subassemblies. This results in a MTTR (Mean Time to Repair) of approximately 30 minutes. NOVA claims that its power conditioning equipment achieves better than 20,000 hours as a Mean Time Between Failure. The PV power system at Sadat City, Egypt, uses a 10 kW NOVA inverter and reports good operational performance.

8.4 Controllers

Chronar/Tri-Solar
10 DeAngelo Drive
Bedford, Massachusetts 01730
617-275-1200

Chronar/Tri-Solar Company is a company formed by the merging of Chronar and Tri-Solar. Chronar designs and sells manufacturing plants for the production

of amorphous silicon technology photovoltaic modules. Tri-Solar is an established PV systems company specializing in PV pumping systems and controller development. Chronar/Tri-Solar manufacturers a "smart" microprocessor controlled programmable controller, developed under contract to NASA-Lewis Research Center (U.S. National Aeronautics and Space Administration Lewis Research Center), which may be used for the operation and monitoring of PV/diesel power systems. The controller is microprocessor based and includes power tracking. Field experience with this controller is limited but approximately 20 were installed in a middle-eastern country in 1985. Performance data relative to this equipment will be important to evaluating similar equipment that may be offered.

Solarex Corporation
1335 Piccard Drive
Rockville, Maryland 20850
301-948-0202

Solarex, as a PV systems company, designs, manufacturers and sells PV system controllers. Solarex offers a limited function series regulator, SR model and a full function controller identified as the ACR model. The ACR model controller has been used in numerous PV applications around the world ranging from health centers to irrigation systems. Development of the ACR controller has been continuous since the first units were manufactured around 1981. The standard ACR controller can be customized with voltage sensing relays which can be used for starting a diesel generator, sounding an alarm or performing other functions.

Balance of Systems Specialists (BOSS)
7745 East Redfield Road
Scottsdale, Arizona 85260
602-948-9809

BOSS designs and manufactures PV system controllers. BOSS offers full engineering and support services and can customize its controllers to meet the requirements of this project.

8.5 Integrating Contractors

In an effort to identify possible contracting companies who would act as the prime (or integrating contractor) a number of organizations are listed below. These companies have acted as the integrating contractors on photovoltaic projects in the past.

Chronar/Tri-Solar
10 DeAngelo Drive
Bedford, Massachusetts 01730
617-275-1200

Tri-Solar acquired by Chronar in 1985 has been an integrating contractor since its inception. Chronar/Tri-Solar has performed as the integrating contractor on many international PV-powered projects. Two of the most notable application areas are PV pumping and village electrification. Chronar/Tri-Solar is currently involved in a major PV lighting systems project in Saudi Arabia.

BDM International Inc.
7915 Jones Branch Drive
McLean, Virginia 22043
703-821-5000

BDM's renewable energy division is based in Albuquerque, New Mexico. They have been the integrating contractor for a number of projects both in the United States and internationally. These include:

- A one Megawatt grid interactive, tracking flat plate PV power system at Hisperia, California
- A 35 Kw installation at McClellan Air Force Base near Sacramento, California
- A demonstration installation in Taipai
- A residential demonstration project at the Southwest Residential Experiments station in Las Cruces, New Mexico

Hughes Aircraft Company
P.O. Box 9399
Long Beach, California 90810
213-513-3487

Hughes is based in Long Beach, California and over a period of about five years has been the integrating contractor for a number of PV-powered installations.

These include:

- o Communications and village power applications in Indonesia and the Marshall Islands for NASA-Lewis Research Center.
- o Design studies and a demonstration project to illustrate low-cost construction methods for Sandia National Laboratories
- o Acted as the integrating contractor for a number of remote power applications for the U.S. Navy at China Lake, California.
- o Georgetown University Intercultural Center, a 320 kW Grid-interactive installation in which the PV models are integrated into the roof of the building.

Integrated Power Corporation
7624 Airpack Road
Gaithersburg, Maryland 20879

Integrated Power is based in Gaithersburg, Maryland. It was formed in 1983 and specializes in engineering and installation of stand-alone PV-battery systems. They have also done significant development engineering of PV/diesel hybrid power systems.

Mobil Solar Power Corporation
16 Hickory Drive
Waltham, Massachusetts 02254
617-890-1180

Mobil Solar is based in Waltham, MA, near Boston. Mobil has had a systems integration capability since about 1981. Mobil has a representative in Saudi Arabia who is an engineer specializing in PV systems design and applications.

Mobil has concentrated in developing PV-powered desalination. Two installations have been built and are operating --one in Jeddah, Saudi Arabia and one in Qatar. In addition, Mobil has a cooperative venture with the University of New South Wales in Australia for a brackish water desalting experimental program. Other installations include:

- o Street lighting project in Dubai, United Arab Emerates
- o Impact 2000, a PV-powered residence demonstration project in the Boston area designed to publicize PV.

Simpler Solar Systems Inc.
1217 Walton Drive
Tallahassee, Florida 32312
904-385-5686

Simpler Solar Systems is based in Tallahassee, Florida. It has been in business as a company since 1980. The company designs, tests, and installs PV-powered systems and has specialized in stand-alone systems in remote areas. Projects include:

- Medical Facility (Bulape Hospital) in Zaire
- PV powered water pumping for irrigation in the Bahamas
- Recreational homes in Florida
- Projects for church-sponsored groups in Caribbean

Solarex Corporation
1335 Piccard Drive
Rockville, Maryland 20850
301-948-0202

Solarex is based in Rockville, Maryland and has been integrating systems primarily with its own modules for about ten years. Projects include:

- The General Petroleum Company project in East Oweinat
- PV-powered portable communications units for the Egyptian military in Egypt
- A grid-independent solar powered manufacturing facility in Frederick, Maryland.
- A 22 kW stand-alone rural hospital power system in Guyana, South America.

Solarex has a distributor in Cairo.

Solavolt
P.O. Box 2934
Phoenix, Arizona 85062
Telex 249901

Solavolt is another photovoltaic company which performs as a "systems" company. Solavolt has participated as a system integrating contractor on a number of projects.

- A NASA-Lewis Research Center project for water pumping and village power in Gabon, Africa

- Numerous irrigation and other pumping applications around the world

Stone and Webster Incorporated
1875 Eye Street, N.W.
Washington, DC 20006
202-466-7415

Stone and Webster, based in Boston, MA, is a large international construction, architectural and engineering company. It has a group within the company which is very active in photovoltaics engineering projects. Included in the projects it has engineered are:

- Beverly, MA High School grid-interactive 100KW installation
- 50 kW grid interactive demonstration project for Virginia Power (a utility) near Richmond, Virginia
- A 300 kW grid interactive installation for Austin Power and Light in Austin, Texas (under conot reaction in 1986)

8.6 Lighting System Contractors

ARCO Solar, Inc.
c/o Solartherm, Inc.
1315 Apple Ave
Silver Spring MD
301-882-4000

ARCO, the world's largest volume manufacturer of PV modules, is also involved in the production of packaged PV lighting systems. Their systems consist of a PV module, battery, battery protector/charge controller, and one or more fluorescent lights. Either two 20 watt lamps or one 40 watt lamp can be included in a standard system.

Balance of Systems Specialists, Inc./BOSS Lighting
7745 E. Redfield Road
Scottsdale AZ 85260
602-948-9809 / 800-223-9580

BOSS Lighting offers packaged outdoor lighting systems utilizing high pressure sodium lamps in the 35 to 150 watt range. Their complete packages include ARCO PV modules, controllers, batteries, lights, fixtures, and light or motion activated switching.

Currin Corporation
P.O. Box 1191
Midland, Michigan 48640

Currin sells an indoor lighting package that consists of a 9 watt fluorescent light in a ceiling-suspended luminaire that includes batteries and controller, fed by a roof-mounted PV module.

Sunnyside Solar
RD 4 Box 295 Green River Road
West Brattleboro Vermont 05301
802-257-1482

Packaged systems are not available from Sunnyside Solar; instead, they provide system components including fluorescent, halogen and incandescent lights, fixtures, and ballasts, adapted for use with DC PV systems.

Mobil Solar Energy Corporation
16 Hickory Drive
Waltham, Massachusetts 02254
617-890-1180

Mobil offers both indoor and outdoor packaged lighting systems, and has had substantial field experience with the products. The outdoor system, intended for street lighting use, utilizes 400 watt high pressure sodium vapor lamps for large area coverage, and 20 watt fluorescent lights for localized coverage. The indoor package is available in either a one or a two light configuration which utilizes fluorescent lamps. Both indoor and outdoor systems come with Mobil PV modules, mounting hardware, battery protecter/charge controller, lamps and fixtures, and battery specifications.

REC Specialties, Inc.
530 Constitution Avenue
Camarillo, Calfornia 93010
805-987-5021

This firm provides lighting components rather than complete PV lighting systems. They offer a variety of indoor fluorescents and outdoor low-pressure sodium lamps, as well as fixtures and accompanying ballasts, all designed for use with DC PV power supplies.

Simpler Solar Systems, Inc.
P.O.Box 12936
Tallahassee, Florida 32308
904-385-5686

A variety of indoor and outdoor PV lighting system packages are available from SSS. They all use fluorescent lamps, and can be equipped with infrared motion detectors and other special switching.

Solar Electric Systems
2995 44th Avenue North
St. Petersburg, Florida 33714
813-526-0793

Their "Lumastar" outdoor PV lighting package is completely self-contained. It includes modules, battery, controller, light, fixture, and mounting hardware. The "Lumastar" is scaled for residential use.

SunAmp Systems Inc.
7702 East Gray Road
Scottsdale, Arixona 85260
602-951-0699

SunAmp also markets a residential outdoor package using a four watt fluorescent bulb. The battery is sized to provide one day of storage.

Solec International, Inc. (Pilkington Group)
12533 Chadron Avenue
Hawthorne, California 90250
213-970-0065

Solec offers indoor and outdoor packaged PV lighting systems using fluorescent lamps. The outdoor units, which have been field-proven, come as an integrated structure that includes the PV module, 18 watt lamp, fixture, management electronics, battery, and switching. The indoor unit comes in either an 8 watt or a 30 watt size.

Texas HiLight, Inc.
P.O.Box 3366
Evergreen, Colorado 80439

A variety of indoor and outdoor packaged PV lighting systems are available from Texas HiLight. Options include fluorescent, sodium and halogen lamps, varying amounts of battery storage, and specialty switching including light and

motion sensors.

8.7 Pumping System Contractors

A.Y. McDonald Mfg. Co.
P.O.Box 508
Dubuque, Iowa 52004-0508
319-583-7311

Primarily a pump manufacturer, A.Y. McDonald produces several lines of direct-connect centrifugal and submersible turbine pumps for use with PV power sources; they are equipped with DC motors. Complete packaged systems including the PV array, controller, etc. are also available.

Dinh Company
P.O.Box 999
Aluchua, Florida 32615
904-462-3464

Dinh produces a single size of packaged PV pumping system. The self-contained package includes a centrifugal pump with a DC motor, a PV array, battery storage, and controls.

Grundfos Pumps Corporation
2555 Clovis Avenue
Clovis, California 93612
209-299-9741

Grundfos manufactures a great variecy of pumps, and has recently developed a line of complete packaged PV pumping systems. These systems include AC pump motors, requiring the use of DC-to-AC inverters, and they do not include battery storage.

Jacuzzi, Inc.
11511 New Benton Highway
Little Rock, Arkansas 72209
501-455-1234

Among the many types of pumps manufactured by Jacuzzi is a relatively new line called the"Solar-Flow". This is a submersible turbine pump incorporating a DC motor, that comes in a variety of sizes, including that which is needed for this field test (40 m^3 @ 20 m). Jacuzzi does not provide complete PV pumping

system packages; it only manufactures pumps suitable for use in such systems.

Monegon Pumping Systems, Inc.
c/o Solartherm, Inc.
1315 Apple Avenue
Silver Spring, Maryland 20910
202-882-4000

Monegon assembles PV pumping systems from a variety of components to meet the specific needs of individual clients. Most of their systems use DC motors, but they offer a choice between jack, centrifugal or jet pump types, the inclusion of battery storage, and in controller capabilities.

Solec International, Inc. (Pilkington Group)
12533 Chadron Avenue
Hawthorne, Califonia 90250
213-970-0065

Solec, which manufactures PV cells, now offers packaged PV pumping systems for both deep and shallow well applications requiring both large and small flow rates. These pumps are submersible, self-priming centrifugal or vertical turbine units powered by DC motors.

SunAmp Systems, Inc.
7702 East Gray Road
Scottsdale, Arizona
602-951-0699

This firm is a system integrator that assembles a variety of PV pumping system types. Their preferred designs include the use of DC motors and no battery storage.

Sunmill/GPL Industries
P.O.Box 306
La Canada, California 91011

"Sunmill" is the name of an unusual jack pump designed specifically for PV powered applications. It incorporates a flywheel to reduce the degree of cyclic fluctuation in the load imposed on the PV array, thereby allowing the DC motor driving the pump to be directly connected to the PV array without a battery buffer. The pump is available in two size ratings. GPL Industries does not provide systems integration services.

Tri-Solar Corporation
10 DeAngelo Drive
Bedford, Massachusetts 01730
617-275-1200

Tri-Solar is one of the best known systems integrators. They offer a wide variety of PV pumping systems, using jack pumps, submersible turbine pumps, and surface mounted centrifugals as appropriate. Their systems are currently in use in more than 25 countries.

Wm. Laml Co.
P.O.Box 4185
North Hollywood, California 91607
213-980-6248

This system integrator offers a variety of packaged PV pumping systems, all of which incorporate DC motors and require no batteries.

9.0 EQUIPMENT/PRODUCT SPECIFICATIONS

A selected number of components and basic specifications are provided in Figure 9-1.

Appendix A contains a selection of manufacturer brochures for lighting equipment and Appendix B contains similar information for water pumping equipment. These data on equipment are provided to show representative equipment specifications that may be received from bidders in response to the RFP. This listing of equipment is not intended to support any manufacturers or products.

FIGURE 9-1 EQUIPMENT DATA BASE

Component	Manufacturer	Equipment Offered	Operating Efficiency	Other Relevant Specifications	Notes
Photovoltaic Modules	ARCO Solar, Inc. Chatsworth, CA	M53, 43 watts 17.3 Vpp M63, 30 watts 14.8 Vpp M73, 40 watts 164Vpp	11.5%	10 year performance guarantee, ± 10%	o Single crystal silicon o Largest manufacturer in the world o American Univ., Sadat City project o Egyptian representative
	Solarex Corp. Rockville, MD	SX-146, 47 watts 18 Vpp SX-42, 42W 16.5Vpp PL-300, 135W 17.5Vpp	9.9%	5 year min. performance guarantee	o Polycrystalline silicon o Second largest manufacturer in the U.S. o Egyptian representative o East Oweinat 10kw project
	Solavolt International Phoenix, AZ	MSVN-4010 MSP43E, 36W 18.8 Vpp	8.7%		o Uses Wacker and Crystal Systems polycrystal silicon o Gabon, West Africa community power system project
	Mobil Solar Power Corp. Waltham, MA	Ra-40 Ra-180, 180 watts-48volt	8.4%		o Ribbon technology o Numerous installations in Arab countries

FIGURE 9-1 EQUIPMENT DATA BASE (Continued)

Component	Manufacturer	Equipment Offered	Operating Efficiency	Other Relevant Specifications	Notes
Photovoltaic Modules (cont.)	Chronar/Tri Solar Princeton, NJ		<5%	Development modules	o Amorphous silicon modules
Battery Storage	GNB-Batteries, Inc. "Absolyte" Longhorne, PA	35A21-397 AH 45A21-510 AH 75A21-850 AH (12 hour discharge rate)	65-80%	50% DOD, 2800 cycles	o Recombination battery technology o Egyptian distributor
	EXIDE Worminster, PA	6E 120-13-750AH 3E-120-27-1652AH	65-80%		o Recombination caps offered o East Owainat project
	Allied C&D Plymouth Meeting, PA	CP75E13-450 AH CP75-25-900 AH CP125-1500 AH	65-80%	Metallic casing	
	Chloride London, Eng.	6V-720 AH	65-80%	Special battery design for PV applications	o American and Egyptian distributors
Power System Controller	Chronar/Tri-Solar Bedford, MA	Microprocessor Based Controller	92-97%	Series regulated ampere hour recording battery SOC	o 23 placed in service 1985, Saudi Arabia o "Smart" controller
	Solarex Rockville, MD	ACR-6, modified	90-95%	Shunt regulated voltage sensing battery SOC	o Primarily PV battery controller but can be equipped with diesel remote start relay.

FIGURE 9-1 EQUIPMENT DATA BASE (Continued)

Component	Manufacturer	Equipment Offered	Operating Efficiency	Other Relevant Specifications	Notes
	BOSS Scottsdale, AZ	Modular units Customized units	90-95%	No off-the-shelf models available	o Services a wide variety of markets in U.S.
Inverters	Abacus Somerville, NJ	743C-3-200 783C-4-200	90%		o Inverters for GPC E. Oweinat installation
	Helicnetics Irvine, CA	Inverters 61300-3500W 61340-1600 KVA		2.5-40 KVA units in stock	
	Heart Interface Federal Way, WA	Inverters	92-95%	300-5000 watt inverters in standard product line	
	BEST Energy Systems Necedah, WI	M Series M 120-6000 M 120-12000	90%	Load demand switch engine-6en set start transfer switch	o Wide experience in variety of applications o Standard models up to 12 kW capacity.
	NOVA Electric Nutley, NJ	3.7 KVA Inverter 240 VDC Input	89% (FOB)	50 Hz, sinewave, 3 phase	o Also supplies rectifiers o Egypt experience: Sadat City. 10 KVA inverter

FIGURE 9-1 EQUIPMENT DATA BASE (Continued)

Component	Manufacturer	Equipment Offered	Operating Efficiency	Other Relevant Specifications	Notes
Lights	ARCO Solar & Solartherm Silver Spring, MD	Indoor Lighting			Supplies complete package
	BOSS Lighting Scottsdale, AZ	Outdoor Lighting			Supplies complete package
	Currin Corporation Midland, MI	Indoor Lighting			Supplies complete package
	Sunnyside Solar West Brattleboro, VT	Indoor & Outdoor Lighting			Lighting components only: no PV
	Mobil Solar Waltham, MA	Indoor & Outdoor Lighting			Supplies complete package
	REC Specialities Camarillo, CA	Indoor & Outdoor Lighting			Lighting components only: no PV
	Simpler Solar Systems Tallahassee, FL	Indoor & Outdoor Lighting			Supplies complete package
	Solar Electric Systems St. Petersburg, FL	Outdoor Lighting			Supplies complete package
	SunAmp Systems Scottsdale, AZ	Outdoor Lighting			Supplies complete package

FIGURE 9-1 EQUIPMENT DATA BASE (Continued)

Component	Manufacturer	Equipment Offered	Operating Efficiency	Other Relevant Specifications	Notes
Lights (Continued)	Solec International Hawthrone, CA	Indoor & Outdoor Lighting			Supplies complete package
	Texas HiLight Evergreen, CO	Indoor & Outdoor Lighting			Supplies complete package
Pumps	A.Y. McDonald Dubuque, Iowa	Pumps & System Packages			AC & DC motors available
	Dihn Co. Aluchua, FL	System Package			DC motors
	Grundfos Pumps Clovis, CA	Pumps & System Packages			AC motors
	Jacuzzi, Inc. Little Rock, AR	Pumps			AC & DC motors available
	Monegon Pumping Silver Spring, MD	System Packages			
	Solec International Hawthrone, CA	System Packages			DC motors
	SunAmp Systems Scottsdale, AZ	System Packages			DC motors
	Sunmill/GPL Industries LaCanada, CA	Pumps			DC motors, Jack Pump w/flywheel

FIGURE 9-1 EQUIPMENT DATA BASE (Continued)

Component	Manufacturer	Equipment Offered	Operating Efficiency	Other Relevant Specifications	Notes
Pumps (Continued)	Tri-Solar Corp. Bedford, MA	System Packages			
	Wm. Lamb Co. N. Hollywood, CA	System Packages			DC motors

10.0 RELEVANT PROJECTS

Sadat City, Egypt--Desert Development Projects Solar Pumping

The Desert Development Demonstration and Training Program utilizes an 8 feddan area (10 acres) for renewable energy/agricultural development work. The site has been entirely powered by a 10-kWp and a 3-kWp PV array since 1981. The 10-kWp array supplies 220-volt, 50-Hz power through a NOVA inverter to the headquarters building and an AC submersible pump at 43 meters of head. It includes 88.8 kWh of Exide battery storage. The 3-kWp system provides power exclusively to a positive displacement deep-well pump with DC motor and a booster pump for irrigation.

The array has performed reliably with an average daily conversion efficiency of 7.2%. The deep-well AC submersible pump has also performed well. The positive displacement screw pump has run reliably without failure since mid-1984. Prior to that, excessive mechanical vibrations in the drive shaft of the pump prevented continuous operation and resulted in a number of pump failures. Additional drive shaft stabilizing bearings were added and the pump operates with an average efficiency of 60 percent. Significant experience was also obtained with the battery systems. Fadel Assabghy, who is responsible for the PV power systems at Sadat City, has indicated that battery maintenance must be completed with unfailing regularity.

Papua New Guinea Lighting and Home Power

The field operating experience with PV systems in rural applications in Papua New Guinea has provided important insight into technical and financial aspects of PV lighting systems. Charge controllers were previously found to be complex in circuit design and operation and were unreliable. In 1980, as a result of Papua New Guinea field experience, fully "tropicalized" charge controllers were made available and have since been proven reliable. For safety

and reliability reasons, a policy was adopted to use 12-volt DC PV lighting systems for village and government patrol post lighting. As to the quality of lighting, a 20-watt fluorescent bulb provides a light intensity of 100 lux at one meter below the lamp. A kerosene pressure lamp provides 12 lux, measured one meter below the lamp and outside the lamp's shadow. In addition to these obvious improvements in quality, the high cost of kerosene (about $1/liter) result in paybacks of from two-to-four years for simple PV lighting kits.

A number of PV systems have been installed in Papua New Guinea for communications, lighting, water pumping, and medical refrigeration. The total was for telecommunications systems. The remaining systems were for mission radios and lights, mobile radios, village water pumping, and village house lighting. The potential for village house lighting systems over the next 10 years was estimated at 500,000 single module units (35 watts each), or 17.5 megawatts.

In related work, the Appropriate Technology Development Institute of the University of Technology in Lae, Papua New Guinea has started testing fluorescent tube "lanterns" powered by rechargeable Ni-Cad batteries. The lanterns are designed to look like their kerosene counterparts but to be charged by PV. A photo is provided in Exhibit 5-1.

Traffic Lighting - United Arab Emirates

Twenty-one PV-powered street lights and a high-mast, traffic-circle light were installed in June 1983 in Dubai, United Arab Emirates by Mobil Solar Energy Corporation. Each street light consists of a 20-watt fluorescent tube, two 35-watt modules and a 12-VDC ballast. The high mast light consists of eight 400-W, high-pressure sodium vapor (HPS) lamps powered by a 15-kW array.

During the design of the street lights, five commercially available tubes were tested. The test results showed large differences in efficiency (lumens

per watt). The most efficient ballast was chosen. The customer has been pleasantly surprised at the illumination delivered by the 20-W fluorescent systems. The light level is sufficient to read a newspaper while standing on the roadway, 18 feet beneath the lamps. Through the first 10 months of operation, the street lighting performed reliably.

There were initial problems with the HPS light because of the inherent difficulty with operating HPS lamps with modified square-wave inverters. The solution was to use a ferroresonant inverter at 77% efficiency compared to a 90% efficient, modified square-wave inverter. Development of high-efficiency, high-power, DC ballasts for these lamps was mentioned as vital to optimizing these PV lighting systems.

Tunisia Village Electrification

Significant multi-use projects have been performed by NASA-Lewis Research Center over the last two years. Included in these is a 27-kWp system in Tunisia. This village electrification project of PV, wind, and solar heating has been operating since February 1983. The PV system consists of a 29-kW, 220-volt, 50-Hz system to serve public and commercial sectors of a village of 120 persons. Additionally, a 1.4-kW drip irrigation systems were installed. Operation and evaluation is the responsibility of the Societe Tunisienne de L'Electricite et du Gas (STEG). There is a very little instrumentation included, although there are kilowatt-hour meters on the system and for individual users. Users are billed for specific consumption. Project participants believe that STEG has been recording basic production data.

The 1-kW inverter in the farm house system has had numerous problems, and extensive time was required to effect repairs. The village system inverter experienced a failure brought on by what appeared to have been improper switch sequencing during manual start-up. Some array wiring has deteriorated due to

abrasion and sunlight damage. It is believed that the wrong wire sheathing was specified or procured.

11.0 CONCLUSION

This review indicates that there should be no insurmountable technical problems associated with this demonstration project. This review supports the following conclusions:

1. Packaged PV water pumping system and decentralized PV lighting system technologies applicable for this field test are proven, reliable and commercially available.

2. The individual subsystem component technologies for a centralized PV village electrification system are also proven, reliable and commercially available.

3. The most important design trade-offs in this field test center on the choice between flexible, but somewhat unreliable AC systems, and more limited, but more reliable DC systems.

4. Many of the factors that will determine the success of these PV applications are not strictly technical; consideration of adequate user training, the local availability of spare parts, and the degree of local interest in maintaining and operating the systems are other crucial items.

5. Lessons drawn from this field test will be applicable to a wide set of potential users of PV technology facing similar conditions in unelectrified rural villages throughout Egypt.

The findings of this Technology Review support the recommendation to proceed with Field Test #7 from the point of view of the potential for widespread use of these technologies in Egypt, and based on the growing availability of proven hardware.

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APPENDIX A

PRODUCT LITERATURE

A selection of manufacturer's product literature for PV Lighting Systems is provided in this Appendix. Additional manufacturer's product literature is available in the Technology Reference Notebook previously submitted under Task 2.2.4.

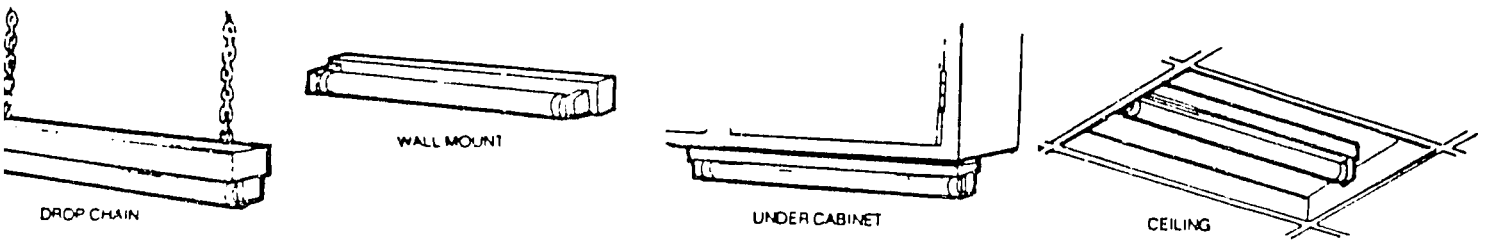
SOLAR POWERED FLUORESCENT LIGHTS

MODELS REC-12-20
REC-12-40

DESCRIPTION

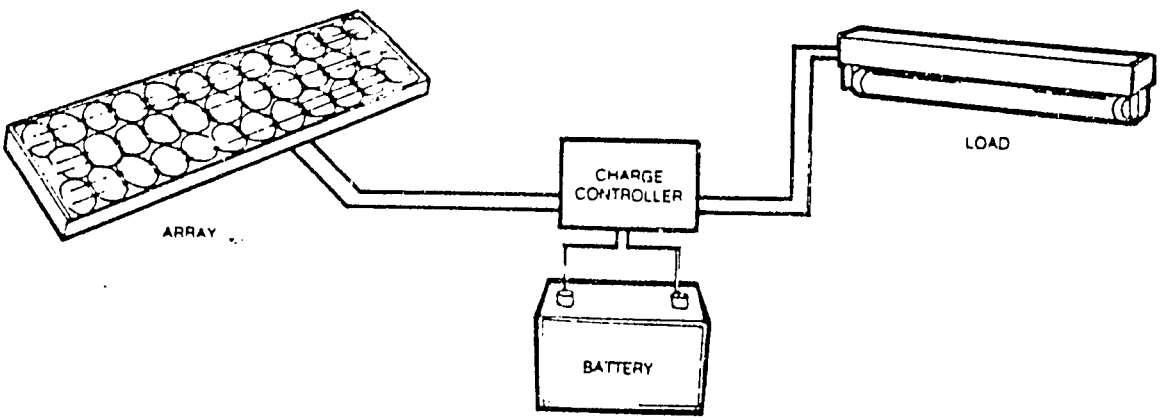
ARCO Solar's fluorescent light assemblies are specifically designed to be used in photovoltaic power systems. Single tube fixtures are available in 20 and 40 watt configurations and operate from 9 to 16 volts DC. The tubes are standard size available worldwide, and the ballast is highly efficient, providing maximum lumens per amp. The ballast has reverse polarity protection and a feature which allows the tubes to be removed while the power is on, without damage. The mounting base, which also houses the solid state inverter ballast, is electrostatically coated with white enamel to prevent moisture damage and fungal growth. These lights are ideally suited for use in remote locations, where grid or generator power is not available or economical.

INSTALLATION



Mounting: If the unit is received with the tube in place, the tube should be disconnected from its receptacles and the cover removed to gain access to the mounting holes. Several "through" holes and "knockout" holes allow the user various methods of attaching the lights to the ceiling or wall. The lights can also be hung by chains or recessed in the ceiling. Mount the fixture in the desired location, making sure that the two wires are accessible, and replace the cover and tube.

Wiring: While the fluorescent lights can be used with any 12VDC power source, this document assumes that they will be used in conjunction with an ARCO Solar Photovoltaic Power Package with a Battery Protector (BP-12-20) or Village Power Panel (VPP-12-20WM), as a charge controller.



TYPICAL SYSTEM DIAGRAM

CAUTION

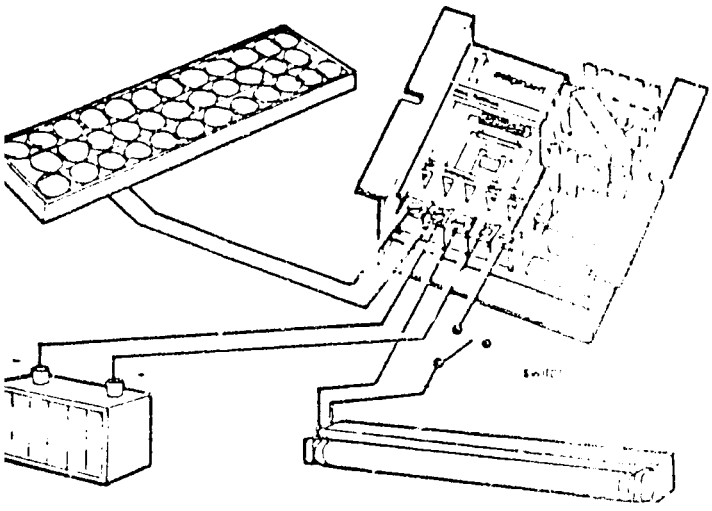
It will be necessary to splice wires long enough to reach from the power source to the existing wires from the light fixture. The fixture wire size is No. 18 AWG with the BLACK wire being positive (+); the WHITE wire negative (−). Care must be taken to insure that the connections are strong and properly insulated to prevent possible shorting.

(OVER)

CHARGE CONTROL WIRING

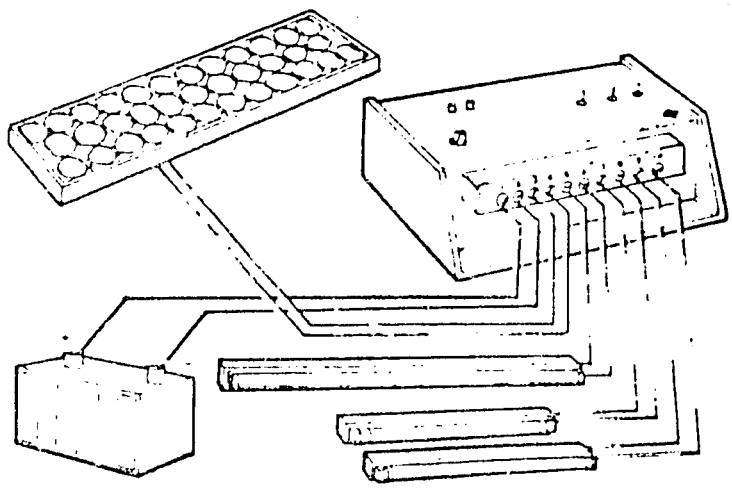
The diagrams below illustrate the correct wiring for the lights. A complement of two 20 watt and one 40 watt light is shown.

BATTERY PROTECTOR WIRING



The BATTERY PROTECTOR should have all wires connected before mounting to the wall to assure access to the terminal block.
SWITCHES: Inline switches can be installed for each light.
OPERATION: Assuming proper battery voltage, the lights should be operational immediately upon completion of wiring. When the BATTERY PROTECTOR is in the full charge mode (indicated by a red light) the load terminal is disconnected, which prevents use of the lights until the batteries reach full charge.

VILLAGE POWER PANEL WIRING



The circuit breaker (BATTERY POWER) and the load switches should be in their "OFF" positions before connecting the wires from the lights.
SWITCHES: The Load switches on the panel front can be used as on/off switches for the lights.
OPERATION: Assuming battery is fully charged, place the circuit breaker (BATTERY POWER) to its "ON" (UP) position. Place LOAD Switches to their "ON" position as desired. The circuit breaker can also be used as an ON/OFF switch for the entire system.

SPECIFICATIONS	MODEL REC-12-20	MODEL REC-12-40
Mechanical:		
Length:	24 inches (60.96cm)	48 inches (121.92cm)
Width:	2¾ inches (6.98cm)	2¾ inches (6.98cm)
Height:	3¼ inches (8.25cm)	3¼ inches (8.25cm)
Weight:	2.1 lb (.95 kg)	4.1 lb (1.86 kg)
Electrical:		
Tube Type:	F20CW (T-12)	F40CW (T-12)
Voltage:	12VDC Nominal	12VDC Nominal
Current:	1.5 amps	3.0 amps
Power:	20 watts	40 watts
Light Output:	1500 lumens	3000 lumens
*AMP. HR/DAY:	9	18

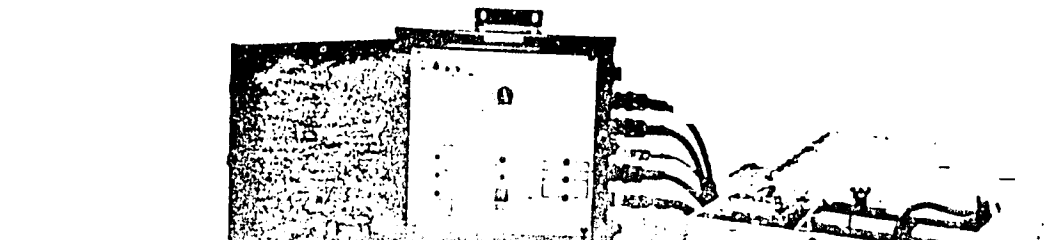
*Based on six hours per day usage.

SOLAR ENERGY SYSTEMS

Solartherm Inc.

1315 Apple Ave., Silver Spring, Maryland 20910

Carl Schlicher
301-882-4000



The "HPS MicroWATT Floodlight Packages" are a new series of photovoltaic powered light-
ng systems available now from Balance of Systems Specialists, Inc., which utilize highly
fficient high pressure sodium lights. The packages provide special advantages for a wide
ectrum of floodlighting applications, particularly commercial and industrial security
ghting, space lighting and billboard advertising lighting, and were developed to provide
"easy-entry" method for businesses to enter the high potential PV lighting markets.

The lighting packages include everything required (except PV modules), including:
dule wiring interconnects and support structures, batteries and battery box, 35 or 100
tt, 24 and 48VDC high pressure sodium light fixtures with electronic ballast, and a
ogrammable controller with 2 to 12 hours run timer and automatic dawn and dusk detection.
ick connect cabling is used throughout to simplify wiring and reduce installation cost.

The HPS light fixtures are made of heavy-duty die-cast aluminum, with a baked-on
atuary bronze enamel finish, and gasketed tempered glass lens for rugged outdoor environ-
nts. All hardware is of corrosion-resistant materials and conforms to UL standards.
x different fixture mounting arrangements are available as standard.

The lighting packages can be operated with as few as 2 PV modules; additional modules
rmit multiple lights and more hours of nightly operating time.

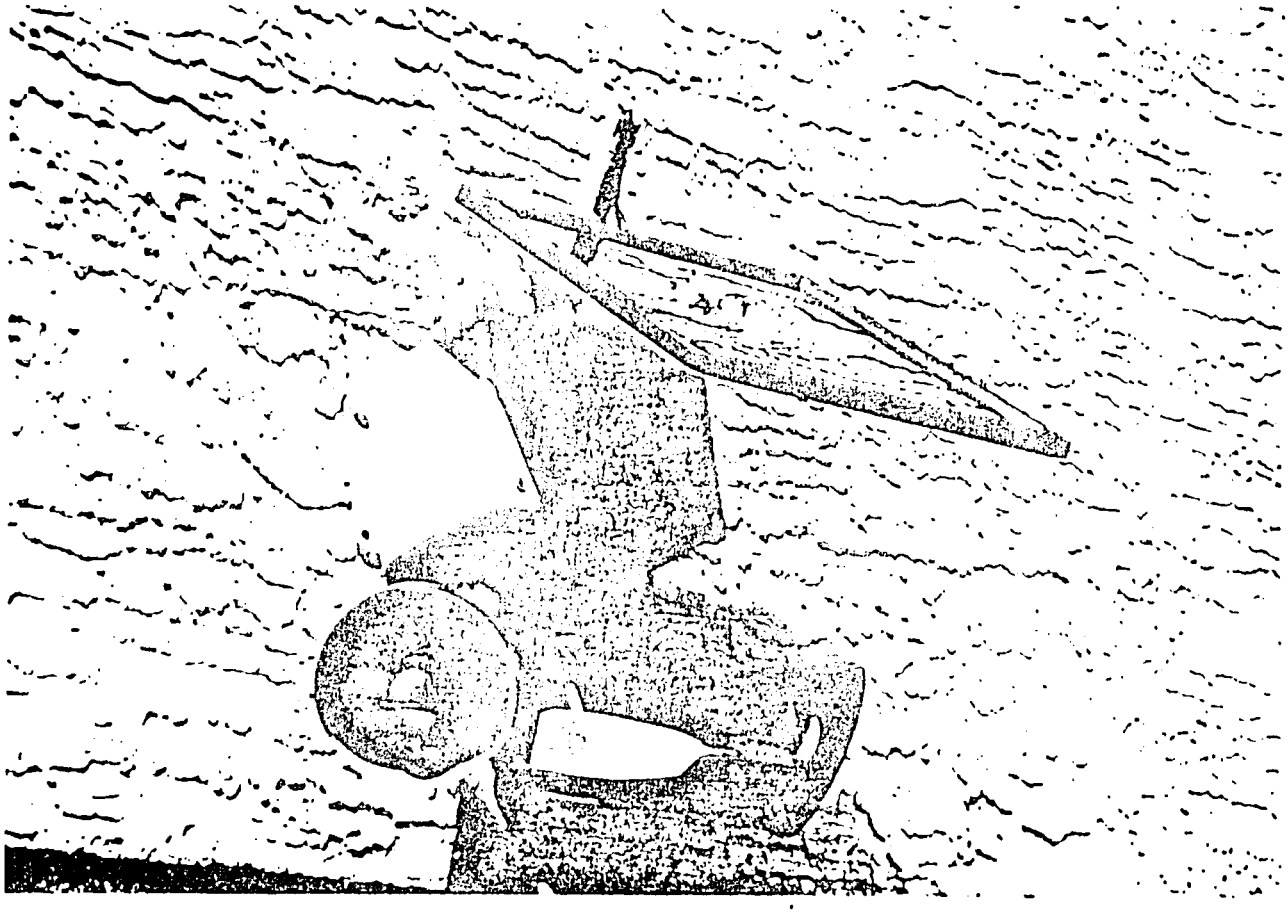
For more information, contact: Richard Cummins at Balance of Systems Specialists, Inc.,
45 E. Redfield Road, Scottsdale, Arizona 85260, (800) 223-9580/(602)948-9809,
lex: 6835043.

MicroWATT SODIUM LIGHTS
Preliminary Sales Data
MW - 100.1
1 of 2

PROGRAMMABLE CONTROLLER SPECIFICATIONS

ARAMETER	CONDITIONS	VALUE	UNITS
C-24-1 to 4	Battery Voltage	24	VDC
C-24-1 to 4	PV array Current	10	Amperes
C-48-1 to 4	Battery Voltage	48	VDC
C-48-1 to 4	PV Array Current	10	Amperes
C-24/48-1	Light Amperage	5	Amperes
C-24/48-2	Light Amperage	5	Amperes
C-24/48-3	Light Amperage	15	Amperes
C-24/48-4	Light Amperage	15	Amperes
mer Duration	Duration	2-12	Hours
w Battery Disconnect	Automatic Shutdown (48 Volt Units)	23.0	Volts
		46.0	Volts

PRODUCT: MicroWATT SODIUM LIGHTS
DOCUMENT: PRELIMINARY SALES DATA
BULLETIN NUMBER: MW-100.1
PAGE NUMBER: 2 OF 2



The BOSS OMNI-ALERT is a passive infra-red security sensor that reacts instantly to body heat, to movement - and activates the exterior lighting before an intruder gets near your home or building. When he is gone, OMNI-ALERT turns off its lights until you need them again. Then, automatically, OMNI-ALERT is there waiting for the next intrusion.

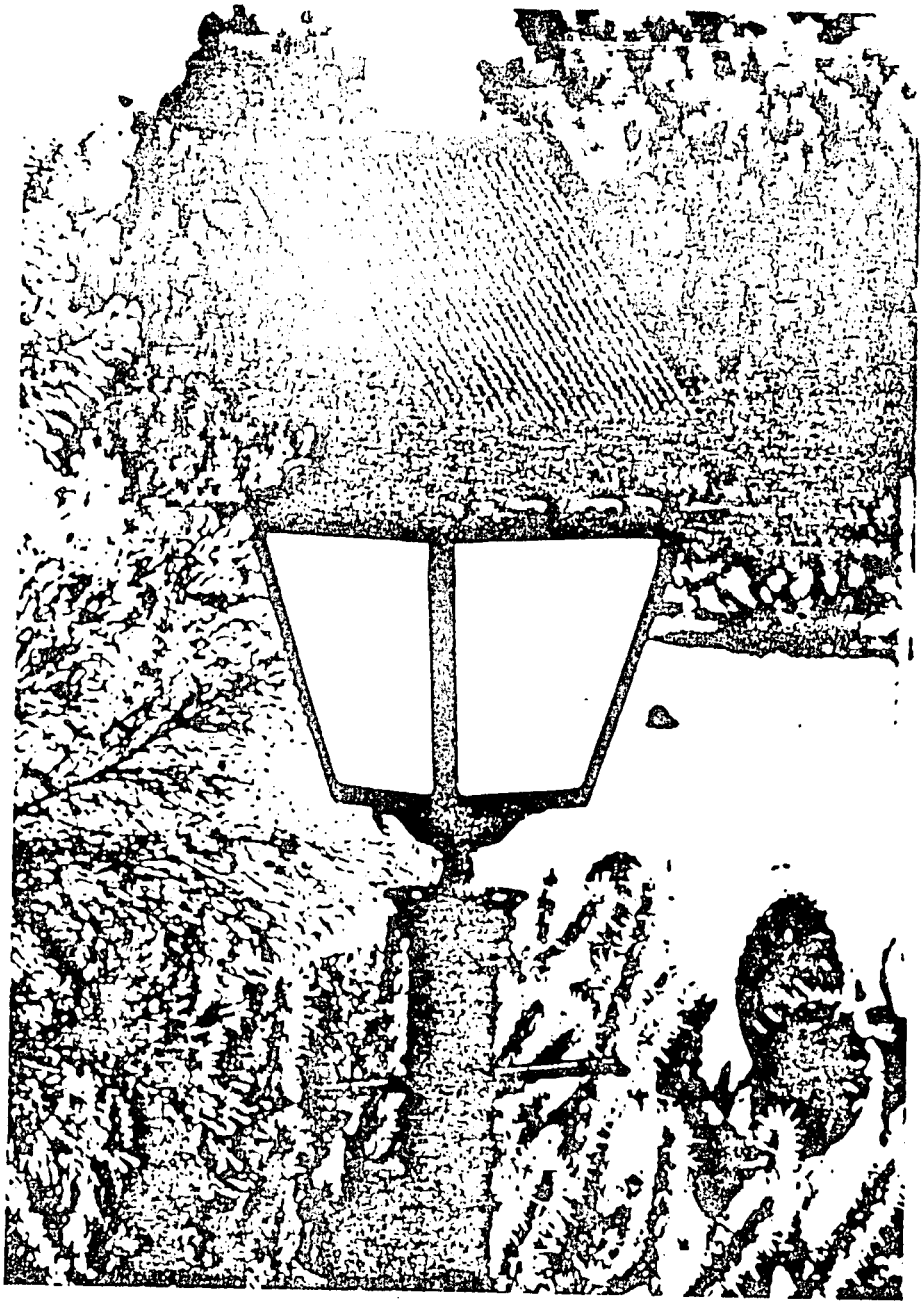
The OMNI-ALERT is self-powered by a photovoltaic (solar electric) panel which charges an internal electric battery. No utility connection is required, as the solar panel and battery storage provide for operation even after several sunless days.

PRELIMINARY SPECIFICATIONS

Detection Range:	40 Feet by 25 Feet Wide
Detection Method:	Passive Infra-Red Detects Thermal Radiation
Sensitivity Adjustment:	Variable of 5:1 Range
Power Requirement:	None - Self Energized
Time Delay:	20 Seconds to 20 Minutes
Aiming Capability:	All Directions
Weather Proofing:	Outside Locations
Solar Panel:	7 Watt
Storage:	5 Days w/o Sunlight
Light Intensity:	1500 Lumens (100W Incandescent Equivalent)
Nightly Run-Time:	1 Hour (Energy Balance)

LANCE OF SYSTEMS SPECIALISTS, INC.
45 EAST REDFIELD ROAD, SCOTTSDALE, ARIZONA 85260
(602) 948-9809, TELEX 6835043

FOR TECHNICAL AND SALES SUPPORT INFORMATION ONLY.
NOT TO BE USED AS PRODUCT LITERATURE FOR END USERS US



The BOSS LumaSTAR II incorporates the photovoltaic industry's state-of-the-art PV module - the ARCO Genesis G-100. The Genesis is the industry's first commercially available module which is manufactured with the thin-film amorphous silicon process. Thin-film amorphous solar cells have been used exclusively in solar calculators and watches for two years now. The Genesis product is the first large size application of this amorphous thin-film silicon technology in a PV module. The LumaSTAR II is the first solar light product to use the Genesis as its power source.

Specifications and cost data available Spring 1985.

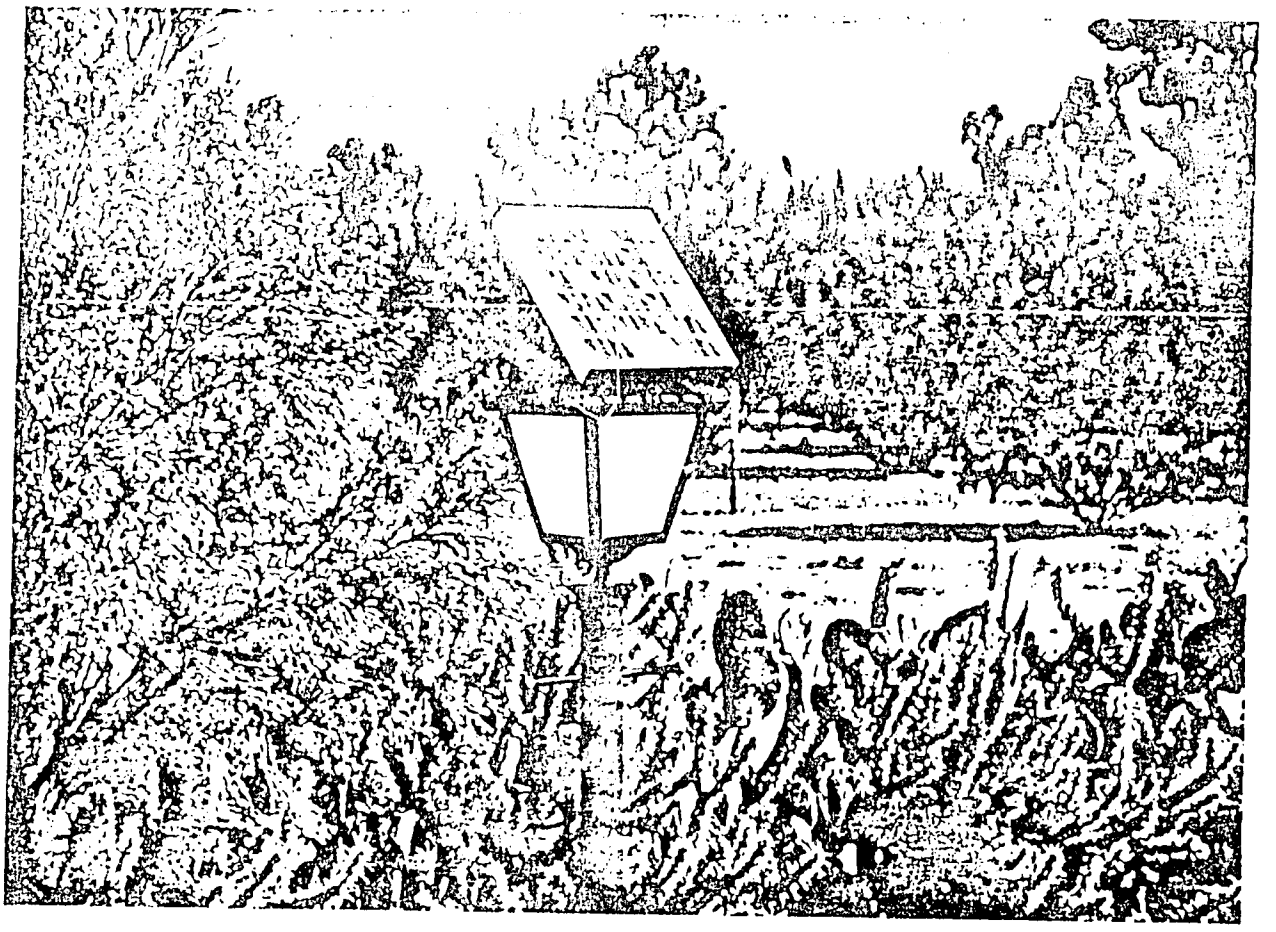
[illegible]

[illegible] TECHNICAL AND SALES [illegible] INFORMATION ONLY. [illegible]

BOSS *introduces*

THE LumaSTAR™ DELUXE LIGHT

LIGHT AT NIGHT FROM SUNLIGHT



- Light Every Night From Sunlight
- **NO MORE COSTLY UTILITY BILLS**
- **TAX CREDIT ELIGIBLE**
- Simple and Easy Installation Eliminates Digging Up Expensive Landscaping
- Installs in Minutes on any Standard 3-Inch Pole
- Maintenance Free
- Dependable Secure Operation for Years
- Durable Rust-Free All Aluminum Construction
- 100% Solid State Electronic Circuitry

LumaSTAR™ is energized directly from sunlight. The solar electric (photovoltaic) panel converts sunlight to electricity to charge an internal storage battery. LumaSTAR™ is automatic, it starts at sunset and runs up to 12 hours a night depending upon location and sunshine level.

ORDER FORM

SHIP TO:

Name _____

Address* _____

City _____ State _____

Zip _____ Phone ( ) _____

*Must have street address, cannot ship to P.O. Box

☐ MC ☐ VISA

Card # _____

Expiration Date _____

☐ Check. Check guarantee; Bank _____

Guarantee # _____

For faster delivery call 1-800-223-9580

Model	Quantity	Cost
LumaSTAP™ Deluxe @ $549. ea.	$	
	$	
	$	
Postage and Handling	$	11.00
In Arizona 6% Tax	$	
TOTAL	$	

Mail Order Form & Payment to:

Balance of Systems Specialists, Inc.
7745 E. Redfield Road
Scottsdale, Arizona 85260
(602) 948-9809 / (800) 223-9580 TELEX 683 5043

LumaSTAR™ THE LIGHT AT NIGHT FROM SUNLIGHT

FEATURES

- Dependable Light
- Eliminates Monthly Utility Bills
- Tax Credit Eligible
- Quick and Easy Installation
- Maintenance Free
- Durable Long Life Construction

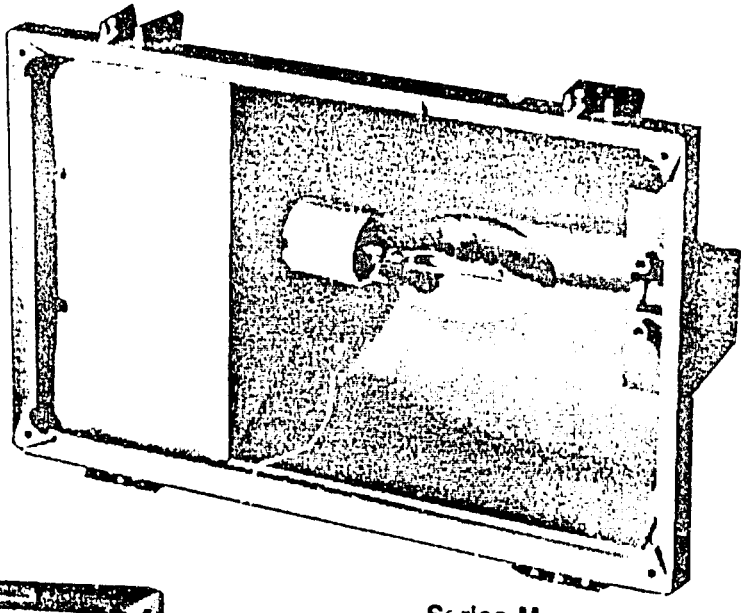
VARIETY OF USES

- Home Lawns and Yards
- Sidewalks and Driveways
- Decks and Patios
- Swimming Pools and Gardens
- Marinas and Boat Docks
- Campgrounds and Beaches

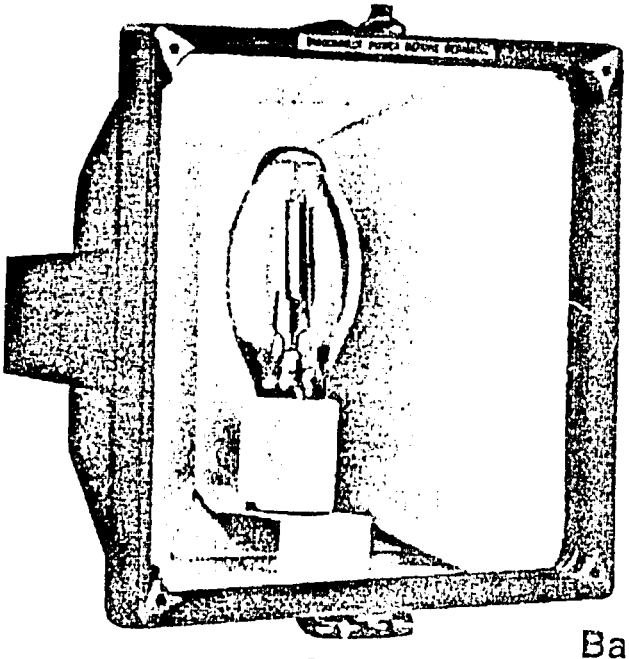
BOSS INC.
BALANCE OF SYSTEMS SPECIALISTS

HPS Micro-Watt Flood

35 to 150 Watt High Pressure Sodium
SERIES: M & MM



Series M



Series MM

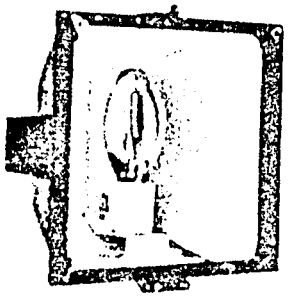
Balance of Systems Specialists, Inc.
7745 E. Redfield Road
Scottsdale, Arizona 85260
(602) 948-9809 / (800) 223-9580 TELEX 683-5043

features

HPS MICRO-WATT FLOOD

COMPACT HEAVY-DUTY FIXTURE

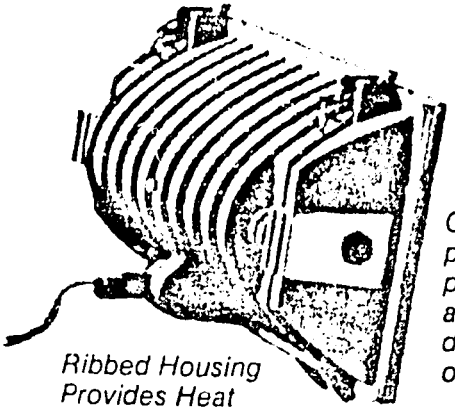
The HPS Micro-Watt Flood features a rugged housing of die-cast aluminum that is ribbed for effective heat dissipation. The unit is gasketed at all critical points to assure weatherproof protection. Standard finish is baked-on bronze enamel. The small size of the luminaire allows inconspicuous concealment while yielding maximum lighting effects. **Luminaire is packaged complete with lamp.**



Enclosed Ballast Housing

LONG LASTING QUALITY

All hardware is of corrosion-resistant materials. The enclosed electrical compartment provides extra protection for the ballast and starter. The unit will operate in temperatures as low as -20°F. The HPS Micro-Watt Flood conforms to UL standards.

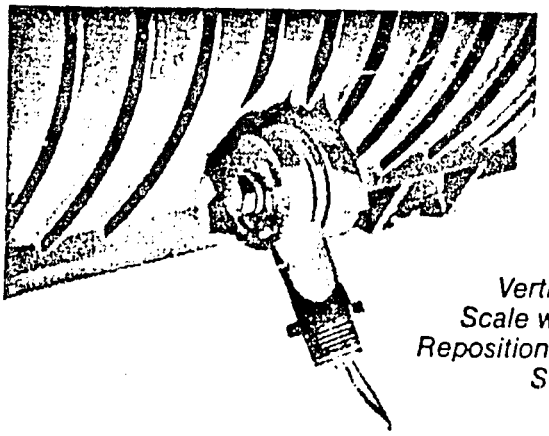


Ribbed Housing Provides Heat Dissipation

Optional photocontrol provides automatic dusk to dawn operation.

VERSATILITY

The HPS Micro-Watt Flood can be individually mounted or grouped for face-down or face-up applications. Each unit is factory prewired with a 6" wire extension from the stem. Six different mounting arrangements are available as standard. (See ordering data, page 6.) A complete 180° aiming sector with repositioning stop is provided. An internal ballast housing simplifies installation and maintenance.



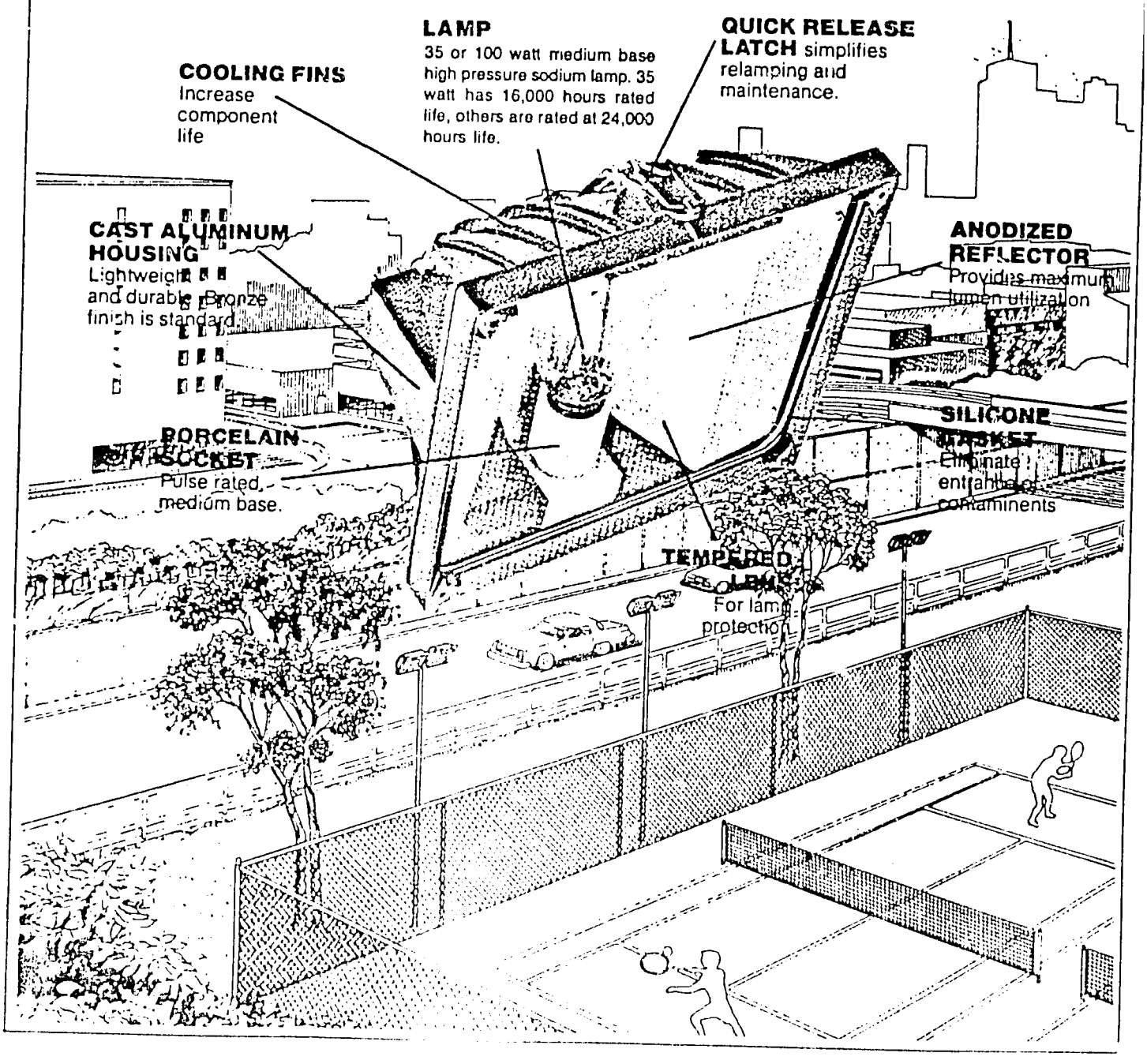
Vertical Scale with Repositioning Stop

APPLICATIONS

The long life and high lumens per watt output of the high pressure sodium lamp, as compared to tungsten halogen or incandescent, provides special advantages for a wide spectrum of low-level floodlighting applications. The high pressure sodium lamp provides a powerful punch of light for its compact size, making it an ideal unit for general floodlighting. Due to the broad beam light distribution, a given area can be illuminated with a minimum number of units . . . an excellent unit for commercial and industrial security lighting applications.

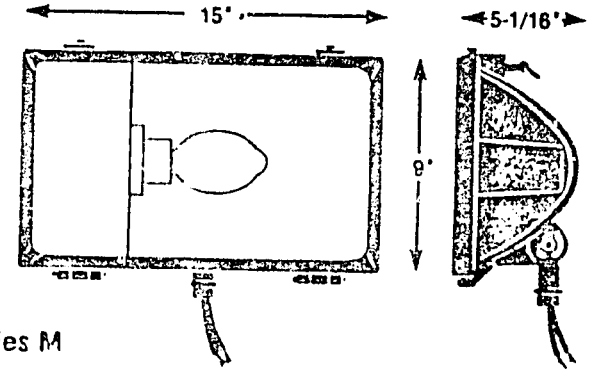
component data

HPS MICRO-WATT FLOOD

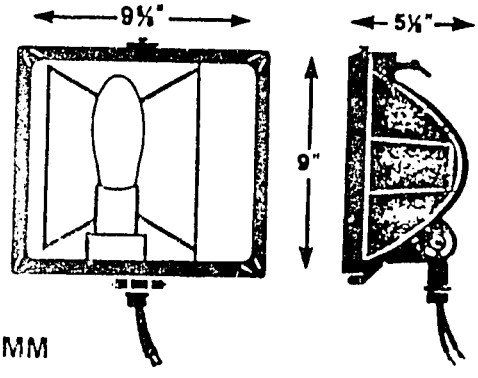


dimensions

HPS MICRO-WATT FLOOD



Series M



Series MM

Effective projected area for HPS Micro Watt Flood for Series M is 1.13 sq. ft. and .72 sq. ft. for Series MM.

specifications

HPS MICRO-WATT FLOOD

Floodlight shall be BOSS Outdoor Lighting HPS Micro-Watt Flood, catalog number_____for _____ watt high pressure sodium lamp.

Housing shall be die-cast aluminum with integral fins for heat dissipation.

High temperature porcelain sockets shall be medium base, pulse rated.

Anodized reflector shall have an anodic finish and produce a beam efficiency of ____% and a beam candlepower of _____ candela.

Tempered lens shall be thermal shock and impact resistant.

Ballast shall be DC solid-state electronic type, 24 volt (MM) 48 volt (M), suitable for operation in temperatures as low as −20°F.

Lens door shall be cast aluminum and securely held to the housing by stainless steel hingepins and latches. Door shall be sealed and gasketed.

Factory prewiring shall be provided to conform to UL standards.

Finish shall be baked-on Statuary Bronze enamel.

(Optional) Photoelectric control shall be provided.

photometric data

HPS MICRO-WATT FLOOD

SERIES MM

HPS MICRO-WATT BEAM SPREAD

Data based on report number P3387, using a 14 foot mounting height with unit aimed at 45°.

I.E.S. Beam Type	7H x 7V
Maximum Candlepower	296
Average Maximum Candlepower	268
Beam Spread	155.4°H x 135.0°V
Beam Lumens	621
Beam Efficiency	62.1%

SERIES M

HPS MICRO-WATT BEAM SPREAD

Data based on report number P3161, using a 14 foot mounting height with unit aimed at 45°.

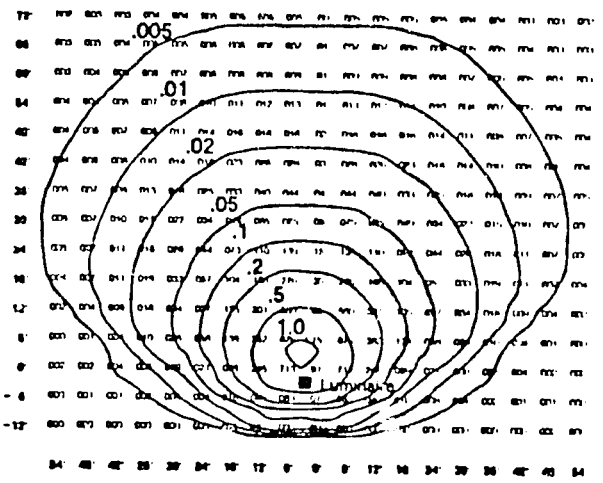
I.E.S. Beam Type	6H x 6V
Maximum Candlepower	380
Average Maximum Candlepower	347
Beam Spread	120.5°H x 113.7°V
Beam Lumens	535
Beam Efficiency	53.5%

Note: Data shown is per 1,000 lamp lumens, for 35W and 100 watt high pressure sodium lamps. Multiply lumen, candlepower and footcandle values by the factor shown in the lamp lumen chart.

LAMP LUMEN CHART

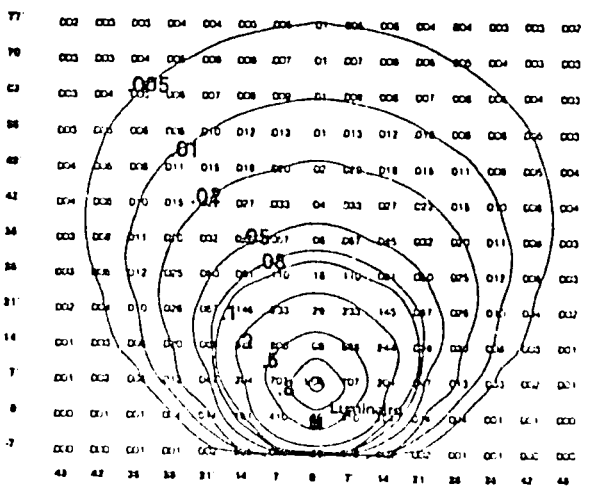
Lamp	Lumens	Factor
35	2,250	2.25
100	9,500	9.5

ISOFOOTCANDLE DISTRIBUTION



DISTANCE FROM LUMINAIRE

ISOFOOTCANDLE DISTRIBUTION



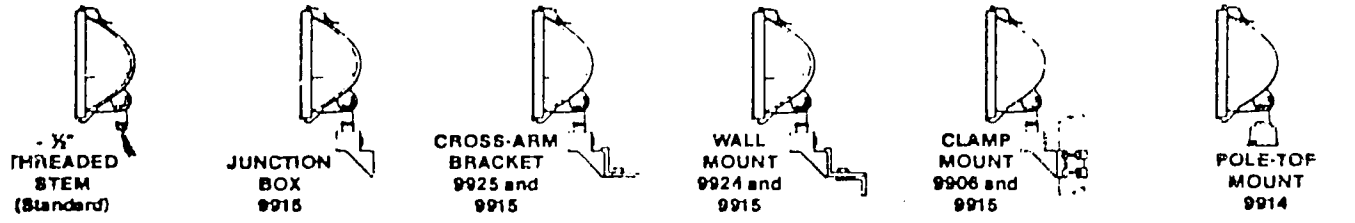
DISTANCE FROM LUMINAIRE

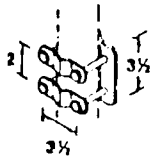
ordering data

HPS MICRO-WATT FLOOD

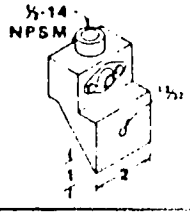
Wattage	Description	Approx Wt. Lbs	Voltage	Current	Without Photo-electric Control
35	HPS Micro-Watt Flood	7	24VDC	1.67 A	MM35
100	HPS Micro-Watt Flood	12	48VDC	2.25 A	M100

NOTE: All units have ½" threaded stem, if other mounting hardware is required, order by catalog number. (See below.)

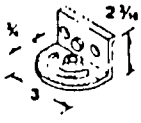




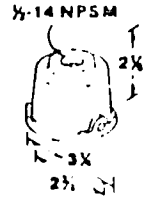
MOUNTING CLAMP
Cast aluminum and steel clamp mount with corrosion-resistant hardware for 1½" or 2" pipe. Use with 9915 Junction Box
Catalog Number
9906 — 3 lbs.



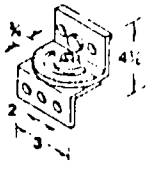
JUNCTION BOX
Aluminum junction box. Must be used with 9906, 9924 and 9925
Catalog Number
9915 — 1 lb.



CROSSARM MOUNT
Crossarm mount of corrosion-resistant materials with universal adjustment of 180°. Requires two mounting bolts. Must be used with 9915 Junction Box
Catalog Number
9925 — 2 lbs.



POLE TOP MOUNT
Aluminum pole top mount for 2" pipe
Catalog Number
9914 — 1 lb.



MOUNTING BRACKET
Mounting bracket of corrosion-resistant steel with universal adjustment of 180°. Use with 9915 Junction Box
Catalog Number
9924 — 2 lbs.

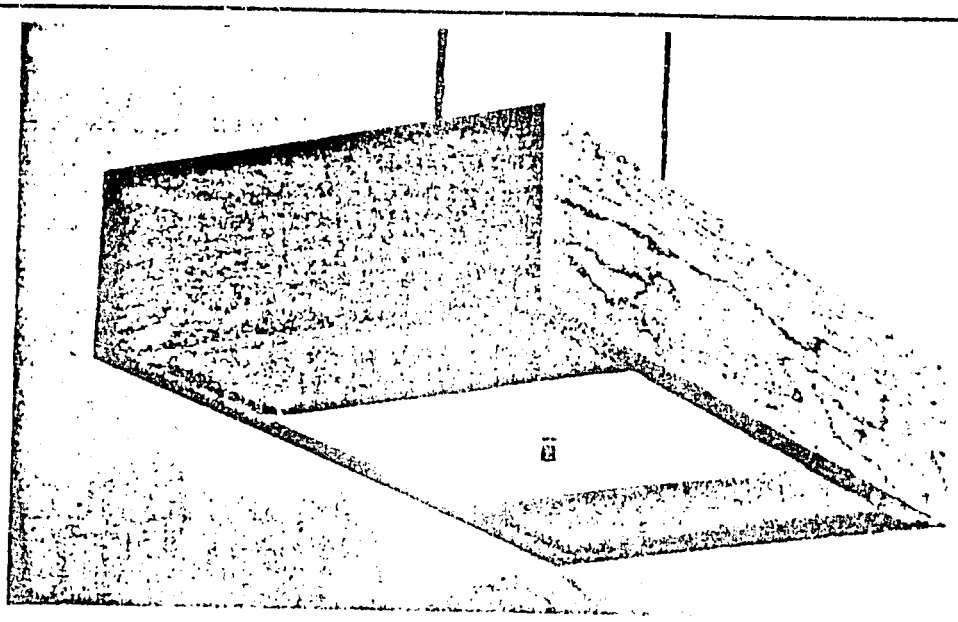
GLARE SHIELD
Glare shield of corrosion-resistant aluminum, may be mounted top or bottom
Catalog Number
474-V (For M series) — 1 lb.

NOTES

1. Lamps are included.
2. Projected area of Series M, HPS Micro-Watt Flood is 1.13 sq. ft. Series MM is .72 sq. ft.
3. Ballasts are DC solid-state electronic type.
4. For further information contact:
   Balance of Systems Specialists, Inc.
   7745 E. Redfield Road, Scottsdale, AZ 85260
   Phone (602) 948-9809 / (800) 223-9580 TELEX 683 5043

Balance of Systems Specialists, Inc.
7745 E. Redfield Road
Scottsdale, Arizona 85260
(602) 948-9809 / (800) 223-9580 TELEX 683 5043

CURRIN SOLAR POWERED LUMINAIRE



The Currin Model CSW-600 Luminaire provides high quality electric lighting for homes, cottages and other buildings that are beyond utility power. Hung from the ceiling over a desk, reading or work table, this solar powered luminaire can supply hours of balanced color light sufficient for reading, writing or handicraft activities. The luminaire is virtually maintenance-free and is safe. It uses a low voltage circuit and requires no dangerous fuel.

The total Currin CSW-600 Luminaire system consists of a lighting fixture with self-contined rechargeable batteries, a ceiling suspension bracket and housing, a solar-electric panel for battery charging, special control circuits, connecting cables and a manual. It can be installed in about one hour.

Features of the Currin CSW-600 Luminaire

- 200 lux of task illumination at table height
- 20 lux of background illumination
- Balanced color spectrum light source
- 2 or more hours of lighting each evening
- 5 hours of lighting using 40% of total battery capacity
- Option for two-way room switch
- Virtually no heat released
- Variety of wood housing available
- Minimum battery life of 3 years
- Lamp and component life of 10 years or more

CURRIN CORPORATION

P.O. Box 1191, Midland, Michigan 48640 USA

CHARACTERISTICS OF CURRIN CSW-600 LUMINAIRE SYSTEM

Light Source

600 lumen twin-tube fluorescent lamp with six times efficiency of incandescent lamps. Lamp uses tri-phosphor technology for full spectrum light over wavelength of 0.38 to 0.75 nm; 2700°K color temperature. Rated life of 10,000 hours, more than 10 years at 2 hours per night.

Optics

Lamp is mounted near focal axis of linear horizonal parabolic reflector of aluminum; molded tough polycarbonate prismatic diffuser; some upward illumination of ceiling.

Solar-Electric Panel

9 watt (peak) silicon photovoltaic (PV) module is standard; optional sizes of 5 or 18 watts for special applications or insolation conditions. Glass superstrate design for self-cleaning. Power degradation is less than 1.0%/year for more than ten years.

Battery Storage

Sealed lead-acid rechargeable batteries with 150 watt-hour total capacity at 12 volts; maintenance-free.

Lamp Ballast and Controls

High efficiency 25kHz electronic ballast is based on NASA development; solid-state battery charge controller to prevent battery over-charging and assure maximum battery life. Primary switch is alternate action push switch at center of diffuser with option of two-way wall switch.

Low battery voltage sensor turns on red indicator lamp on ceiling bracket at about 70% battery discharge; lamp is automatically turned off at 95% discharge.

Lamp Fixture Housing

Custom crafted from solid oak, maple, edge-grain fir, cherry, walnut or other hardwood on special order. Fixture hangs by two power cables from suspension bracket mounted on the ceiling in a wood housing.

Installation

Requires about one hour using common tools.

Dimensions, Weight

Lamp fixture:	500x250x105 mm (20x10x4.1 inches)
	8 kilograms (18 pounds)
PV module:	450x305x55 mm (17.5x12x2.1 inches)
	2.5 kilograms (5.5 pounds)
Shipping weight:	Approximately 16 kilograms (35 pounds)

==========

Design is subject to change by Currin Corporation for improved luminaire system performance.

850515:CGC

SUNNYSIDE SOLAR NEW ENGLAND PHOTOELECTRIC POWER COMPANY
RD 4 Box 295 Green River Road West Brattleboro, VT 05301 (802) 257-1482

AUGUST 1984

---LAMPS AND ADAPTERS FOR USE WITH LOW VOLTAGE DC LIGHTING---
(all lamps are 12 volt unless otherwise noted)

FLUORESCENT LIGHTING
(all fluorescent lighting is polarized)

IOTA BALLASTS:

101:	1D12-1-7/9	low wattage	$19.50
102:	1D12-1-11/13	low wattage	19.50
103:	1D12-1-15/20	high wattage	29.50
104:	1D12-1-30/40	high wattage	29.50

STANDARD FLUORESCENT TUBE LAMPS: 20, 30, 40 watt lamps available in local hardware stores. Each lamp would require one appropriate high wattage ballast.

NORELCO SCREW BASE LAMPS:

		needs ballast:	
201:	PL 7 watts (400 lumens)	#101	8.50
202:	PL 9 watts (525 lumens)	#101	8.75
203:	PL 13 watts (850 lumens)	#102	9.00

INCANDESCENT LIGHTING
(all incandescent lighting is not polarized)

MEDIUM SCREW BASE INCANDESCENT LAMPS:
(Screws into standard light fixture)

301:	15 watts	2.65
302:	25 watts	2.85
303:	50 watts	3.30
304:	100 watts	4.00

The following are 24 volt:

251:	25 watts	4.50
252:	60 watts	3.90

QUARTZ HALOGEN WEDGE BASE:
(Needs adapter #902 for use in standard screw socket light fixture)

401:	17 watts	5.90
402:	25 watts	5.90
403:	34 watts	5.90

The following is 24 volt:

451:	17 watts	6.25

All prices are FOB Brattleboro, Vermont. Quantity pricing: $100 to $250 less 8%; $250 to $500 less 12%; Over $500 less 20%. Payment by check/ money order in U.S. funds made payable to SUNNYSIDE SOLAR.

OSRAM HALOSTAR (Tungsten Halogen incandescent lamps)
(Needs adapter #903 for use with standard screw socket light fixture)

With silver reflector:

501:	Flood light	20 watts	$10.00
502:	Flood light	50 watts	12.00
503:	Spot light	20 watts	10.00
504:	Spot light	50 watts	12.00

With gold reflector:

505:	Flood light	50 watts	12.00
506:	Spot light	50 watts	12.00

OSRAM LOW VOLTAGE TWO FILAMENT HALOGEN LAMPS (Three way)
(Nees adapter #901 for use with standard screw socket light fixture)

601:	60 watt/55 watt (115 watts)	12.50
602:	100 watt/80 watt (180 watts)	13.75

The following is 24 volt:

651:	75 watt/70 watt (145 watts)	15.00

901: Low voltage halogen three way bulb to Edison Medium screw base...$8.00

902: Quartz halogen wedge base to Edison Medium screw base...$7.00 (NIS)

903: Double contact candelabra bayonett to Edison Medium screw base (three way) ...$6.50

906: Single contact candelabra bayonette to miniture screw base...$5.50

904: Single contact candelabra bayonette to Edison Medium screw base
a. 1/2" ...$5.00
b. 1 1/2"... $5.50
c. 2 3/8"... $6.00

905: Halostar Adaptor...$6.00

907: Torpedo bulb to Edison Medium screw base...$5.50

Mail to: Sunnyside Solar, RD Box 295, West Brattleboro, VT 05301

Name: _____ Telephone: _____

Address: _____

_____ ZIP: _____

Shipping Address: _____

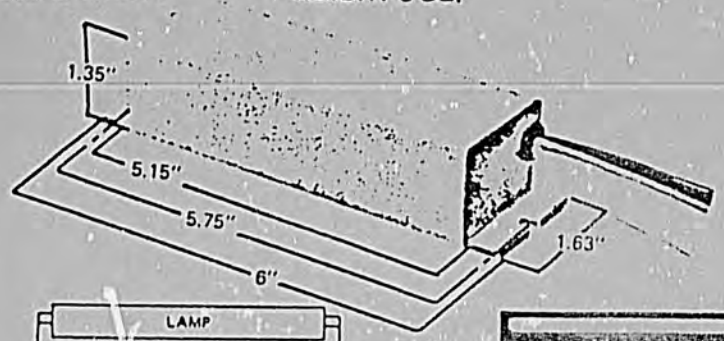
How many	Catalogue #	Description	Amt/Each	Total

Shipping and Handling:
10% on orders up to $100
5% on orders $100 to $500
We pay shipping on orders over $500

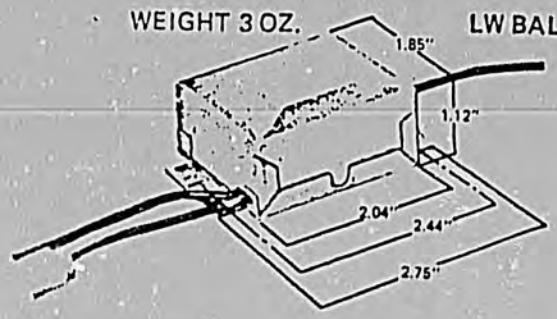
Vt. 4% Sales Tax _____
(or resale number)
Shipping/Handling _____

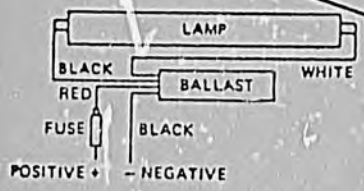
Total _____

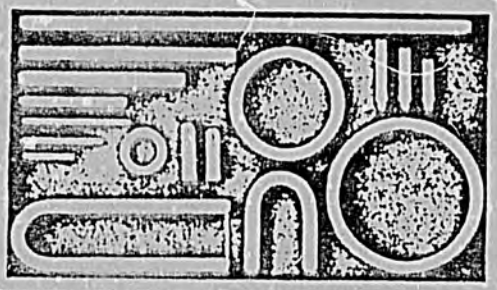
HW BALLAST WEIGHT 8 OZ.

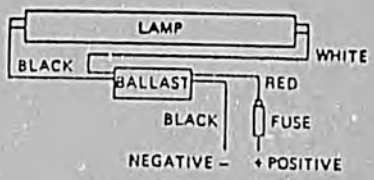


WEIGHT 3 OZ. LW BALLAST









WARNING—Reverse polarity blows fuse on 12V and 24V units. One spare fuse is provided. Use only specified fuses.

ATTACH BALLAST TO METAL HEAT SINK.

NOMINAL DC VOLTAGE	IOTA MODEL NUMBER	VOLTAGE RANGE	LAMP MODEL NUMBER	CURRENT NOMINAL VOLTAGE	APPROX. LIGHT OUTPUT LUMENS	OPERATING FREQUENCY RANGE KHZ	FUSE RATING	TYPE BALLAST
12V	1D12-1-4/6/8	10-14	F4T5	.55A	125+	22-24	2A	LW
12V	"	10-14	F6T5	.65A	275+	22-24	2A	LW
12V	"	10-14	F8T5	.80A	375+	22-24	2A	LW
12V	1D12-1-7/9	10-14	PL*7	.70A	375+	22-24	2A	LW
12V	"	10-14	FUL 7	.70A	400+	22-24	2A	LW
12V	"	10-14	PL*9	.85A	525+	22-24	2A	LW
12V	1D12-1-11/13	10-14	FUL 11	1.05A	600+	22-24	2A	LW
12V	"	10-14	FUL 13	1.25A	750+	22-24	2A	LW
12V	"	10-14	PL*13	1.25A	850+	22-24	2A	LW
12V	1D12-1-15LW	10-14	F15T12	1.30A	700+	22-24	3A	LW
12V	"	10-14	F15T8	1.30A	700+	22-24	3A	LW
12V	1D12-1-15/20	10-14	F15T12	1.40A	800+	30-32	3A	HW
12V	"	10-14	F15T8	1.40A	800+	30-32	3A	HW
12V	"	10-14	F20T12	1.70A	1200+	30-32	3A	HW
12V	1D12-1-30/40	10-14	F30T12	2.40A	1900+	22-24	4A	HW
12V	"	10-14	F40T12	2.80A	2100+	22-24	4A	HW
24V	1D24-1-15/20	21-28	F15T12	.60A	800+	26-28	2A	HW
24V	"	21-28	F20T12	.80A	1200+	26-28	2A	HW
24V	1D24-1-30/40	21-28	F30T12	1.20A	2200+	20-22	3A	HW
24V	"	21-28	F40T12	1.50A	2800+	20-22	3A	HW
36V	1D36-1-20	33-42	F20T12	.60A	1250+	27-29	2A	HW
36V	1D36-1-30/40	33-42	F30T12	.80A	2200+	22-24	2A	HW
36V	"	33-42	F40T12	1.00A	2800+	22-24	2A	HW
48V	1D48-1-20	43-53	F20T12	.40A	1250+	22-24	2A	HW
48V	1D48-1-30/40	43-53	F30T12	.50A	2200+	22-24	2A	HW
48V	"	43-53	F40T12	.70A	2300+	22-24	2A	HW

Case operating temperature limit for all ballasts is: 65°C/150°F

WARRANTY: All IOTA solid state ballasts are warranted against defects in material and workmanship for a period of one (1) year. If failure occurs, return the defective ballast(s) to IOTA, freight collect. Repair or replacement will be made at no charge, if our inspection and testing show that operating conditions had been within specified limits.* IOTA will not be responsible for any customer incurred labor charges.

*SPECIAL NOTE: IOTA ballasts are designed to operate within the specified voltage range and with a ballast case temperature that does not exceed 65°C/150°F. To assure adequate heat sinking, the ballast should be mounted in a standard metal fixture or on a metal surface. Operation outside of the voltage or thermal limits voids the warranty.

STANDARD WIRE LENGTHS (See Wiring Diagrams)

CASE TYPE	WATTAGE	RED WITH FUSE TO +	BLACK TO NEG	BLACK TO LAMP	WHITE TO LAMP
LW	4W in 12W	7"	7"	7"	7"
LW	15W	14"	14"	14"	13"
HW	15 & 20W	14"	14"	14"	13"
HW	30 & 40W	14"	14"	14"	31"

LOW WATTAGE BALLAST (LW)
$15.00

HIGH WATTAGE BALLAST (HW)
$22.75

IOTA ENGINEERING CO.

4700 SOUTH PARK AVENUE, SUITE B · TUCSON, ARIZONA 85714 · USA · TELEPHONE (602) 294-3292

Printed in USA IEC 7-83

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DC SOLID STATE BALLASTS

IOTA ENGINEERING CO.

SPECIFICATION DATA - ADDENDUM ------ June 1, 1984

VOLT	MODEL	VOLTAGE RANGE	LAMP	CURRENT AT NOM. VOLTAGE	APPROX. LUMENS	APPROX. FREQ.	FUSE	TYPE BALLAST
6V	1D6-1-4/6/8	5.2-7.2	F4T5	1.1A	125+	22-24	2A	LW
6V	"	"	F6T5	1.4A	295+	"	3A	LW
6V	"	"	F8T5	1.6A	400+	"	3A	LW
6V*	1D6-1-5	5.2-7.2	PL-5 and equivalent	1.1A	225+	26-28	2A	LW
6V*	1D6-1-7	5.2-7.2	PL-7 DULUX-7W F7TT/27K & equivalent	1.5A	375+	22-24	3A	LW
6V*	1D6-1-9	5.2-7.2	PL-9 DULUX-9W F9TT/27K & equivalent	2.0A	575+	22-24	3A	LW
24V	1D24-1-4/6/8	21-28	F4T5	.19A	125+	20-22	2A	LW
24V	"	21-28	F6T5	.25A	280+	20-22	2A	LW
24V	"	21-28	F8T5	.29A	360+	20-22	2A	LW
24V	1D24-1-7/9	21-28	PL-7	.29A	400+	19-21	2A	LW
24V	"	21-28	DULUX-7W	.29A	400+	19-21	2A	LW
24V*	"	21-28	F7TT/27K	.29A	400+	19-21	2A	LW
24V	"	21-28	FUL-7 & equivalent	.31A	450+	19-21	2A	LW
24V	"	21-28	PL-9	.35A	590+	20-22	2A	LW
24V*	"	21-28	DULUX-9W	.35A	590+	20-22	2A	LW
24V*	"	21-28	F9TT/27K & equivalent	.35A	590+	20-22	2A	LW
24V	1D24-1-11/13	21-28	PL-13	.55A	900+	21-23	2A	LW
24V*	"	21-28	DULUX-13W	.55A	900+	21-23	2A	LW
24V*	"	21-28	F13TT/27K	.55A	900+	21-23	2A	LW
24V	"	21-28	FUL-11 & equivalent	.53A	650+	20-22	2A	LW
24V	1D24-1-13T5	21-28	F13T5	.55A	800+	32-34	2A	LW

* NOTE: A starting aid may be required with these ballasts and lamp combinations - and even with some of the other DC voltage combinations that involve compact lamps with built-in starters. Most fluorescent lamp manufacturers always recommend that their lamps be mounted close to a negatively grounded metal reflector or plate to better assure reliable starting and longer life. While the aid is NOT REQUIRED with the majority of IOTA DC ballasts it will, in all cases, be beneficial - and especially so with the compact lamps with built-in starters.

IOTA ENGINEERING CO.

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SOLID STATE BALLASTS

AC/DC and DC ONLY

IOTA ENGINEERING CO.

FOR AC/DC APPLICATIONS

------- FOR PHOTOVOLTAIC and WIND-POWERED SYSTEM APPLICATIONS - June 1984 -------

MODEL: 2A/D120-2-4C (AC/DC)

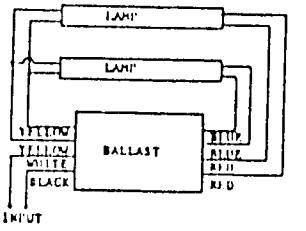
LAMPS: 2-F30T12 2-F34T12
2-F35T12 2-F40T12
2-FC12T10 2-FC16T10

INPUT: 120VAC-60Hz-0.60A
120VDC -- 0.50A } FOR 2-F40T12

CLASS P - THERMALLY PROTECTED

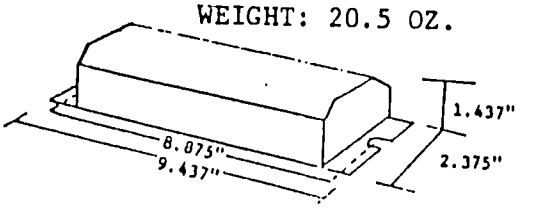
CASE MUST BE HEAT SINKED

LAMP MUST BE MOUNTED WITHIN 1/2" OF GROUNDED METAL REFLECTOR.



VOLTAGE RANGE:
VAC ±10%
VDC +20% -5%

WEIGHT: 20.5 OZ.



WIRE LENGTHS: YELLOW 37"
WHITE 21"
BLACK 21"
BLUE 26"
RED 26"

POWER FACTOR CORRECTED

LENGTHS SHOWN ARE FOR 48" FIXTURE.
OTHER LENGTHS TO SUIT APPLICABLE FIXTURES.

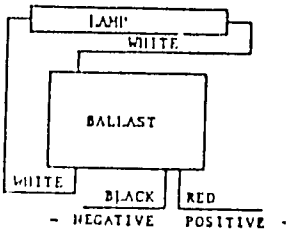
MODEL: 2D120-1-20 (DC ONLY)

LAMP: 1-F20T12
INPUT: 120V-0.17A

CLASS P - THERMALLY PROTECTED

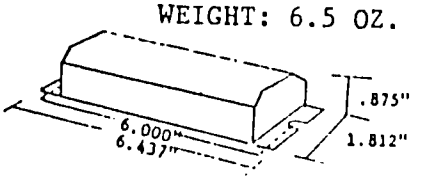
CASE MUST BE HEAT SINKED

LAMP MUST BE MOUNTED WITHIN 1/2" OF GROUNDED METAL REFLECTOR.



VOLTAGE RANGE:
+20% -5%

WEIGHT: 6.5 OZ.



WIRE LENGTHS: WHITE 15"
BLACK 15"
RED 15"

LENGTHS SHOWN ARE FOR 24" FIXTURE.
OTHER LENGTHS TO SUIT APPLICABLE FIXTURES.

SMALL QUANTITIES AVAILABLE WITHIN 30 DAYS ARO.
LARGER QUANTITIES REQUIRE APPROPRIATE LEAD TIME.

PATENTED UNDER ONE OR MORE OF THE FOLLOWING
US PATENTS: 3,889,153; 4,005,335; 4,017,785;
4,127,789; 4,330,736 AND/OR PENDING PATENTS.

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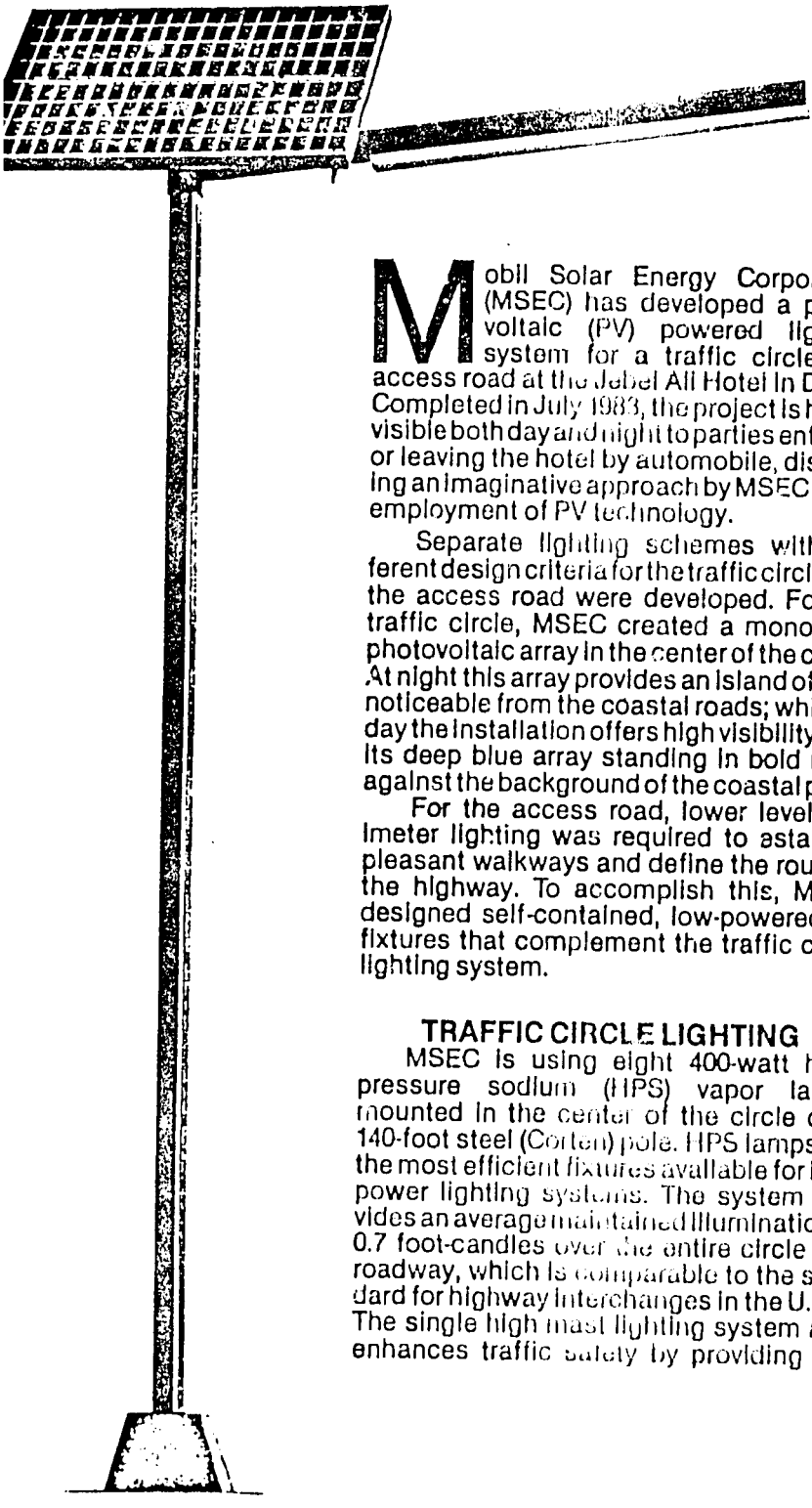
PHOTOVOLTAIC LIGHTING SYSTEMS

APPLICATION NOTE NO. 3

STREET LIGHTING



Mobil Solar Energy Corporation (MSEC) has developed a photovoltaic (PV) powered lighting system for a traffic circle and access road at the Jebel Ali Hotel in Dubai. Completed in July 1983, the project is highly visible both day and night to parties entering or leaving the hotel by automobile, displaying an imaginative approach by MSEC in the employment of PV technology.

Separate lighting schemes with different design criteria for the traffic circle and the access road were developed. For the traffic circle, MSEC created a monolithic photovoltaic array in the center of the circle. At night this array provides an island of light noticeable from the coastal roads; while by day the installation offers high visibility with its deep blue array standing in bold relief against the background of the coastal plain.

For the access road, lower level perimeter lighting was required to establish pleasant walkways and define the route of the highway. To accomplish this, MSEC designed self-contained, low-powered PV fixtures that complement the traffic circle lighting system.

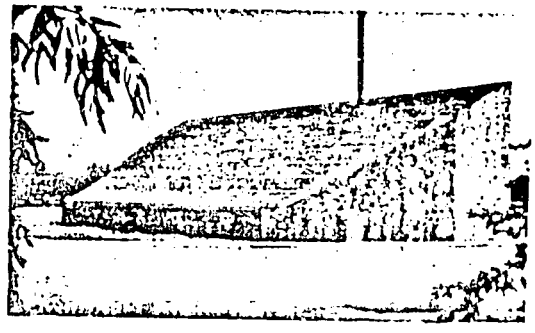
TRAFFIC CIRCLE LIGHTING

MSEC is using eight 400-watt high-pressure sodium (HPS) vapor lamps mounted in the center of the circle on a 140-foot steel (Corten) pole. HPS lamps are the most efficient fixtures available for high power lighting systems. The system provides an average maintained illumination of 0.7 foot-candles over the entire circle and roadway, which is comparable to the standard for highway interchanges in the U.S.A. The single high mast lighting system also enhances traffic safety by providing uniform illumination and natural shadow patterns to assure appropriate visual cues to drivers in the circle.

The lamp system includes a lowering device that transports the luminaires between the ground and mast top, thereby permitting testing and repairs to be carried out at ground level.

MSEC'S PV ARRAY

The traffic circle system is powered by an array of 432 Mobil Solar Ra40 ribbon cell photovoltaic modules mounted in the southern half of the circle (to prevent shading from the lamp mast located in the center). The array is rated at a peak power of 15.1 kilowatts and has been sized to accommodate the power consumption of the load (lamps plus system losses) and the effect of climatic conditions at the site. The average daily output of the array for December, the month with the least sunshine, will still permit the lamps to operate. During other months there will be an excess of PV electrical power available for auxiliary purposes.



An array of 432 Ra40 Solar modules supplies approx. 15 kw peak, powering eight 400 watt high-pressure sodium vapor lamps.

Mobil Solar Energy Corporation

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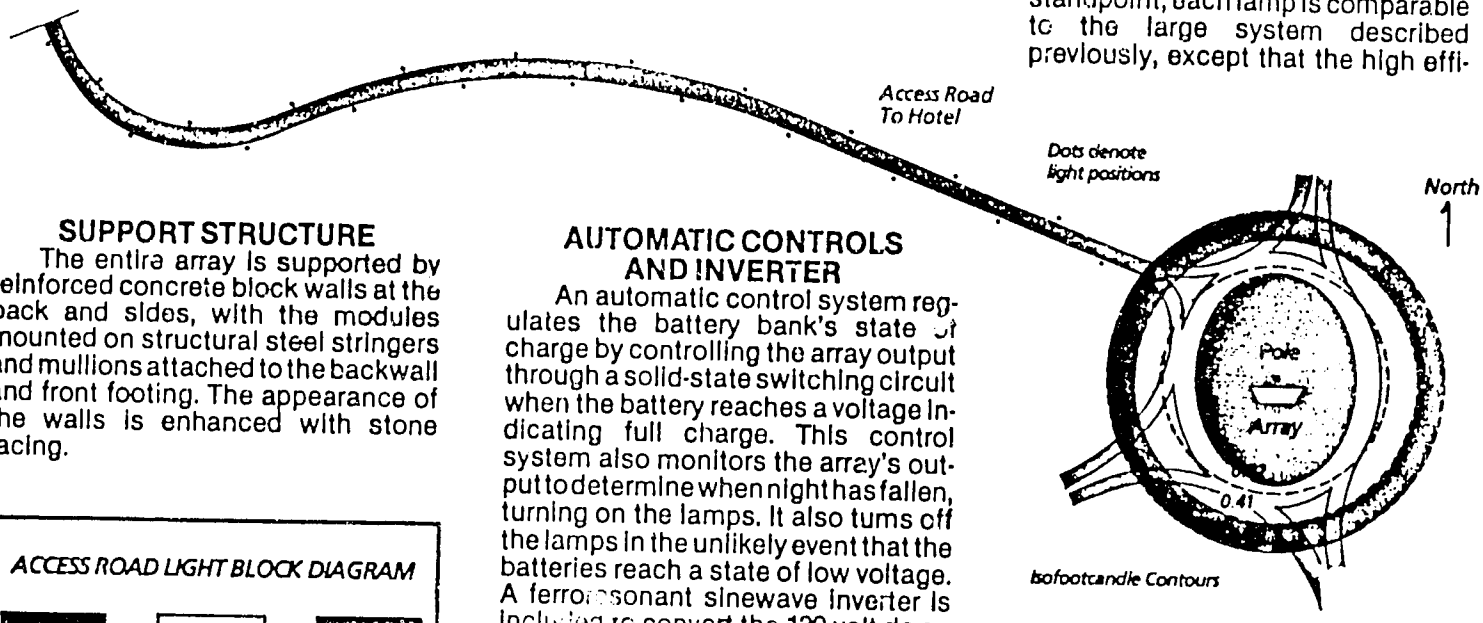
The array's PV modules are wired in series and parallel combinations to produce a dc nominal operating voltage of 144V, ideal for charging a 120V battery bank.

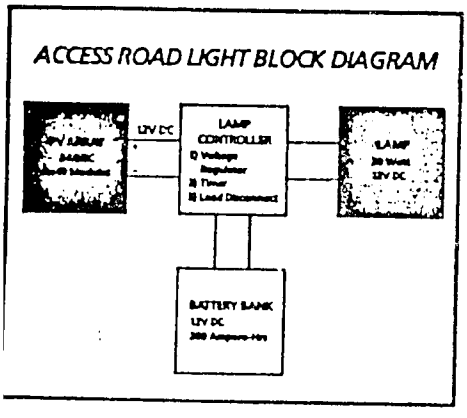
The battery bank stores four times the maximum expected daily load so that the lamps can run for four days with no sunshine at all. Under normal weather conditions in Dubai, there is little chance that there won't be enough stored energy to operate the lights on any particular night.

of fluorescent luminaires powered by two Ra40 modules, which are mounted atop steel poles. Two individual Delco 2000 batteries and control systems completing the system are located in an enclosure at the base of the pole. This makes each lamp self-contained. From a functional standpoint, each lamp is comparable to the large system described previously, except that the high efficiency "dc ballast" provided with each luminaire eliminates the need for a DC-AC inverter. Each system has a 20-watt fluorescent tube to provide 12 hours illumination under worst case conditions. A total of 21 lamps, spaced at 100 ft. intervals, outline the access road approaching the hotel.



SUPPORT STRUCTURE

The entire array is supported by reinforced concrete block walls at the back and sides, with the modules mounted on structural steel stringers and mullions attached to the backwall and front footing. The appearance of the walls is enhanced with stone facing.



BATTERY BANK

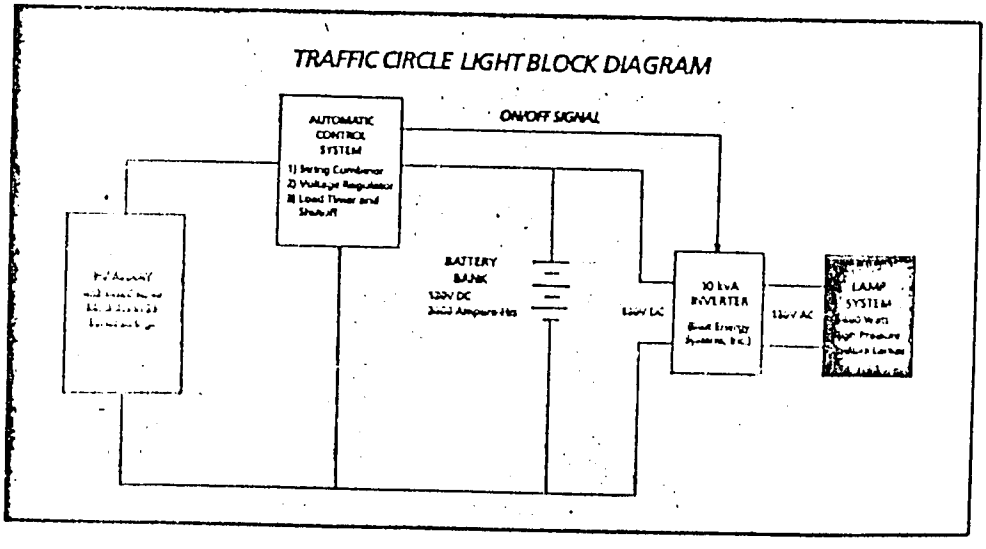
The battery bank stores the electricity produced during the day for evening use. By proper choice of battery bank voltage, the array always operates very close to its maximum power, thereby maximizing the energy produced. Single cell (2 volt) Exide DH-5 batteries have been utilized for the system, thus allowing the operating voltage to be "fine tuned."

AUTOMATIC CONTROLS AND INVERTER

An automatic control system regulates the battery bank's state of charge by controlling the array output through a solid-state switching circuit when the battery reaches a voltage indicating full charge. This control system also monitors the array's output to determine when night has fallen, turning on the lamps. It also turns off the lamps in the unlikely event that the batteries reach a state of low voltage. A ferroresonant sinewave inverter is included to convert the 120 volt dc array output to 120 volt a.c. required by the lamps.

ACCESS ROAD LIGHTING

For the access road from the traffic circle to the Hotel, MSEC has developed a low-key lighting system



Mobil Solar Energy Corporation

16 Hickory Drive, Waltham, Massachusetts 02254 (617) 890-1160 Telex 951272 MOBIL WHA

THE BLUE RIBBON KIT I INCLUDES:

- The Ra30 module, nominal 30 watts: 1.94A at 15.5V.
- A high efficiency 12V fluorescent light, with switch and protective fuse (spare fuse included): 1.4A consumption, producing 800 lumens of light.
- A compact battery protector, with blocking diode and adjustable voltage setting.
- A versatile, variable tilt mounting system — for wall, roof, pole or ground mounting.
- 50 feet of #14 AWG hook-up wire, fastening hardware and flashing materials to install the system.
- A brief, easy-to-follow installation guide.

A 12 volt, 60 to 100 Ah battery is required to complete the system. It can be easily obtained locally.

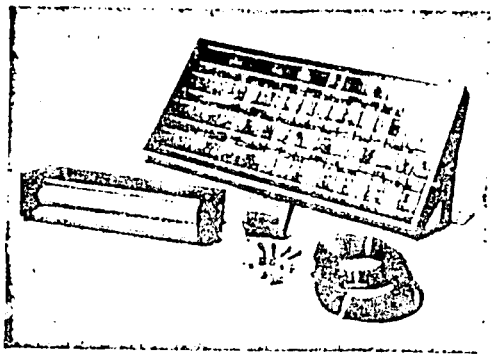
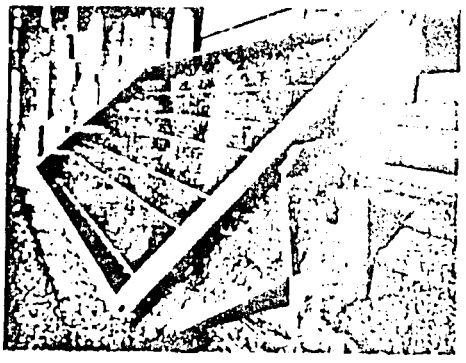


Figure 1: *Components of the Blue Ribbon Kit I*

Figure 2: *Variable Tilt Mount on the Blue Ribbon Kit I*



KIT CHARACTERISTICS:

Module:	2.0" X 16.2" X 35.7" (50.8mm X 411.5mm X 906.8mm) 11.2 lbs. (5.1 kg.)
Light:	18.5" X 4.5" X 4.5" (469.9mm X 114.3mm X 114.3mm) 3.15 lbs. (1.43 kg.)
Mounting Space Required:	16.2"W X 40.2"L (411.5mm X 1021.1mm)
Total Kit Weight (Net):	Approx. 15.0 lbs. (6.8 kg.)
Support Structure Tilt Range:	0° to 45° (in increments of 15°)

AVAILABLE KIT LIGHTING TIME:

Available lighting time will depend upon the total sunlight energy falling on your location. The chart below provides a general guide:

Average Daily Sunlight Energy (kWh/m^2)	Location (Examples)	Approximate Hours of Lighting (Hours/Day)
4	Boston, Benin City, Kinshasa, Singapore, Bogota:	4-5
5	Atlanta, Panama, Bangkok, Palau, Sidney:	5-6
6	Honolulu, Bangalore, Bulawayo, Jeddah, Santiago, Phoenix, Cuzco:	6-7
7	Santa Fe, Wake Island, Jodhpur:	8+

(Double "APPROX. HOURS OF LIGHTING" figures with the Blue Ribbon Kit II)

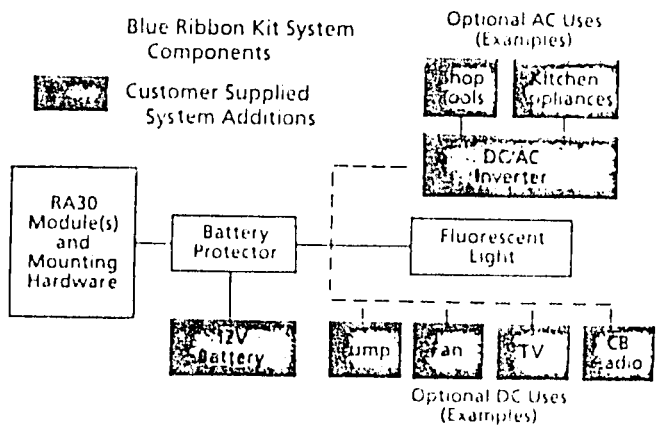
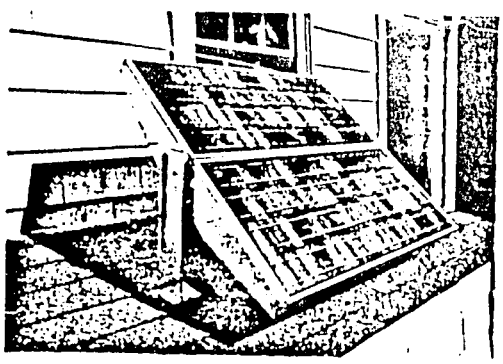


Figure 3: *Basic System Diagram*

Figure 4: *Blue Ribbon Kit II — Roof Mount Capability*



THE BLUE RIBBON KIT II INCLUDES:

- Two Ra30 modules, nominal 60 watts: 3.8A, 15.5V.
- Two module, variable tilt mounting system.
- Two high efficiency fluorescent lights.
- Battery protector, as in the one module kit.
- 70 feet of #14 AWG hook-up wire, fastening hardware and flashing materials to install the system.
- Mounting space required: 34"W X 40.2"L (863.4mm X 1021.0mm)
- Total Kit Weight (Net): Approx. 29.0 lbs. (13.2 kg.)

A 12 volt, minimum 100 Ah battery is required to complete the system. It can be easily obtained locally.

The Blue Ribbon Kit is your inexpensive entry into the Solar Age. Start with the Blue Ribbon Kit for lighting. As your electric needs and budget increase, add modules and other electrical appliances. Install it yourself; it's easy. Say goodbye to dangerous kerosene, dim candles, and noisy generators. Live off the sun!

To obtain the Blue Ribbon Kit I (BRK I) or Blue Ribbon Kit II (BRK II) contact your Mobil Solar Distributor/Dealer at:

Mobil Solar Energy Corporation (MSEC) reserves the right to make changes to any products herein to improve reliability, function or design. MSEC does not assume any liability arising out of the application or use of any product described herein, neither does it convey any license under its patent rights nor the rights of others.

Mobil Solar Energy Corporation

Subsidiary of Mobil Oil Corporation

16 Hickory Drive, Waltham, Massachusetts 02254 (617) 890-1180 Telex 951272 MOBIL SOLAR WHA

Mobil Solar Energy Corp., 1984

Printed in U.S.A. (E 84) NEL 10M

LOW PRESSURE SODIUM LIGHTS: LOW VOLTAGE

REC Specialties, Inc. is now in production on low voltage, Low Pressure Sodium lights.

These were developed specifically for the photovoltaic industry for use in remote areas where street lighting is required, and grid power is unavailable.

We manufacture two models for 12 volt DC operation. Model LPS-118LT is an 18 watt light; model LPS-135LT is a 35 watt light.

These lights have a cast aluminum housing, with a vandal resistant polycarbonate diffuser. They operate at about 95% efficiency. The provided photocell will activate the lights at dusk. The timer, which comes standard on all lights, can be adjusted in increments of one hour from 1 to 15 hours, or it can be by-passed.

If the timer is by-passed, the light will turn on at dusk and turn off at dawn.

Low Pressure Sodium lights are monochromatic: it has poor color rendering. It produces only 2 main spectral lines in the yellow region, so all colors are rendered in tones of yellow, brown and gray. However, these 2 lines are at the peak of the eye's response curve, so Low Pressure Sodium lights are a highly efficient, energy saving light source for street lighting, security lightin and factory yards. In fact, they are ideal anywhere that light is needed, with low energy consumption, and color is not a prime consideration.

The wavelength of the light produced is close to that at which the human eye has its maximum sensitivity. It is also less inhibited by fog or other pollutants.

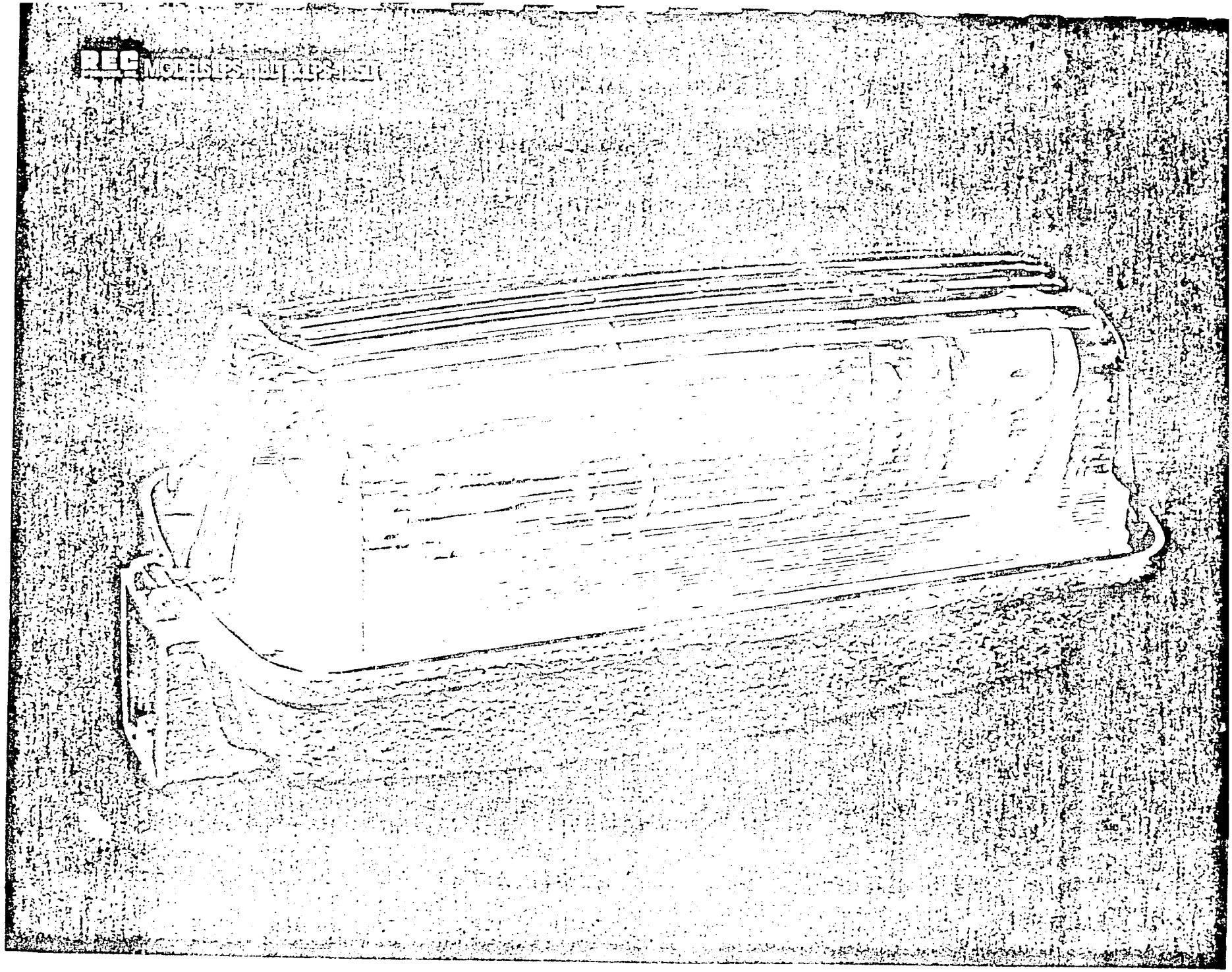
Low Pressure Sodium lighting is the most efficient available of all lighting applications. They are about twice as efficient as fluorescents.

The enclosed specification sheet will provide you with further details.

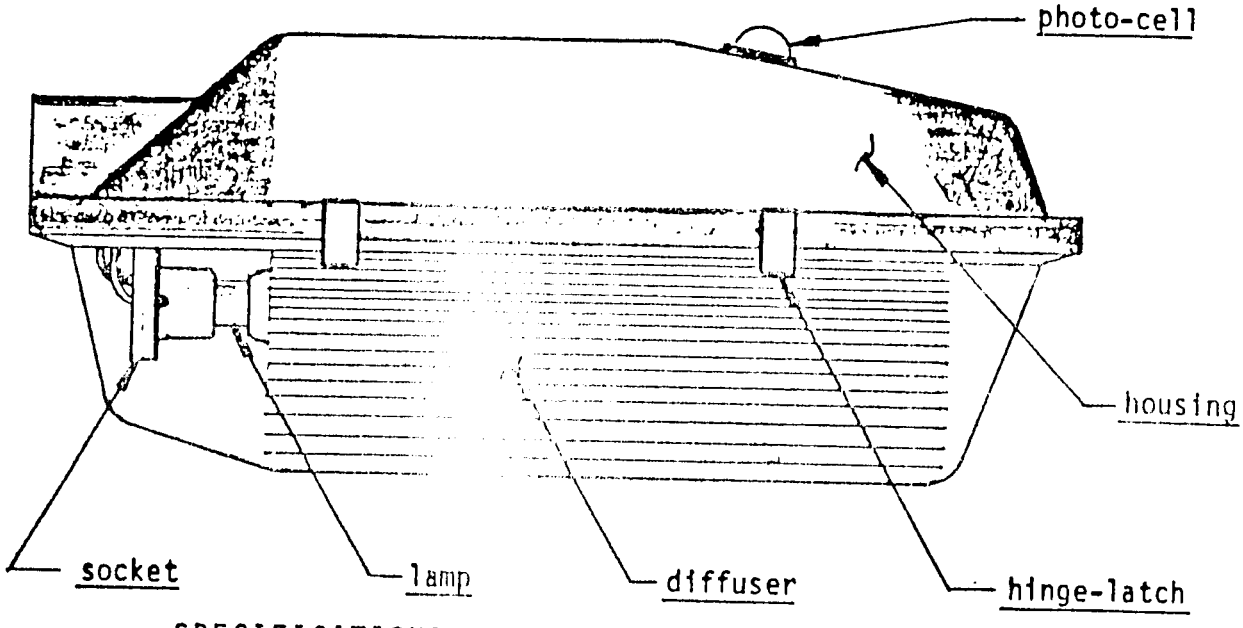
REC
SPECIALTIES, INC.
LEADERSHIP IN CREATIVE LIGHTING

530 CONSTITUTION AVENUE
CAMARILLO, CA 93010
U.S.A.

(805) 987-5021
Telex: 662203 RECSPEC CAMA


REC

EXTERIOR STREET/SECURITY LIGHT
LOW PRESSURE SODIUM
WITH AUTOMATIC PHOTOELECTRIC CELL AND TIMER



SPECIFICATIONS:

HOUSING:	cast aluminum
DIFFUSER:	polycarbonate - vandal resistant
MOUNTING:	tenon 1¼" pipe;. wall or wood pole mounting bracket included (10¼" pipe)
LAMP WARM UP TIME:	7 to 10 minutes at 25°Centigrade
TIMER:	adjustable from 1 to 15 hours (can be by-passed)

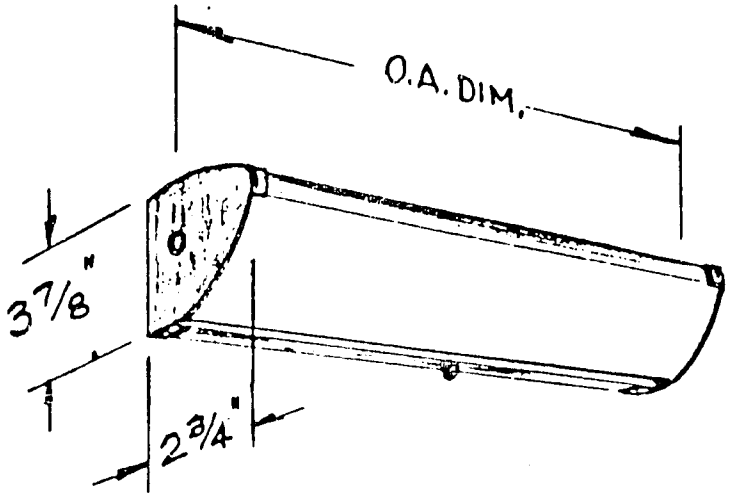
MODEL NUMBER	WATTAGE	INPUT VOLTS	CURRENT	DESIGN LUMENS
LPS-118LT	18 watts	12 VDC	2.2 amps	1800 lumens
LPS-135LT	35 watts	12 VDC	3.4 amps	4800 lumens
LPS-218LT	18 watts	24 VDC	1.1 amps	1800 lumens
LPS-235LT	35 watts	24 VDC	1.7 amps	4800 lumens

WEIGHT: approx. 13 lbs. (6 Kg.)
DIMENSIONS: approx. 16.5" long, 7" wide, 7" deep
INCLUSIONS: lamp, timer, photocell, mounting bracket

Specifications subject to change without notice.

REC SPECIALTIES
830 CONSTITUTION AVENUE
CAMARILLO, CA 93010, U.S.A.
(805) 987-5021

DWN. [illegible] 1/25/85	CAT. NO. LPS	
APPRV. [illegible]	DWG. NO. 1-316	
DATE: 2/7/83		



SPECIFICATIONS:

HOUSING - EXTRUDED ALUMINUM - ANODIZED.

INVERTER - 12 V.D.C.

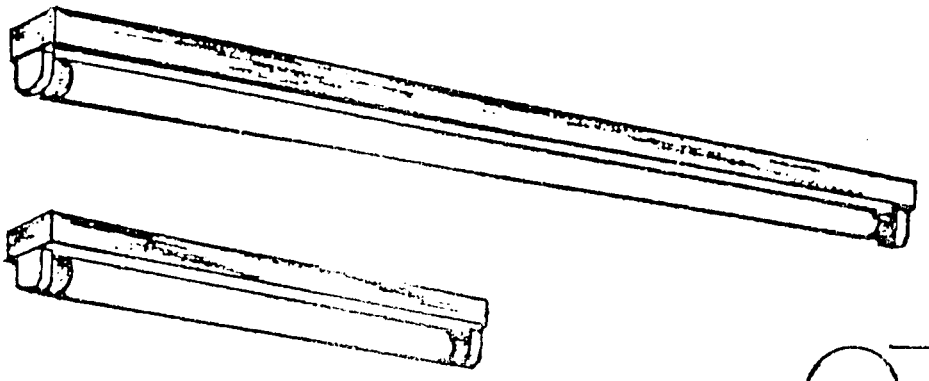
ENDS - ABS PLASTIC - BLACK

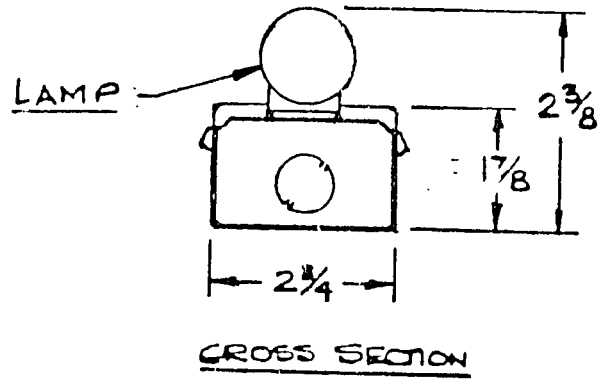
DIFFUSER - AMBER STANDARD - AVAILABLE IN CLEAR & WHITE ACRYLIC.

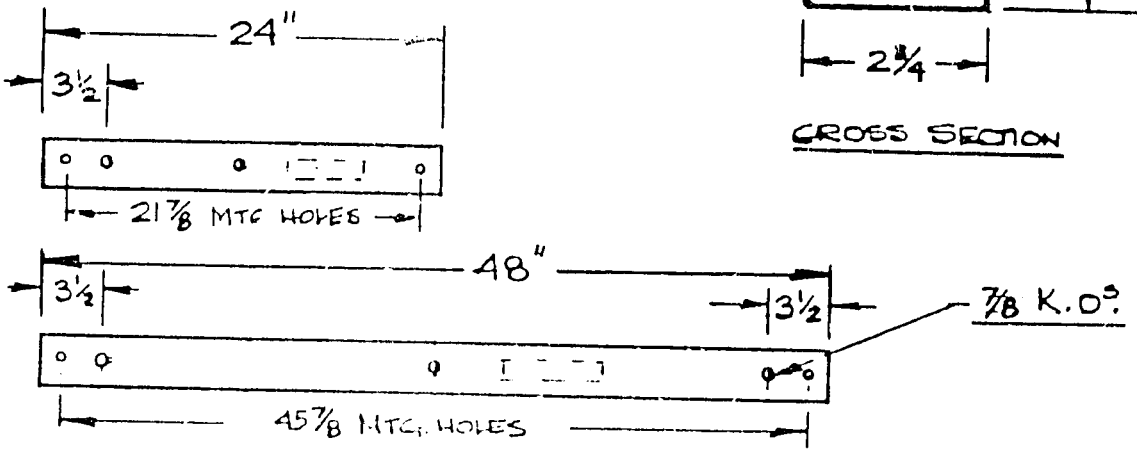
LAMP - SEE CAT. Nº BELOW.

CAT. Nº	LAMP-WATTS	OVERALL DIM.	NOTE
.167	(1) 18W. TB	24 3/8	
165	(1) 30W. TB	36 5/8	
163	(1) 15W. TB	18 3/8	
162	(2) 8W. T5	12 5/8	
161	(1) 8W. T5	12 5/8	

REC SPECIALTIES		DWN. 2/23/84	CAT. NO. 160 SER.
		APPRV.	DWG. NO.
		DATE:	







SPECIFICATIONS:

HOUSING - RIGIDLY DIE CONSTRUCTED #22 GA. CRS.
END PLATE - DUAL PURPOSE - END PLATE OR COUPLER FOR CONT. ROW APPLICATIONS.
FINISH - BAKED WHITE ENAMEL 85% REFLECTIVITY.
INVERTER - 12 VDC SOLID STATE, WITH 9' LEADS BLACK +, WHITE -.

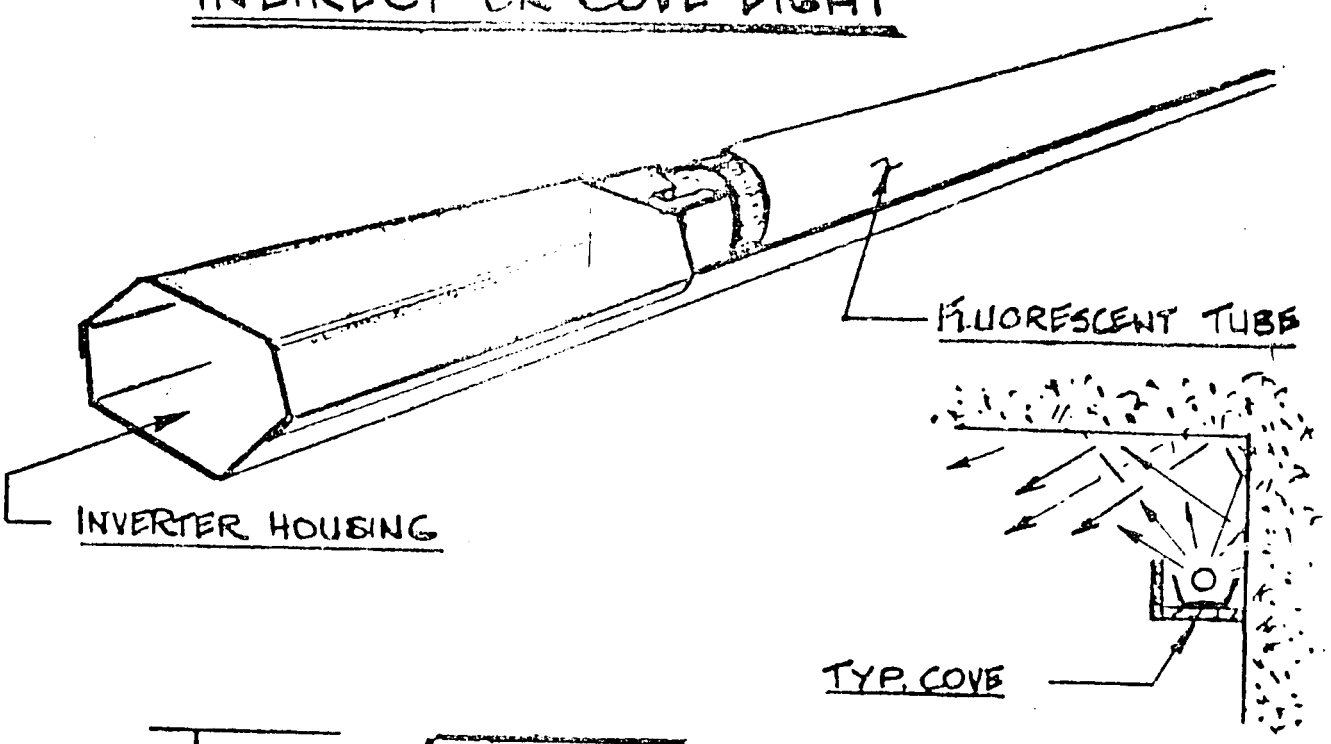
153	F40T12 C/W	3.0	48"
151	F20T12 C/W	1.5	24"
CAT. NO	LAMP	AMPS	FIX. LENGTH

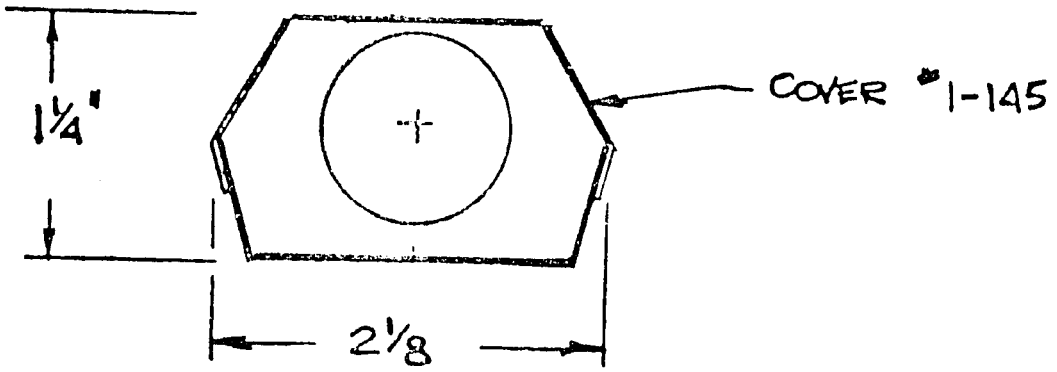
REC RECREATIONS
530 CONSTITUTION AVENUE
CAMARILLO, CA 93010, U.S.A.
(805) 987-5021

DWN. [illegible] 1/7/80
APPRV. [illegible]
DATE [illegible]

CAT. NO. 151 & 153
DWG. NO.

INDIRECT OR COVE LIGHT





SPECIFICATIONS:

24 GA. CRS - STANDARD

ALUMINUM AVAILABLE AT ADDITIONAL COST — SPECIFY ALUMINUM AFTER CATALOG Nº

FINISH: BAKED WHITE ENAMEL

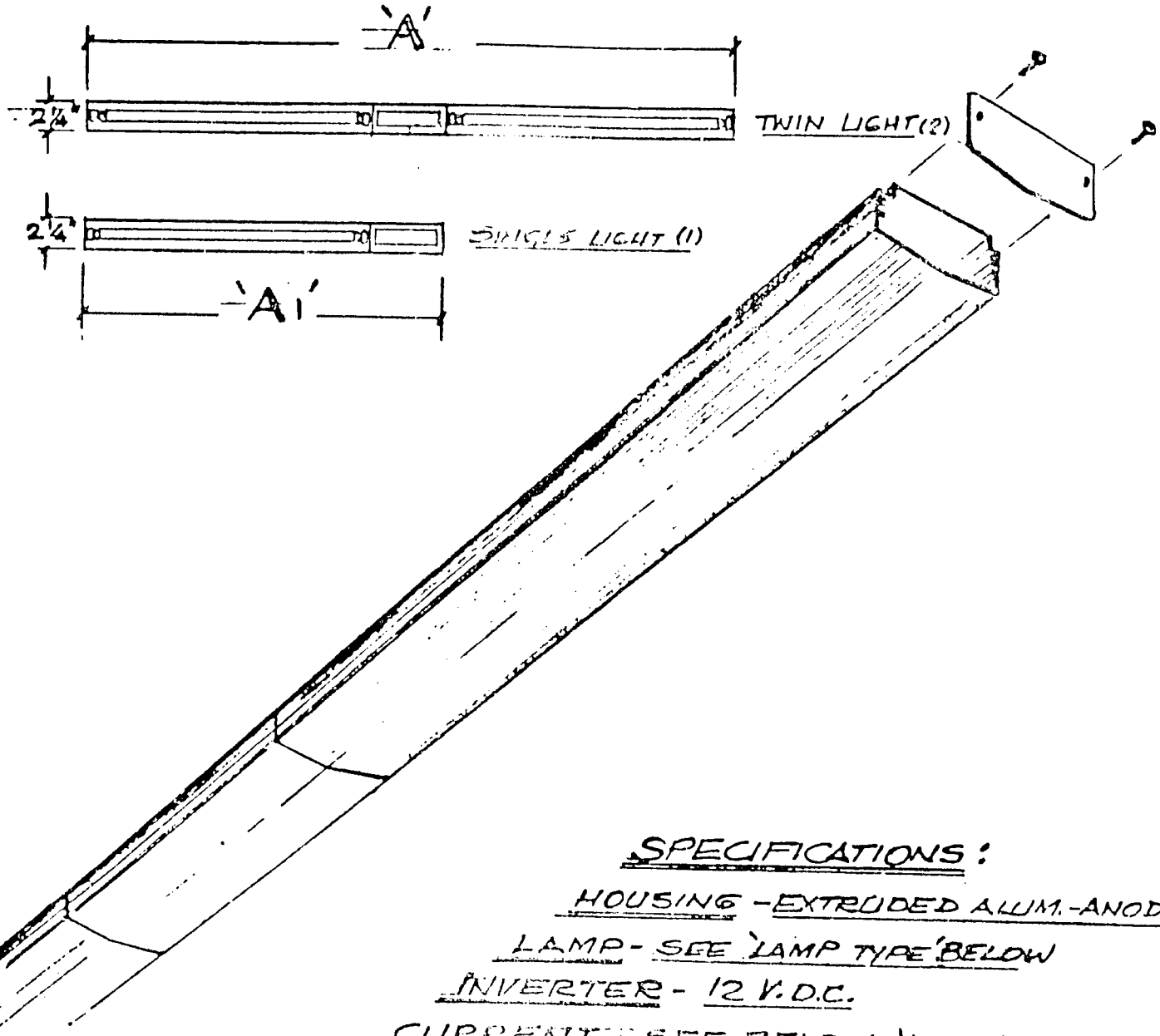
DASH Nº	OVERALL LENGTH	LAMP TYPE
-7	41 3/8	1-F30T8
—		
-5	29 3/8	1-F24"T8
-3	23 3/8	1-F15T8
-1	17 9/16	1-F8T5

REC SPECIALTIES

530 CONSTITUTION AVENUE
CAMARILLO, CA 93010, U.S.A.
(805) 987-5021

DWN. [illegible]
APPRV. REV. [illegible] 10/14/82
DATE: 8/8/75

CAT. NO. 140-
DWG. NO. 2-132 S



SPECIFICATIONS:

HOUSING - EXTRUDED ALUM.-ANODIZED

LAMP - SEE 'LAMP TYPE' BELOW

INVERTER - 12 V.D.C.

CURRENT - SEE BELOW - 'AMPS'

DIFFUSER - WHITE ACRYLIC

END - BLACK ABS PLASTIC

NOTE: DIMENSIONS 'A1' WITH SWITCH.

#174SP	48	—	(2) 18 WATT T5	1.9
#174	47.75	—	(2) 18 WATT T5	1.9
#173	—	26.75	(1) 13 WATT T5	1.1
#172	29.75	—	(2) 8 WATT T5	1.4
#171	—	17.87	(1) 8 WATT T5	.7
CAT. Nº	'A'	'A1'	LAMP TYPE	AMPS

REC

RECEIVED

530 CONSTITUTION AVE.
CAMARILLO, CA 93010
(805) 987-2021

DWN. [illegible] 1/1/93

APPR'V.

DATE

CAT. NO. 170 SERIES

DWG. NO.

10 CONSTITUTION AVENUE
CAMARILLO, C.A. 93010
U.S.A.
(805) 987-5021
TX: 662203 RECSPEC CAMA

REC SPECIALTIES, INC.
LEADERSHIP IN CREATIVE LIGHTING

FLUORESCENT TUBE (S)	RATED LAMP* LIFE (HRS)	RATED* LUMENS	MAXIMUM AMP DRAW AT 12.8VDC	LAMP* WATTS	FITS MODEL NUMBERS:
1 F4T5/CW	6,000	135	0.5	4	inverter ballast only
2 F4T5/CW	6,000	270	1.0	8	inverter ballast only
1 F6T5/CW	7,500	295	0.6	6	179
2 F6T5/CW	7,500	590	1.1	12	128TOP
1 F8T5/CW	7,500	400	0.8	8	101, 111, 141, 161, 171, 180, 711
2 F8T5/CW	7,500	800	1.9	16	112, 130, 162, 172, 712
1 F13T5/CW	7,500	820	1.5	13	102, 125, 131, 173
2 F13T5/CW	7,500	1640	2.2	26	126, 132, 174
2 F14T8/CW	9,000	1350	2.2	28	114
1 F15T8/CW	7,500	870	1.5	15	103, 115, 133, 143, 163, 190, 715
2 F15T8/CW	7,500	1740	2.2	30	116, 134, 716
1 F24"T8/CW	7,500	1175	1.8	18	145, 167
1 F20T12/CW	9,000	1250	1.8	20	104, 137, 151
2 F20T12/CW	9,000	2500	2.9	40	138
1 F30T8/CW	7,500	2200	2.2	30	105, 135, 147, 165, 175, 717
2 F30T8/CW	7,500	4400	4.4	60	136, 718
1 F40T12/CW	20,000	3150	3.3	40	106, 139, 153
2 F40T12/CW	20,000	6300	6.6	80	139-2
1 FC8T9/CW	12,000	1050	2.2	22	107, 109C, 109S
1 FC12T9/CW	12,000	1900	2.6	32	110

Ratings according to lamp manufacturers' 60 Hz data for CW lamps. Specifications subject to change without notice

SIMPLER SOLAR SYSTEMS, INC.

P.O. BOX 12936
TALLAHASSEE, FLORIDA 32317
PHOTOVOLTAICS DIV. (904) 385-5686/THERMAL DIV. (904) 5 SOLAR-1

****
SOLAR POWERED DOME LIGHT
****

(1) 36 watt Photovoltaic Panel (self regulating)

(1) D.C. Electronic Ballast FL7 Light Assembly
(equivalent to a 60 watt light bulb)

(1) Globe and Base Assembly

(1) 10ft. 2 1/2" Galvanized Conduit Pole

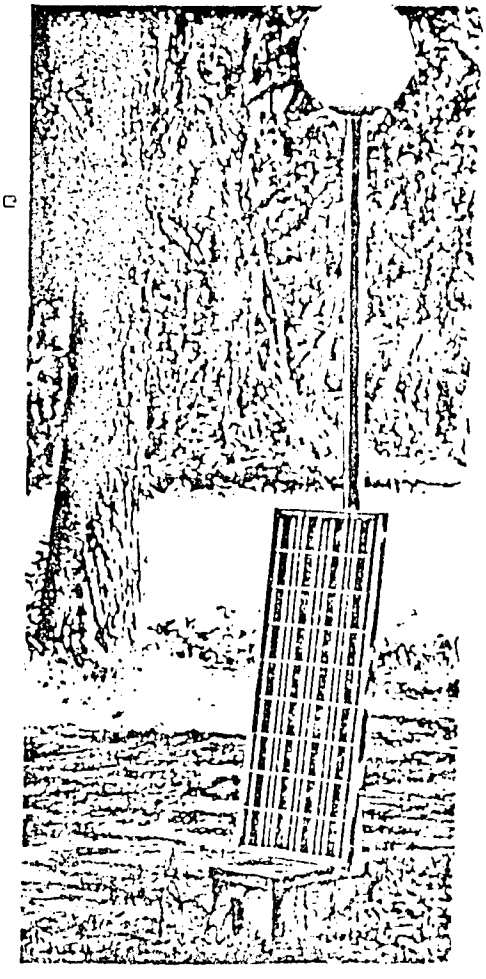
(1) 12V40 Recombination Chloride Battery

(1) Weatherproof Aluminum Battery Box

(1) Dusk to Dawn Electronic Sensing and Switching Circuit

	========
Total Package	$985.00
	========

NOTE: This solar powered light poleassembly can be locatedas far away as 80 ft. from the photovoltaic panel, and should use nothing smaller than 14/2 wire. This system needs no complicated voltage regulators, or any other circuitry to control the light from dusk to dawn. The battery storage is capable of lighting the light for approx. eight (8) days without sunshine. The recovery period is approx. three (3) days of lighting for every one full solar day.



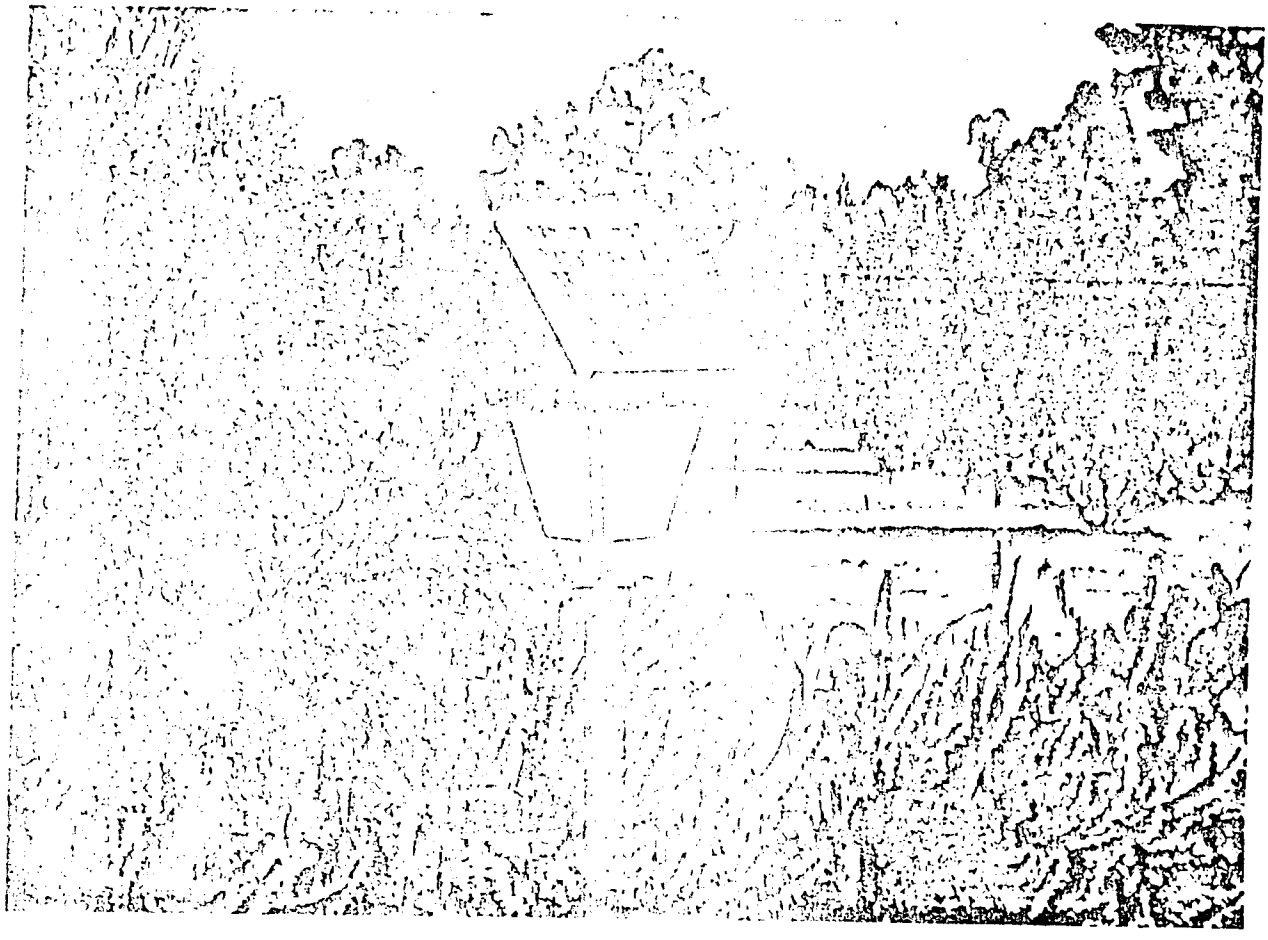
B0527

SOLAR ELECTRIC SYSTEMS
2995 44th Avenue North • St. Petersburg, Florida, U.S.A. 33714 • (813) 526-0793

introduces

THE LumaSTAR™ DELUXE LIGHT

LIGHT AT NIGHT FROM SUNLIGHT



- Light Every Night From Sunlight
- NO MORE COSTLY UTILITY BILLS
- TAX CREDIT ELIGIBLE
- Simple and Easy Installation Eliminates Digging Up Expensive Landscaping
- Installs in Minutes on any Standard 3-Inch Pole
- Maintenance Free
- Dependable Secure Operation for Years
- Durable Rust-Free All Aluminum Construction
- 100% Solid State Electronic Circuitry

LumaSTAR™ is energized directly from sunlight. The solar electric (photovoltaic) panel converts sunlight to electricity to charge an internal storage battery. LumaSTAR™ is automatic, it starts at sunset and runs up to 12 hours a night depending upon location and sunshine level.

Best under the sun.

ORDER FORM

SHIP TO:

Name _____

Address* _____

City _____ State _____

Zip _____ Phone ( ) _____

*Must have street address, cannot ship to P.O. Box

☐ MC ☐ VISA

Card # _____

Expiration Date _____

☐ Check. Check guarantee; Bank _____

Guarantee # _____

Model	Quantity	Cost
LumaSTAR™ Deluxe		$ 410.59
		$
		$
	Postage and Handling	$ 11.00
	TOTAL	$

Mail Order Form & Payment to:

Solar Electric Systems
2995 - 44th Avenue North
St. Petersburg, Florida 33714
(813) 526-0793

LumaSTAR™ THE LIGHT AT NIGHT FROM SUNLIGHT

FEATURES

- Dependable Light
- Eliminates Monthly Utility Bills
- Tax Credit Eligible
- Quick and Easy Installation
- Maintenance Free
- Durable Long Life Construction

VARIETY OF USES

- Home Lawns and Yards
- Sidewalks and Driveways
- Decks and Patios
- Swimming Pools and Gardens
- Marinas and Boat Docks
- Campgrounds and Beaches

SOLAR ELECTRIC SYSTEMS
2995 44th Avenue North • St. Petersburg, Florida, U.S.A. 33714 • (813) 526-0793

BULK RATE
U.S. POSTAGE
PAID
PERMIT # 195
PINELLAS PARK
FLORIDA

DEBORAH ESKINAZI
MERIDIAN CORP
5113 LEESBURG PIKE, SUITE 700
FALLS CHURCH VA 22041

Best under the sun.

SunAmp Systems Inc.

PHOTOVOLTAIC PRODUCTS

PHOTOVOLTAIC PRODUCTS, ASSOCIATED COMPONENTS & GENERATORS

Photovoltaic Modules

Mobil Solar
Kyocera International
Arco Solar

Regulators and Controls

PV Battery System Regulators - 12V and 24V
PV Battery System Junction Boxes - 12, 24, 48, 120V
Maximum Power Tracking Pump Controllers
Cathodic Protection Controllers

Batteries

SunAmp Systems Lead Acid Deep Cycle - 6V and 12V
Bulldog Battery
Gates, Panasonic, Mule, Dynamic Energy, Yuasa, Electrochem
Nife,
Globe

Battery Chargers

Bulldog
Lester
Custom Chargers

Inverters

Heart
Best
Tripplite
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International Power Machine
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Uninterruptible Power Supplies

SunResearch
Best Ferrups (TM)
Custom Systems

Cathodic Protection

SunAmp Systems Cathodic Protection Controllers & Full Systems

7702 East Gray Road Scottsdale, Arizona 85260 (602) 951-0699

Packaged & Custom Systems

Home Electric Systems, Stand Alone & Line Tie
Recreational Vehicle Electric Systems
Electric Boat Kit
SunLight Solar Yardlight
Swimming Pool Systems
DC Evaporative Cooler
Solar Water Pumping Systems

Appliances

DC Fluorescent Lights - REC, Iota
DC Refrigerators - Arctic Kold
DC Color TV
DC Evaporative Cooler

Miscellaneous

Module Mounts - Fixed and Tracking
Module Interconnects
Battery Interconnects
Bypass Diodes

02/85

SunAmp™ **SUNLIGHT.** A space age technology transfer product. Born to power satellites, solar cells are now being used for inexpensive, practical applications in the marketplace. What is this **SUNLIGHT?** It's a compact lighting system that captures a bit of the sun's *light* energy, converts it to *electrical* energy and stores it in a battery. A fluorescent light is turned on automatically at dusk. With fully charged batteries this light can be illuminated for at least eight hours each night.

"Dig a hole, plant a pole, attach the light and see tonight," describes the simplicity of installing the SunAmp™ **SUNLIGHT.** No extensive and expensive trenching for AC lines, no wire pulling through conduit, and no expensive electrician to do the work. Installation is a simple job.

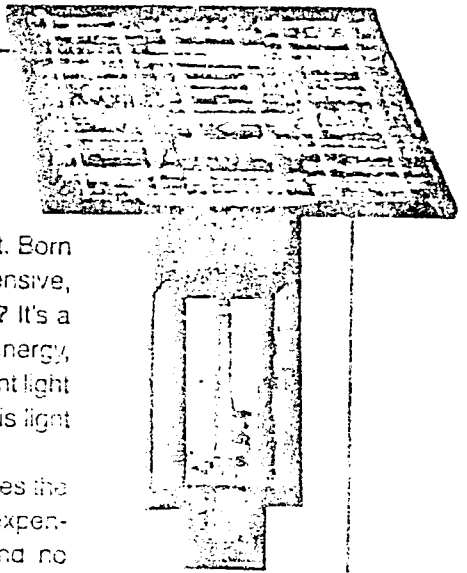
And don't fear the photovoltaic portion of the system. There's no need for complicated calculations. It's all done for you! The seven watt photovoltaic module, four watt fluorescent lamp and 12.5 ampere hour battery have been joined to give you at least eight hours of nighttime illumination. Of course, if clouds prevent full charge of the battery, the circuit automatically turns off the light to prevent battery damage.

The **SUNLIGHT** will:

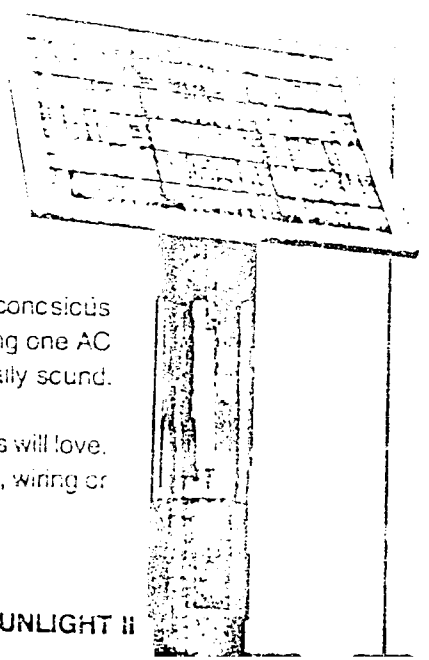
- rid the shadows in your back yard at night.
- outline your sidewalk.
- define your driveway.
- guide you and your boat to your boatdock.
- show your youth camp's nature trails.
- mark your fields if you farm at night.
- light your corral or barn.

Why a photovoltaically powered light? We're all energy conscious and replacing one energy wasting natural gas lamp or displacing one AC light helps our country's energy program. It is also economically sound. You'll save money! **SUNLIGHT** is just $495.

Dealers, here's a ready made photovoltaic unit your customers will love. A chance to enter solar electric without the bother of array sizing, wiring or other calculations inherent to home electric systems.



SUNLIGHT I



SUNLIGHT II

Yes, I would like **SUNLIGHT** at night. Enclosed is my check for _____. Please send **SUNLIGHT** model # _____ with complete installation instructions. You'll pay shipping.

Name _____ Title _____

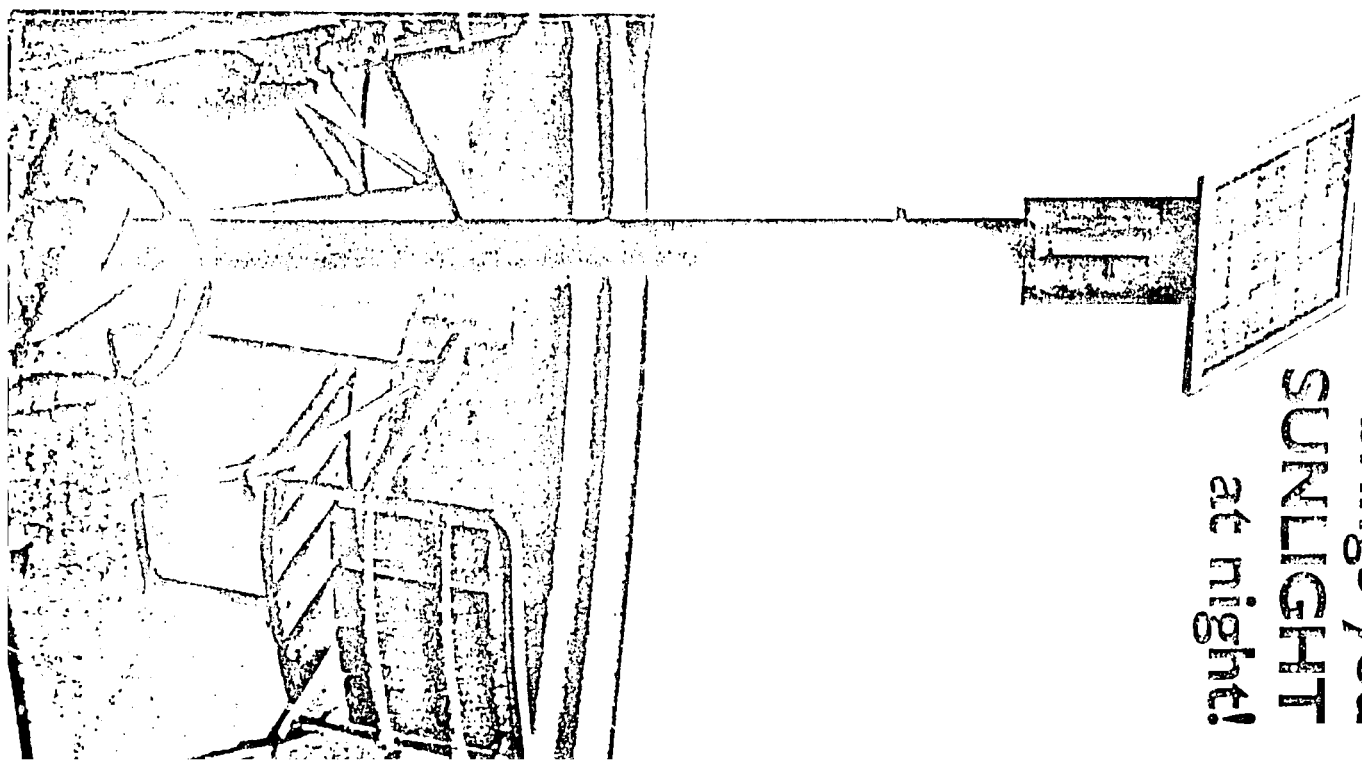
Company _____

Address _____

City _____ State _____ Zip _____

Please send me dealer information.

SunAmp Systems Inc.
7702 East Gray Road
Scottsdale, Arizona 85260

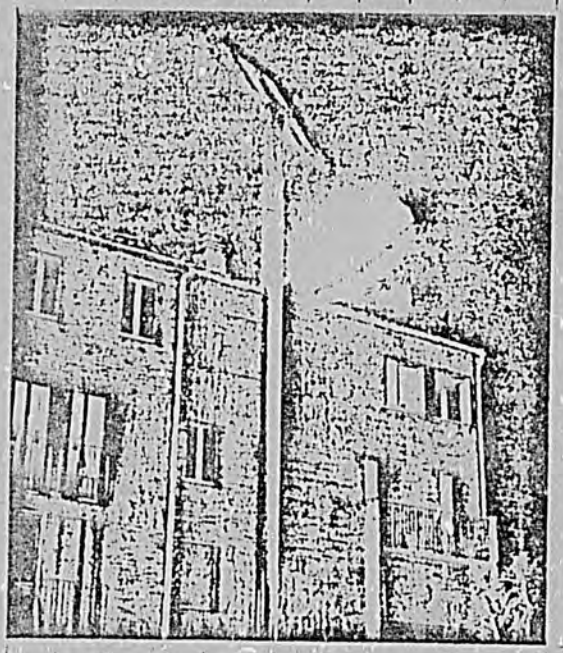


SunAmp Systems Inc.
7702 East Gray Road
Scottsdale, Arizona 85260
(602) 951-0699

Bob Rule
U.S. Postage Paid
Scottsdale, Arizona
Permit No. 524

Here

NOW USE THE SUN TO LIGHT THE NIGHT.



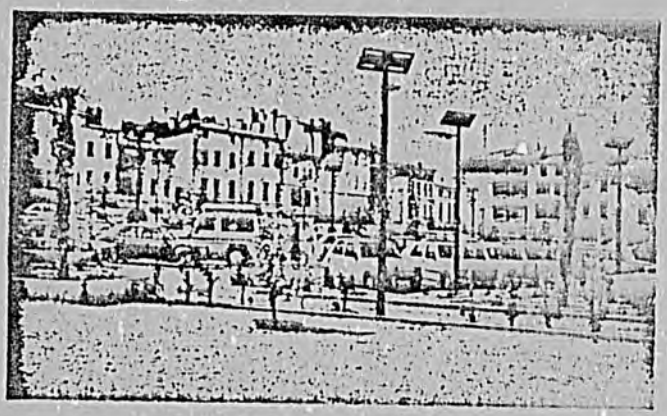
Introducing the Lumisol™ solar-powered area light for pathways, greenbelts, parks, driveways and other area lighting needs.

solec

A member of the Pilkington Group

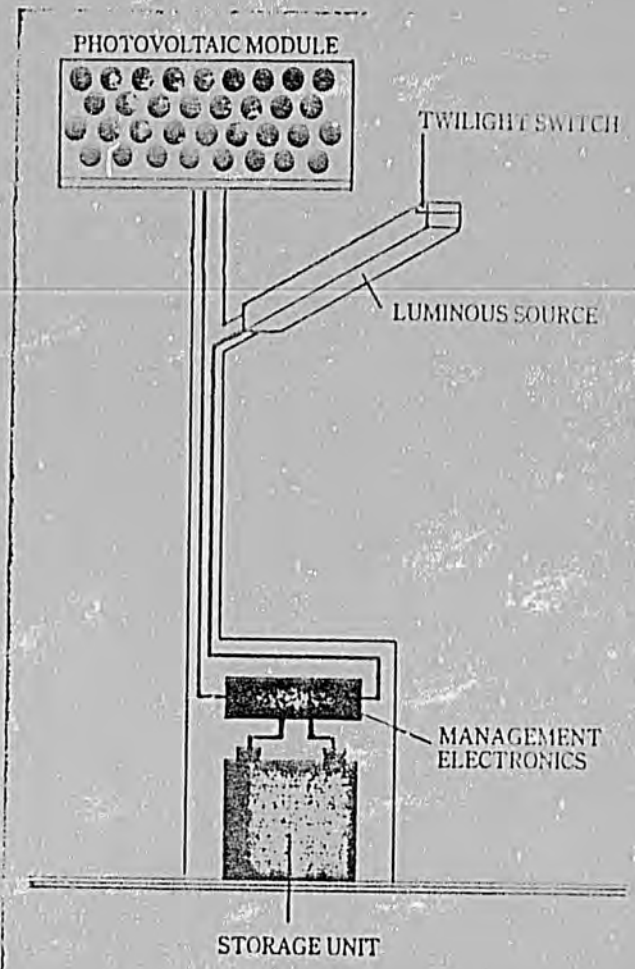
Why you should consider a solar-powered outdoor lighting system.

Solec's Lumisol is the first practical solar-powered system designed to meet today's municipal requirements for bright, reliable energy and cost-efficient lighting. It utilizes advanced low voltage lighting elements allowing maximum light with minimum energy consumption. It simply and directly applies the principles of photovoltaics and microelectronics, converting solar energy into electricity, which is stored in the system's batteries for delivery as needed at nightfall.



Easy to install, operates almost anywhere and requires no maintenance. It is completely self-contained and can be relocated as the lighting needs change.

Lumisol is a complete system, including photovoltaic modules, batteries, and charge controller with simple instructions for connecting the components. The luminous source consists of a fluorescent tube or low-pressure sodium lamp and bracket. The mechanical support is available in anodized aluminum or galvanized steel treated with polyester. It can be operated in regions receiving as little as 2,000 hours of direct sunlight per year. In places where temperatures drop below −10°C., optional battery protectors are available. Lumisol is virtually maintenance-free. To ensure constant, uninterrupted service rain or shine, the system is totally weatherproofed. Lumisol systems are ideal for locations difficult to access and supply with conventional electrical power.



Operating Principles

Lumisol solar lighting systems consist of 3 main elements:

— The Generator Unit — This incorporates the photovoltaic module. It is fixed on top of the mast, converting the sunlight to electricity.

— The Storage Unit — This consists of special maintenance-free photovoltaic batteries with a life expectancy of 4-5 years. Depending on equipment type, this unit is protected with a buried or above ground water tight box.

— Management Electronics — This has several functions which include:

- avoiding overvoltage on very sunny days
- avoiding any dangerous discharging that could damage batteries
- controlling floating of the batteries, in case they are completely charged and modules continue to produce energy
- ensuring the system's automatic on-off light switch
- managing lighting time either continuously or periodically

Lighting Performance

The main functions of any lighting equipment are lighting time and intensity. Lighting time of a solar lighting system is dependent upon the amount of sunlight energy that can be harnessed and stored.

Insulation varies according to location. Insulation also varies according to the day of the year. Despite these variables, Lumisol lighting equipment is designed and constructed to guarantee a predetermined amount of lighting time wherever it is used. Moreover, it ensures continued operation even in absence of sun.

Predetermined Lighting Time:

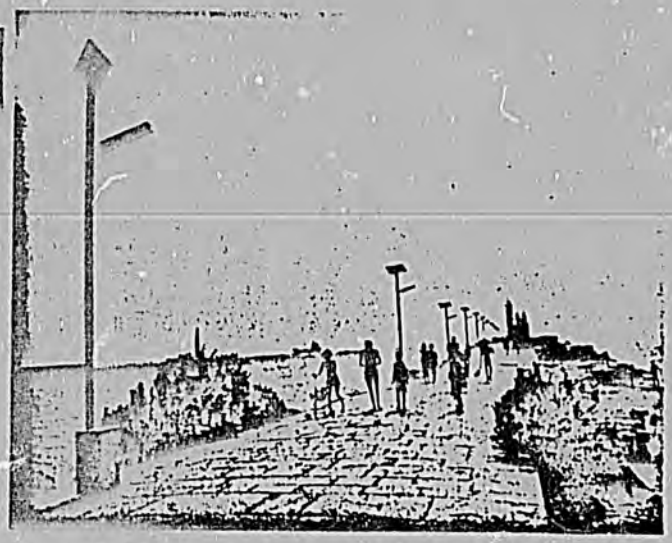
With fluorescent or monochromatic light, the Lumisol range includes about 5 types of equipment with different lighting performances. Very sophisticated management electronics allow the optimization of this performance according to the sun zone. A switch allows the user to choose between the continuous or sequential mode.

Lighting Intensity:

The lighting intensity output varies from 1100 to 3000 Lumens according to the lighting equipment type. Fluorescent and monochromatic lighting sources are available.

System characteristics

Lumisol systems are complete and autonomous. They do not require any special excavation work for installation. This eliminates prolonged rerouting of traffic or excavation programs. In the case of port sites, the use of Lumisol avoids construction of special embankments.



Easy Set Up:

Lumisol requires only a concrete foundation to set up. It allows the realization of a lighting project in simple steps without additional construction.

Maintenance-Free:

The charge regulation of the maintenance-free storage battery avoids the terminal sulphating and any check up of the electrolyte. The supply electronics of the Lumisol and the management electronics are completely encapsulated in epoxy resins ensuring a perfect tropicalization.

Built to Last:

Its simple and solid design confers to the Lumisol a resistance to winds in excess of 114 mph. Materials and treatments used (galvanized steel treated with polyester and anodized aluminum) ensure a good resistance in very harsh environments while meeting the aesthetic and easy integration necessities.

We'll help you put the sun to work in your town.

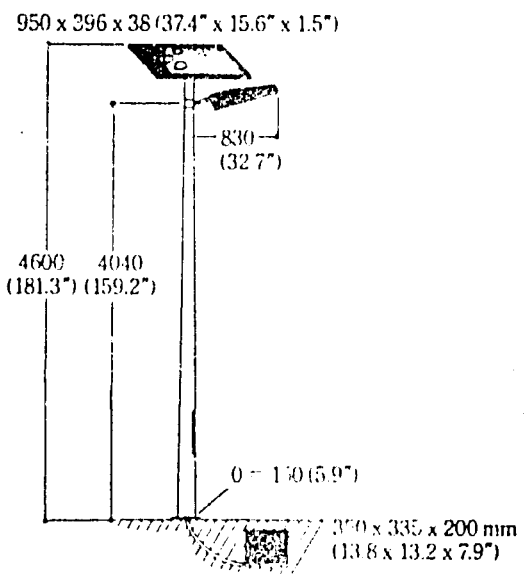
We are known around the world for our wide experience in developing bright ideas with the sun. The Solec Lumisol lighting system is another example of these ideas at work. Contact us today to find out how we can help you light your streets, your parks, your shopping centers. Lumisol's constant, dependable cost-efficient lighting will make for a safer, more desirable way of life.

MECHANICAL CHARACTERISTICS

Total Weight (without battery):	45 kgs (99 lbs)
Concrete Foundation:	600 x 600 x 600 mm (23.6 x 23.6 x 23.6")

TECHNICAL CHARACTERISTICS

Lighting intensity	1200 lumens
Lighting power	18 w
Voltage	12 v
Running temperatures	−10°C/+60°C
Storage capacity	105 Ah
Life expectancy of fluorescent tube	15,000 hours/20,000 cycles
Bracket type	Extruded aluminum
Mast type	Duralinox – Dark bronze anodization
Operating mode	Direct or sequential



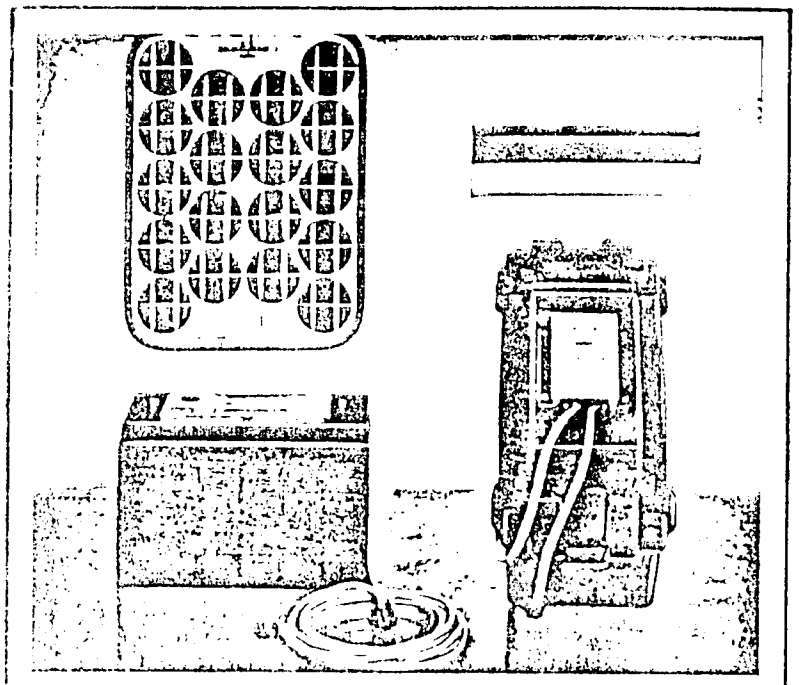
solec

One bright idea after another.

Solec International, Inc., a member of the Pilkington Group,
12533 Chadron Avenue, Hawthorne, CA 90250
Telephone: (213) 970-0065 TWX: 910-325 6215 Solec HWTH

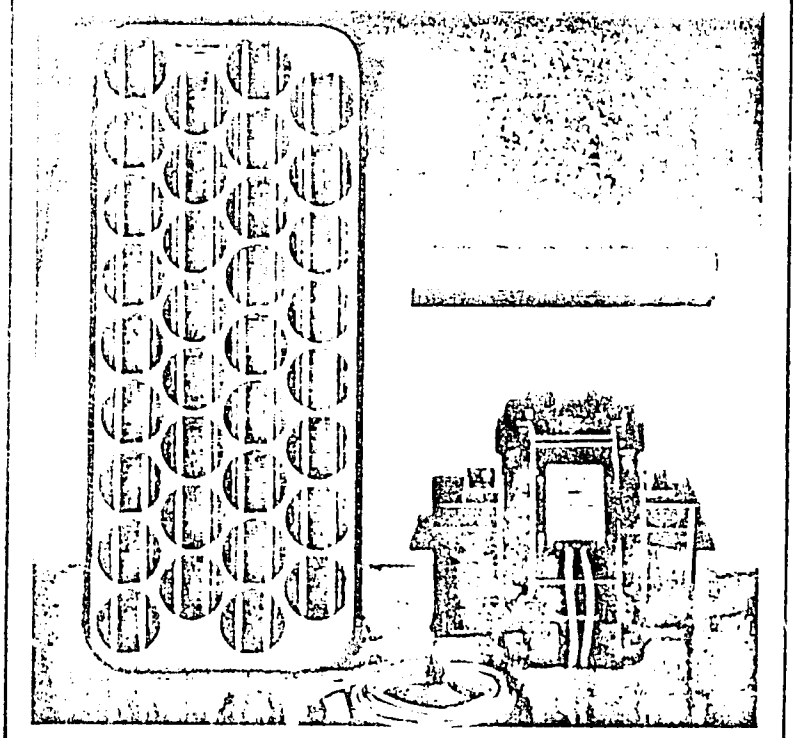
Solec's lighting systems are designed and constructed for ease of installation and reliable performance.

Lighting System CLS-1010
The CLS-1010 is an 8-watt fluorescent lighting system designed for lower power consumption and maximum lighting output.
All solec systems are fitted with polarized plugs, battery box, battery lugs, charge regulator, etc. to permit immediate installation of the light package.



Lighting System CLS-1030
The CLS-1030 is Solec's 30-watt lighting package that produces an equivalent light output to a 150-watt incandescent lamp.
Both the CLS-1010 and CLS-1030 systems utilize the modern tech., Tedlar™ front face and anodized aluminum backsheet Solarcharger. Because of its unique design and construction, it does not suffer from the same breaking and vandalism as other standard glass-front modules.

*Batteries are not included with lighting systems.



Lighting Systems

solec

Solec's Lighting System is a complete operating package. It allows an individual to assemble and install a solar lighting system quickly without the normal fears of connecting and splicing wires together. This system contains all the necessary components in order to set up your lighting package, including 20 feet of cable. Batteries can be obtained from a local supplier.

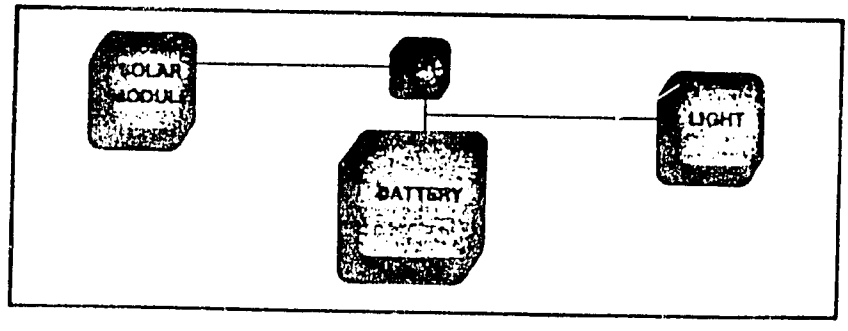
System Components

	CLS 1010	CLS 1030
Solar Module	M-1136	M-4134
Charge Regulator	SR-1202A	SR1202A
Fluorescent Lamp	REC-12-8 (8 watts, 0.7 amps)	REC-12-30 (30 watts, 1.9 amps)
Battery Box (polyethylene)	B-100 (9.2" x 18.1" x 10.4")	B-100
Battery* (recomm. 75-100 AH)	not incl.	not incl.
Wire	20'	20'
Weight	12 lbs.	18 lbs.

All necessary wire, plugs, and battery plugs which are required for installation are included inside the lighting system. (For further details, check other data sheets or see your local Solec dealer).

Hours of Operation

Solec's lighting systems will supply approximately 6 to 12 hours of light each day based on a fully charged battery. The two L.E.D. indicators located on the battery charger unit should be monitored in order to more accurately determine the number of operating hours. The "green" light denotes a fully charged battery. The "red" light signifies the battery is charging. At night, the green light means you are operating within the limits of the battery storage.



Data Sheet 600-5M-783* Solec International, Inc. 1983 Printed in U.S.A.

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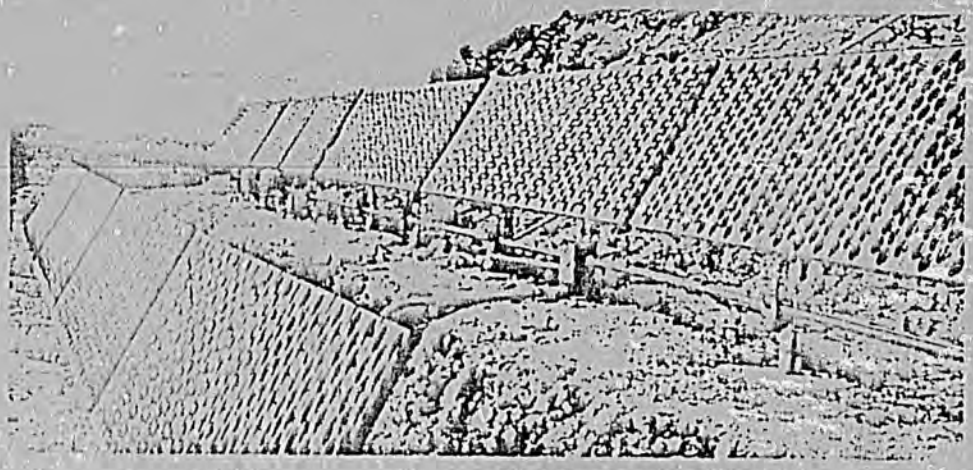
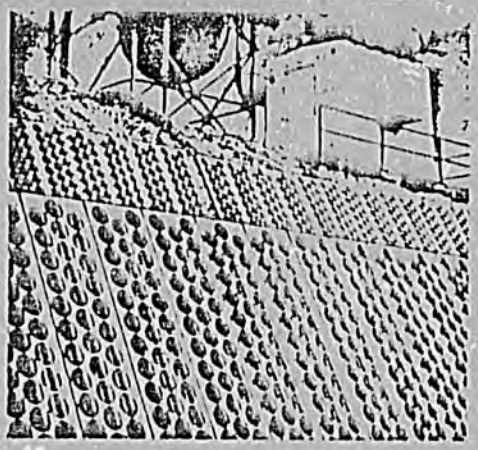
International, Inc
A Member of the Pilkington Group
12533 Chadron Avenue
Hawthorne, California 90250
Telephone (213) 970-0065
TWX 910-325-6215 SOLEC HWTH

solec

- *Remote sites*
- *Motor generator backup*
- *Rocky terrain*
- *Adjustable tilt angle*





Project Summary

Solec was requested by the United States Air Force to design photovoltaic power systems for two sites in eastern Nevada. The sites are located on rocky, remote hilltops, far from AC line power.

The sites were originally installed with motor generators. Since that time, fuel costs have risen significantly. And refueling is difficult at certain times of the year, due to bad weather and unimproved roads. The requirement, then, was to design a photovoltaic system that would carry nearly all the load, reducing motor generator operation to a minimum.

Power Requirement

When operating, each site has a continuous power consumption of 750 watts: 31.25 amps at a nominal 24 volts DC. The sites operate on slightly different duty cycles. Site A consumes an average of about 500 ampere hours per day, while Site B takes about 430 ampere hours.

Storage Requirement

The customer requested a battery storage capacity equal to five days operation under worst-case (24 hr/day) conditions. In addition, the motor generators would serve as contingency storage, running at infrequent intervals to completely recharge the batteries when terminal voltage falls below a certain level. To prolong generator service life, the generator would need to run for several hours each time, to avoid "short-cycling." Therefore, the battery had to be large enough to absorb several hours of output from the motor generator.

Mounting

The sites are remote hilltops in eastern Nevada, one at 7000 feet, the other at 8200 feet. The terrain is uneven, consisting of loose rock on top of fractured rock layers.

Blasting into the rock was not feasible, because of possible damage to the electronic equipment and motor generators. This limited the amount of excavation and called for a special type of solar array mounting structure.

System Sizing

This was not an ordinary system to design. Most photovoltaic systems are intended to provide 100% of the load, year round, with near-absolute certainty. Therefore most photovoltaic systems include a moderate amount of "oversizing," to allow for conversion efficiencies, cloudy weather, and seasonal variations in sunlight. Typical stand-alone systems have solar arrays and storage batteries large enough to cope with the worst expected winter. They also have excess power during summer months.

This customer intended to have the photovoltaic system carry 100% of the load in Spring, Summer, and Fall, but only provide 80% of the load in Winter. The balance would be carried by the motor generators, which would be needed about 5-7 times per year. In a severe winter, the generators might run once every three weeks.

Design Solution: A Unique Subarray

Solec engineers developed a new configuration of their standard mounting hardware. The new subarray holds seven of the type S4611 modules, each conservatively rated to provide 55 peak watts: 11.1 amps at 4.9 volts. Each subarray, then, can provide 381 peak watts: 11.1 amps at 34.3 VDC.

Site A required eleven subarrays connected in parallel, for a peak power of 4188 peak watts: 122.1 amps @ 34.3 volts DC. Site B, with its lesser duty cycle, required nine subarrays, for a peak power of 3427 watts: 99.9 amps @ 34.3 VDC.

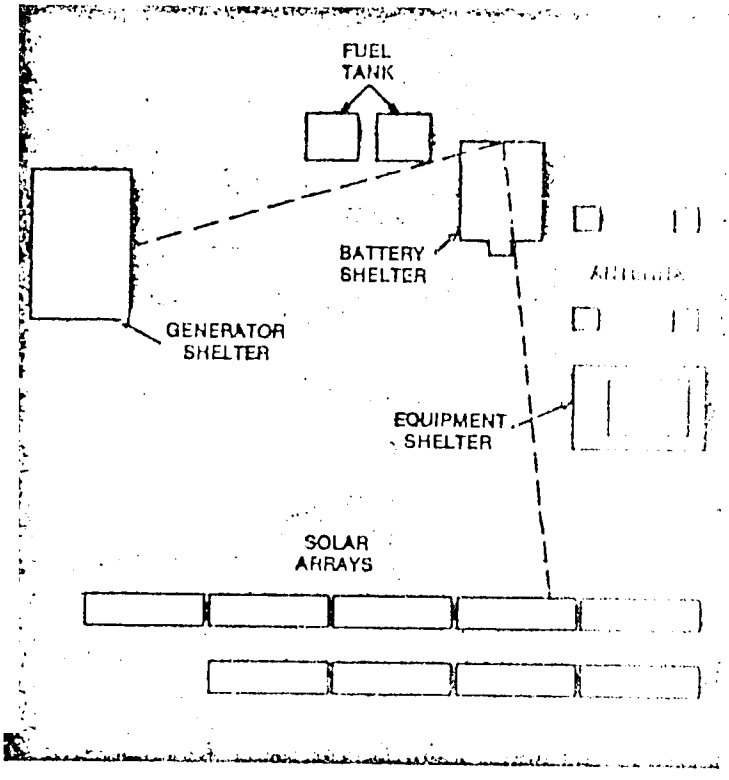
The new mounting structures are very simple. The modules bolt to a horizontal "backbone"—an aluminum U-channel—which in turn clamps to a horizontal pipe. The clamps have multiple attachment points, allowing the modules to rotate around the horizontal pipe for tilt angle changes.

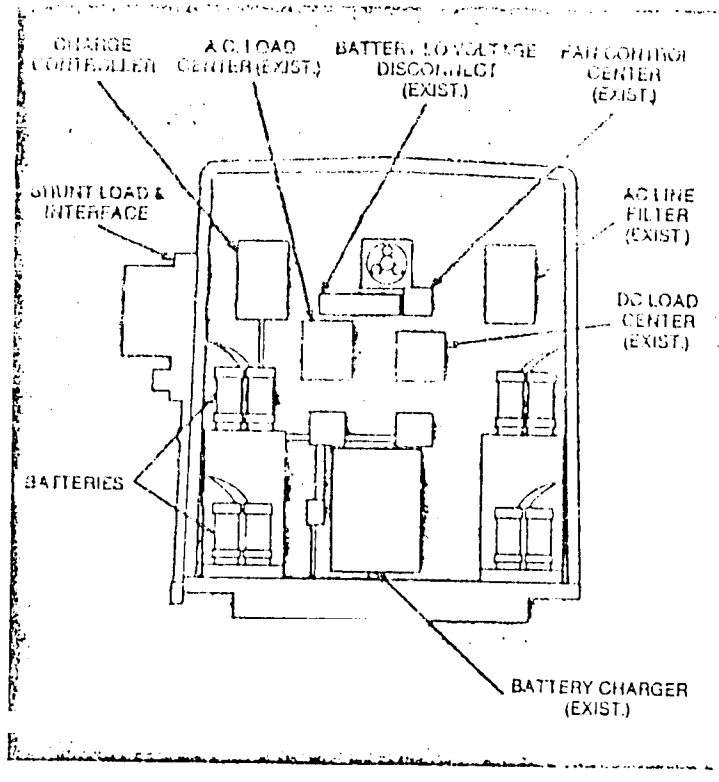
Both sites have battery storage capacity of 4000 ampere hours at 24 VDC. Each site has 96 cells (2V, 500 AH each), arranged 12 in series by 8 in parallel.

The Net Result:

To date, the Solec systems have met or exceeded all their design goals. Solar power output has been better than the specified minimum, and the controls have worked reliably, interfacing well with the customer's existing monitor and control system.

116





Specifications

	Site A	Site B
Power Consumption		
Nominal voltage	24 VDC	24 VDC
Peak current drain	31.25 Amps	31.25 Amps
Average amp hours/day	500	430
Solar Array		
Nominal voltage	24 VDC	24 VDC
Peak power voltage	34.3 VDC	34.3 VDC
Current @ peak power	122.1 Amps	93.9 Amps
Number of subarrays	11	9
Modules per subarray	7	7
Solar Modules		
Total required	77	63
Peak power voltage, each	4.9 VDC	4.9 VDC
Current @ peak power	11.1 Amps	11.1 Amps
Storage Battery System		
Cells in series	12	12
Cells in parallel	8	8
Amp hours per cell	500	500
Total Amp Hours	4000	4000

What about your system?

These two installations were specially built for a particular customer. However, the components and subsystems are part of our standard range of products.

For example, the subarray design can be used for any rocky site. And the control interface is adaptable to a wide variety of customer needs.

We invite you to call or write us today with your remote power needs.

Solec International, Inc.
12533 Chadron Avenue
Hawthorne, California 90250
(213) 970-0065
TWX: 910-325-6215 SOLEC HWTH

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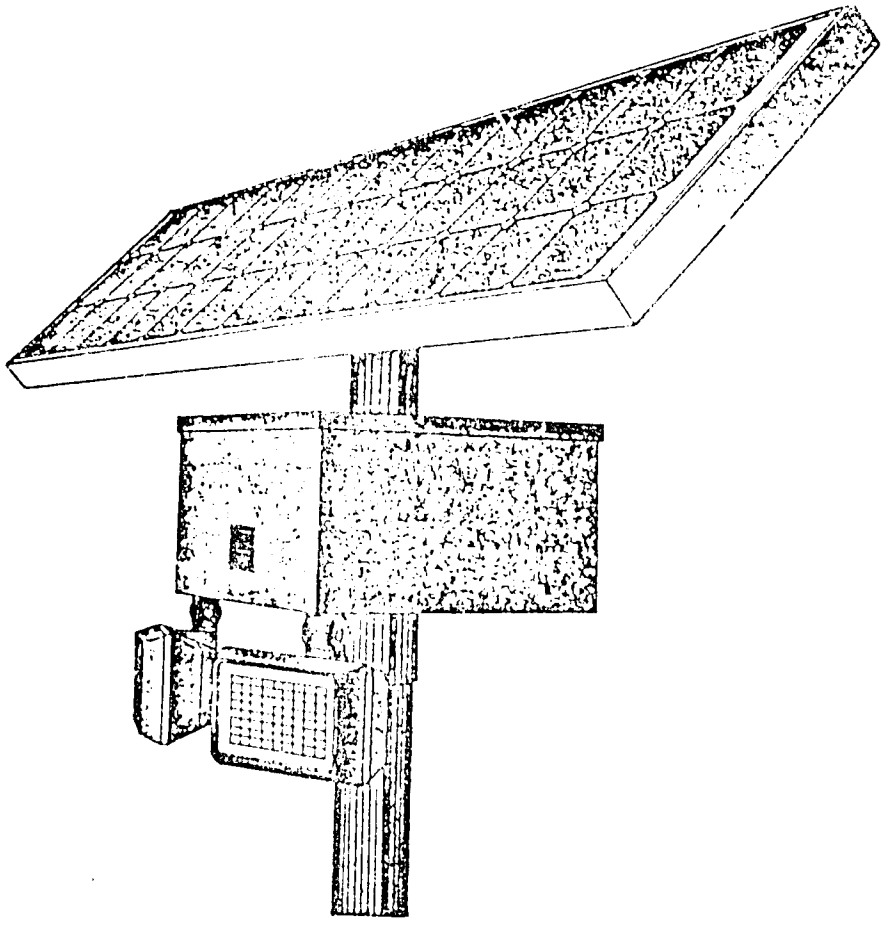
1stWATCH II SOLAR SECURITY LIGHT



AFFORDABLE, PORTABLE SECURITY

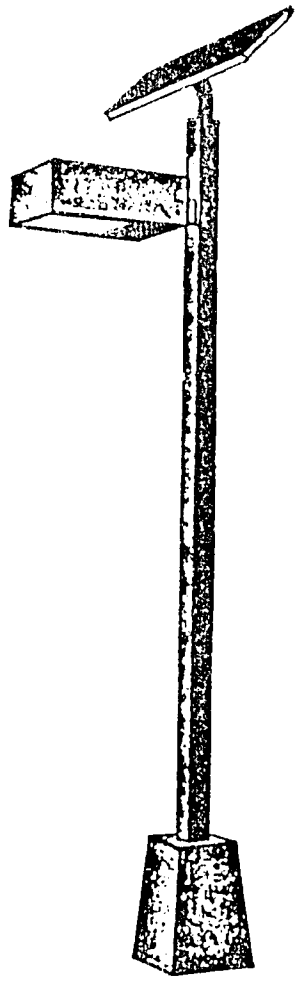
The IstWatch II Solar Security Light is a security system designed especially for the needs of business in protecting property and people. It uses a passive infra-red sensor to detect the presence of persons or automobiles, and then automatically turns on two sealed-beam halogen floodlights to light the area. The lights stay on as long as the intruder is within the 80° field of view up to 40 feet away, and turns off a short time after he leaves.

Because the IstWatch II Solar Security Light gets its power from the sun, it has an endless supply of FREE energy. No wiring is needed to install the light, so it can be placed at critical locations as long as the sun shines on the IstWatch II through the day.

Let IstWatch II protect your business with all-night automatic security lighting.

TEXAS HILIGHT, INC. P.O. BOX 3366 EVERGREEN, CO 80439 (303) 526-0217

1stSTAR II SOLAR LIGHTING SYSTEM



SIMPLE, ECONOMICAL AREA LIGHTING

The 1stStarII Solar Lighting System is a practical, affordable lighting package for commercial applications in parking lots, streets, storage areas, and outdoor activity areas. The system has independent power, needs no wiring, and can be installed by your own trained personnel.

The 1stStarII commercial lighting system uses very efficient low pressure sodium lamps for illumination. Four models are offered, with options for all-night operation and for the area covered by each unit. Once installed, the units need little maintenance and use FREE power from the sun.

TEXAS HILIGHT, INC. P.O.BOX 3366 EVERGREEN, CO 80439 (303) 526-0217

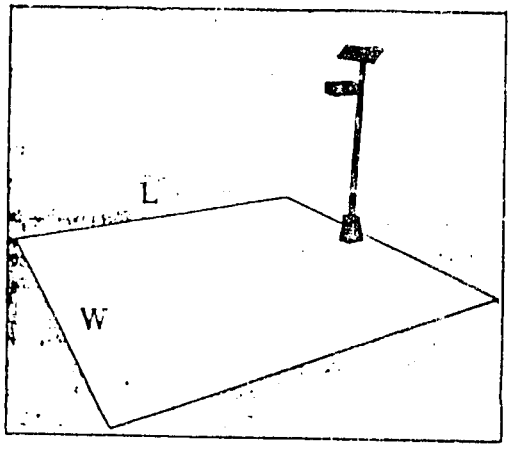
1stSTAR II SOLAR LIGHTING SYSTEM

FEATURES

- -Low pressure sodium lamps for efficient lighting
- -Reliable photovoltaic power supply
- -Simple, easy installation
- -No external wiring required
- -No digging or trenching required for hook-up
- -Three day battery backup for cloudy days
- -Light turns on automatically at dusk
- -Little maintenance required
- -One year limited warranty

MODELS

	Lamp Type	Lumens Output	Operating Time	Coverage L	W	Area
THL3001	10W LPS	1000	6 hours	25ft	25ft	625ft^2
THL3002	10W LPS	1000	All night	25ft	25ft	625ft^2
THL3101	18W LPS	1800	6 hours	30ft	30ft	900ft^2
THL3102	18W LPS	1800	All night	30ft	30ft	900ft^2



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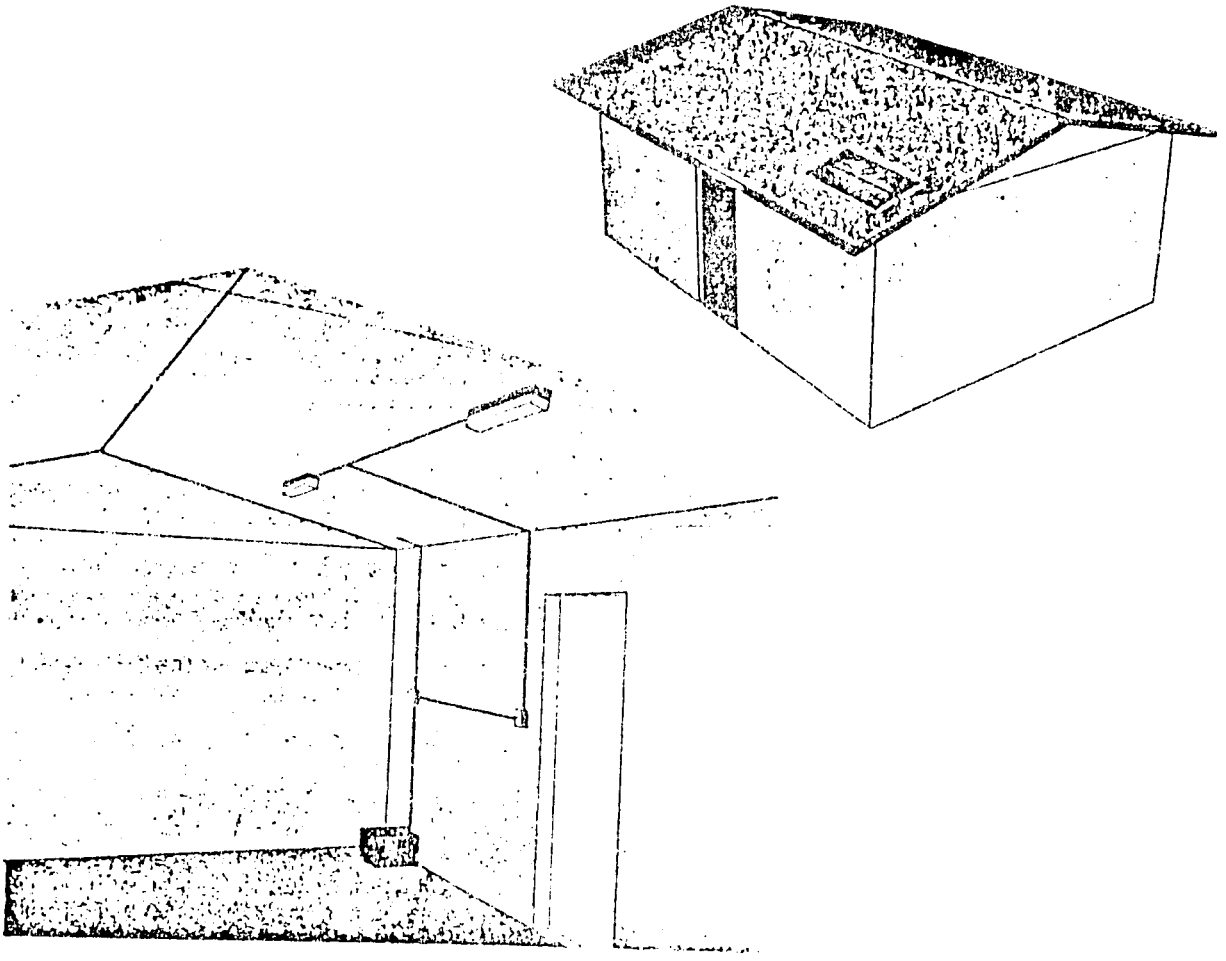
RESIDENTIAL SOLAR LIGHTING SYSTEM



ECONOMY, DEPENDABILITY.

The THL-400 residential solar lighting system provides reliable, independent lighting and power for remote or seasonal residences. The package includes the latest in solar photovoltaic panels for producing electricity from sunlight. Batteries are used to store the electric power generated during daylight hours for use at night. This storage capacity will hold enough power to supply the household needs for up to four days of cloudy weather.

The THL-400 residential solar lighting system uses efficient fluorescent lamps to light up the night in your home. Two 20-watt weatherproof fixtures are provided, suitable for mounting indoors or outdoors. Connections are available for operating small television, radio, or cassette player.

Let the THL-400 system provide safe, reliable light and power for your remote or vacation home.

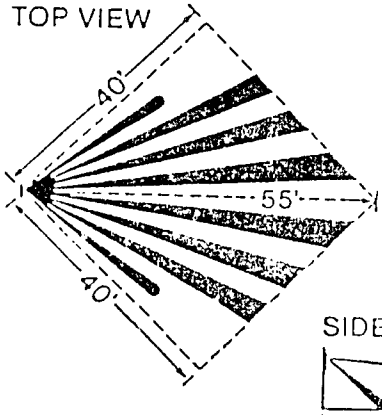
TEXAS HILIGHT, INC. P.O.BOX 3366 EVERGREEN, CO 80439 (303) 526-0217

SOLAR SECURITY LIGHTING SYSTEMS

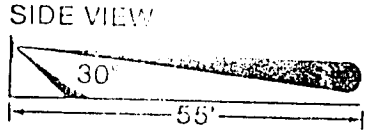
FEATURES

- Passive infrared sensor for intrusion detection
- Halogen spotlights for bright area lighting
- Reliable photovoltaic power system - no wiring required
- Three-day battery back-up for cloudy days
- Adjustable sensitivity to minimize false alarms
- Adjustable on-time for lights after intruder leaves
- Fully adjustable sensor aiming
- Wide range of lighting options
- Simple installation, no permits required

PASSIVE INFRARED INTRUSION DETECTION



PIR intrusion detectors work by sensing changes in temperature as an object, such as a person, moves across background temperatures. The passive infrared sensor is similar to a video camera, but recognizes heat instead of light. When the infrared heat picture changes, the sensor alarms and the spotlights are turned on.

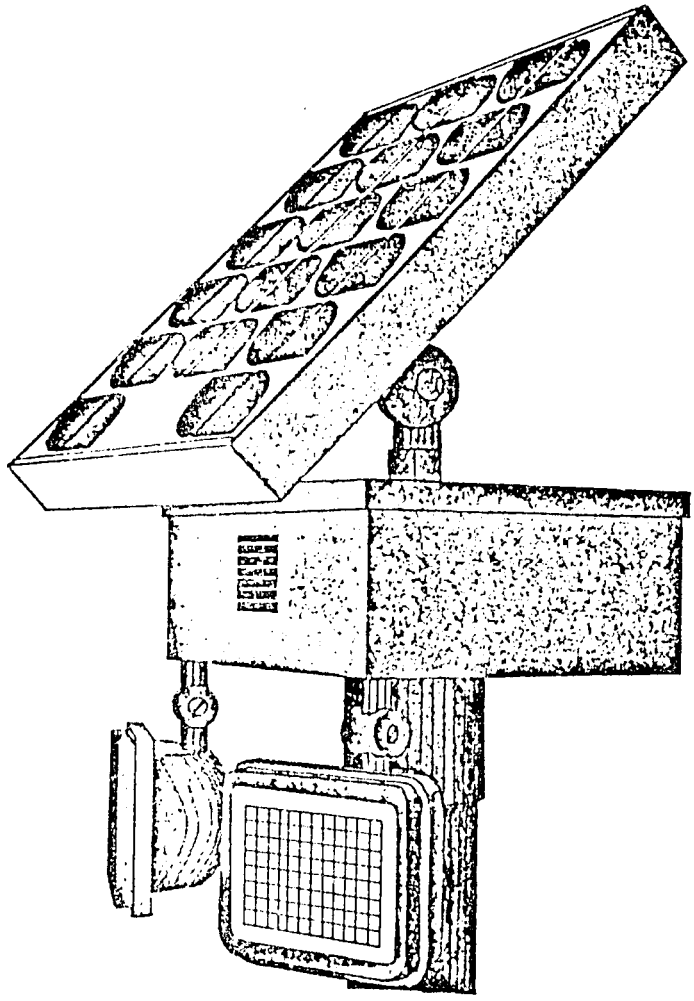


MODELS

	Lamp Size	Total Candlepower	Operating Time/Night
IstWatch	2x5 watts	1,600 CP	3 hours
	2x12 watts	4,000 CP	1 hour
	2x20 watts	7,200 CP	40 mins.
IstWatch II	2x55 watts	19,000 CP	1 hour

TEXAS HILIGHT, INC. P.O.BOX 3366 EVERGREEN, CO 80439 (303) 526-0217

1stWATCH SOLAR SECURITY LIGHT



ECONOMY, SIMPLICITY, SECURITY.

The IstWatch Solar Security Light is an all-night security/convenience lighting system. It uses a passive infra-red sensor to detect the presence of people, automobiles, or other large moving objects, and then automatically turns on two halogen floodlights. The lights stay on as long as the person is within the 80° field of view up to 40 feet away.

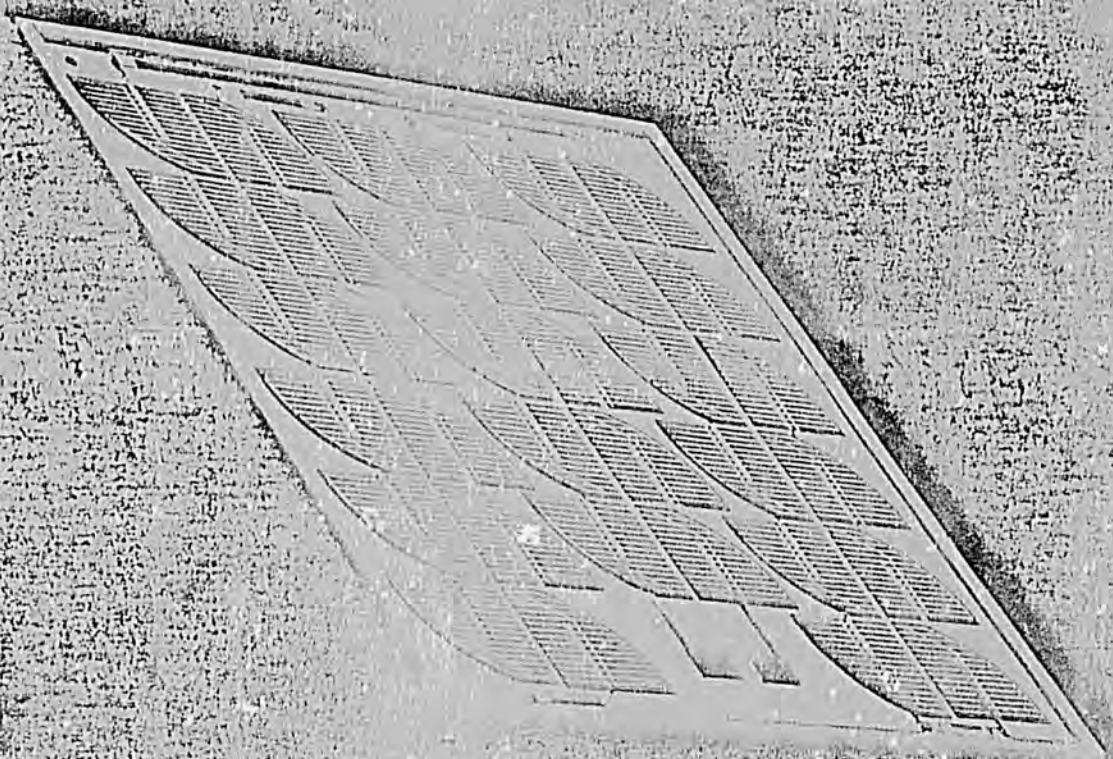
Because the IstWatch Solar Security Light gets its power from the sun, it has an endless supply of FREE energy. No wiring is needed to install the light, so it can be located anyplace where the sun shines clearly throughout the day.

Let IstWatch provide all-night, year-round security for you and your family.

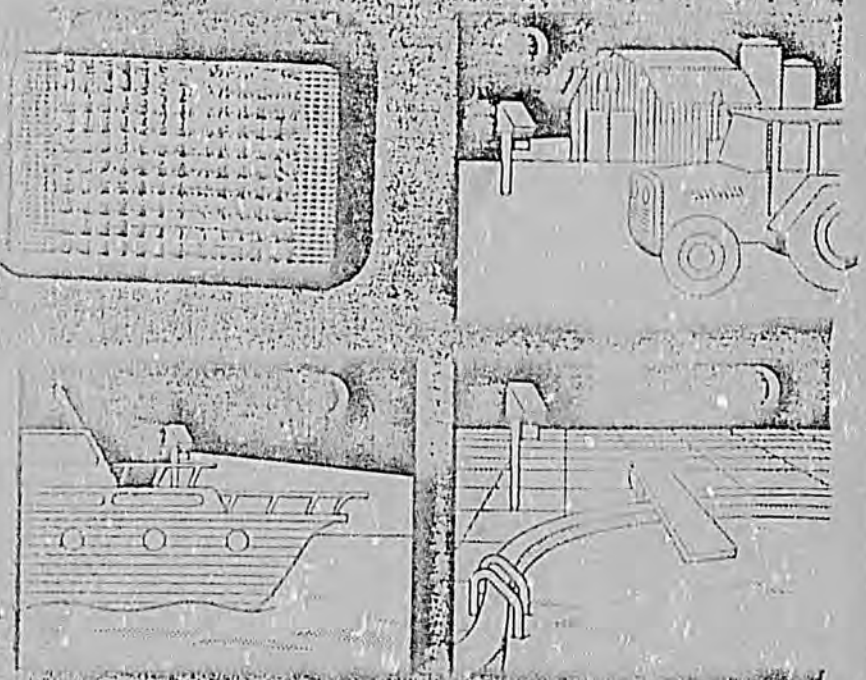
TEXAS HILIGHT, INC. P.O.BOX 3366 EVERGREEN, CO 80439 (303) 526-0217

1st Star™

Solar Powered Outdoor Light



- No consumption supply of energy
- Very maintenance
- Location Flexibility, absolutely no wiring is required to install and operate
- No operation costs
- Eliminates danger of electrical shock or fire
- Security of independent power year round
- Illumination light totally flexible
- Replace bulbs or fixtures without tools or detaching
- Automatically priced
- Has qualified for the federal and state tax credit



Model THL 1000

1st Star™ Solar Powered Outdoor Light

© Copyright 1984 Patent Pending

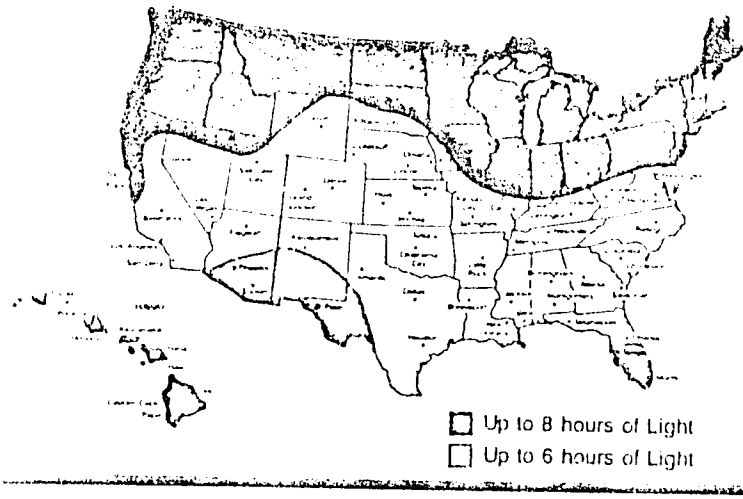
1st STAR OUTDOOR LIGHT OFFERS YOU THE LATEST IN SOLAR TECHNOLOGY to provide light in areas of darkness for up to 8 hours every night. At sunrise, 1st STAR photovoltaic panels begin to generate solar electricity and charge the battery. At sunset, the light automatically turns on with the energy stored in the battery. The design of 1st STAR's structure was guided by simplicity, function, and durability. Here the photovoltaic module, light, battery, and associated electronics are housed in one enclosure made of aluminum. This enclosure is designed to position the array at a 45 degree angle and may be attached to an eight foot yard lamp pole made of galvanized steel, or may be mounted to any structure, as long as the array is facing south. The light, however, may be turned in any direction to illuminate desired areas. **Unobstructed solar access is critical.** Therefore, careful site selection is vitally important.

1st STAR modules should be situated so that they will receive maximum exposure to direct sunlight for the longest possible time each day. Installation requires only a concrete foundation. Because wiring excavation expenses are eliminated, 1st STAR lights can be easily relocated as your lighting needs change. 1st STAR outdoor light is attractive, simple and acceptable for any decor or environment.

APPLICATIONS:
FROM PUBLIC INSTALLATIONS TO RECREATIONAL FACILITIES, TO YOUR OWN BACK YARD!

1. Residential applications such as patios, decks, driveways, yards, sidewalks, flower gardens, fountains, or storage sheds.
2. Recreational facilities such as boats, boat docks, camp or picnic grounds, remote cabins, parks, tennis courts, golf courses, swimming pools, amusements parks, beaches & resorts, RV's.
3. Agricultural applications such as barns, livestock holding areas, greenhouses, feed lots and storage facilities.
4. Industrial and commercial uses such as construction sites, security lighting for warehouses, oil derricks, telephone booths, bill boards, sign posts on highways and detours, railroad crossings and other dangerous intersections, public driveways, fire hydrants, school yards, and playgrounds.
5. Emergency lighting for remote medical clinics, emergency exits, high crime districts, alleyways, emergency equipment and escape routes.
6. Navigational and aviation facilities such as remote landing strips, beacons, bus stops, channel markers, and lighthouses.

Areas Within Which 1st STAR™ Operates Efficiently



SPECIFICATIONS

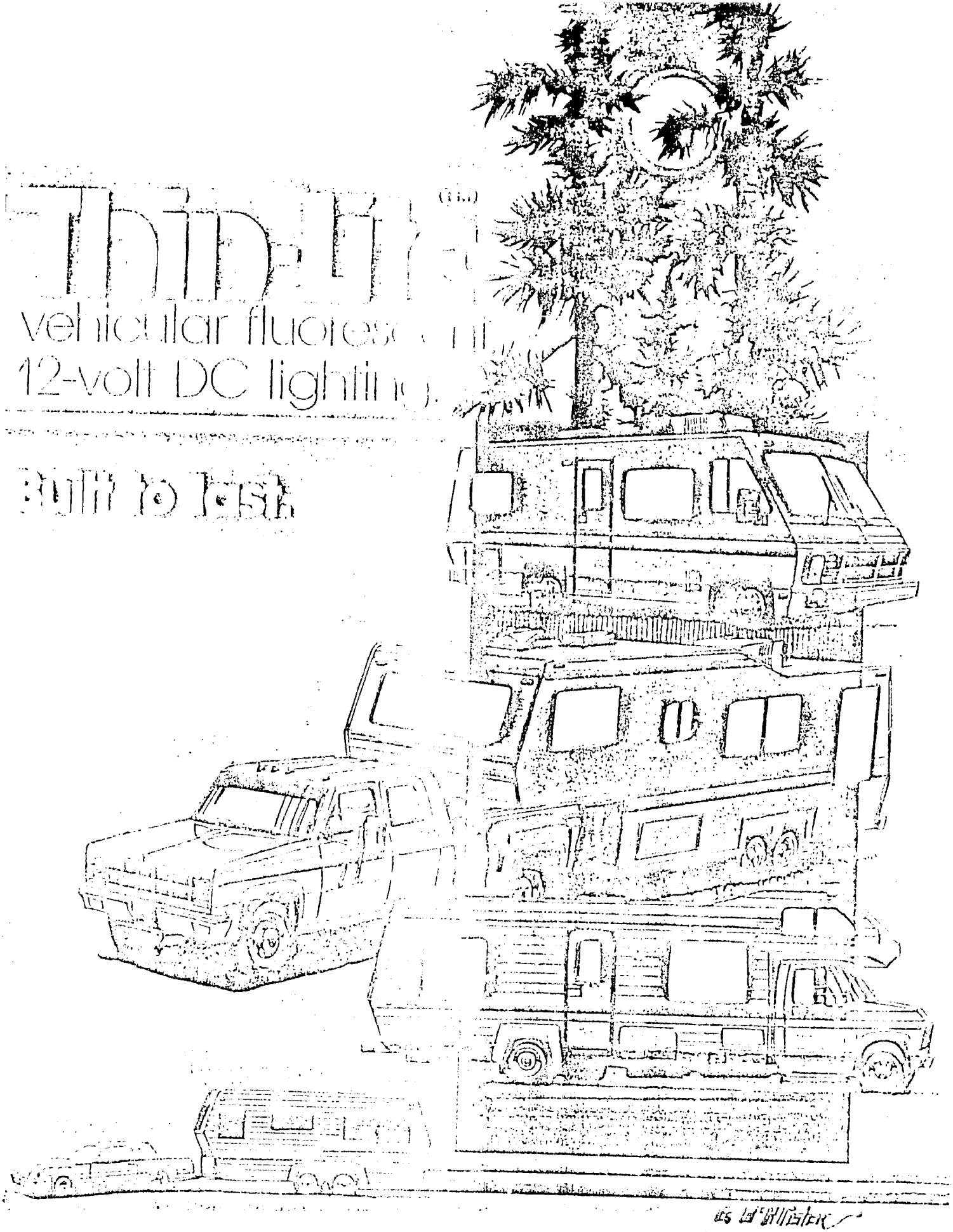
Operating Voltage	12 Volts
Photovoltaic Module - THL #M-87	7½ Watts
Photovoltaic Single cell crystal silicon	
Halogen Lamp - THL #S 2076	5 Watts
Daily Light Duration	8 Hours
Light Output	40 Candle Power, 500 Lumens
Battery - THL #12V12	12 Volt rechargable with 4 day storage
Weight of Battery	10¾ lbs.
Weight of unit without Battery	5¾ lbs.
Control-Solid State tuning with low charge protection	
Housing-Powder-painted aluminum	
Unit Dimensions	Height - 13¼", Width - 12⅛", Depth - 11¾"
Shipping Weight	16.5 lbs.
Box dimensions	16¼" x 16¼" x 16¼"

1 Year Limited Warranty

Texas HiLight, Inc. warrants this 1st Star™ outdoor light against any defects in materials or workmanship within one (1) year from the date of purchase. It will be replaced or repaired at the discretion of Texas HiLight, Inc.

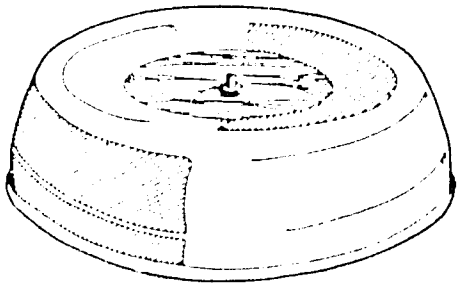
Texas HiLight, Inc.
P.O. Box 3366
Evergreen, Colorado 80439
303-526-0217

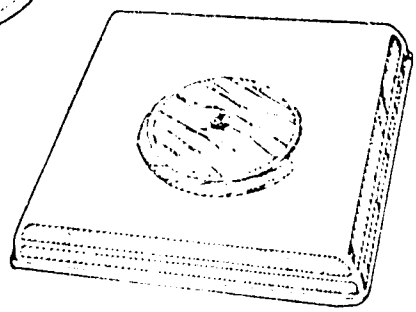
A wholly owned subsidary of Texas HiTech, Inc., Oklahoma City, OK.

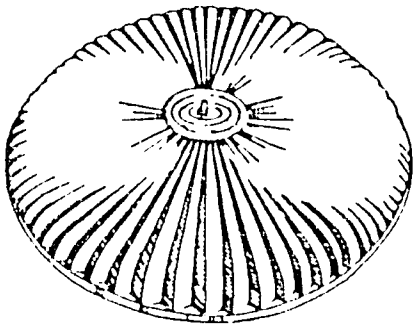

Thin-Lite
vehicular fluorescent
12-volt DC lighting.
Built to last.

When it comes to lighting, nobody does it brighter

Thin-Lites by REC Specialties, Inc., are all U.L. Listed and easy to install. All *Vehicular* lights feature all-metal housings, with non-yellowing acrylic lenses. A baked, white enamel finish, along with attractive woodgrain trim, complete the long-lasting fixtures, warranted for two years. All Thin-Lites include standard fluorescent tubes, powered by REC's highly efficient inverter ballast.



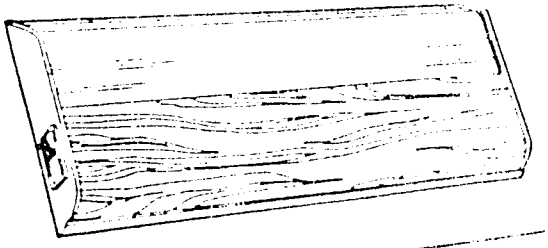


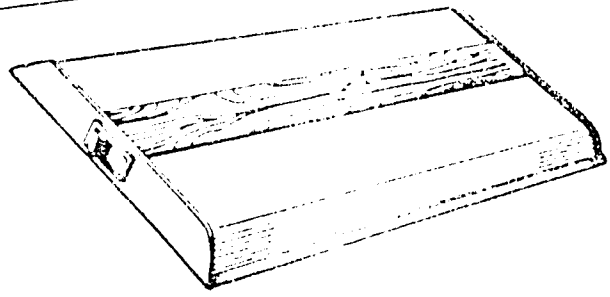


109C 22 watt 12VDC circline 9½" diameter x 1½" deep, 1.8 amps. Uses one FC8T9/CW fluorescent tube. Light output: 1100 lumens

109S 22 watt 12VDC circline 9½" square x 1½" deep, 1.8 amps. Uses one FC8T9/CW fluorescent tube. Light output: 1100 lumens

110 32 watt 12VDC circline 13¼" diameter x 2¼" deep, 2.1 amps. Use one F12T9C/W fluorescent tube. Light output 1900 lumens.





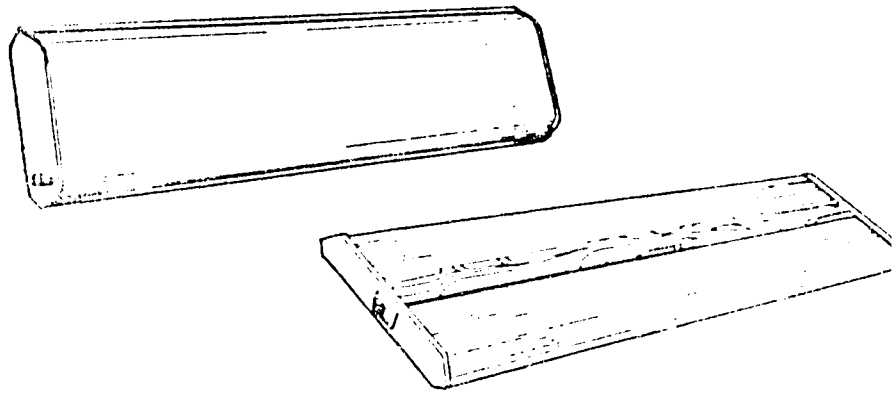
111 8 watt 12VDC light 12" x 4" x 1" thin; 0.7 amps. Uses one F8T5/CW fluorescent tube. Light output: 400 lumens

112 16 watt 12VDC 1.6 amps 12" x 5½" x 1" thin. Uses two F8T5/CW fluorescent tubes. Light output: 800 lumens

180 Dimensionally the same as model 112. Three way rocker switch allows for choice of red light or white light. Red light will not impair driver vision at night, while allowing for passenger activity.

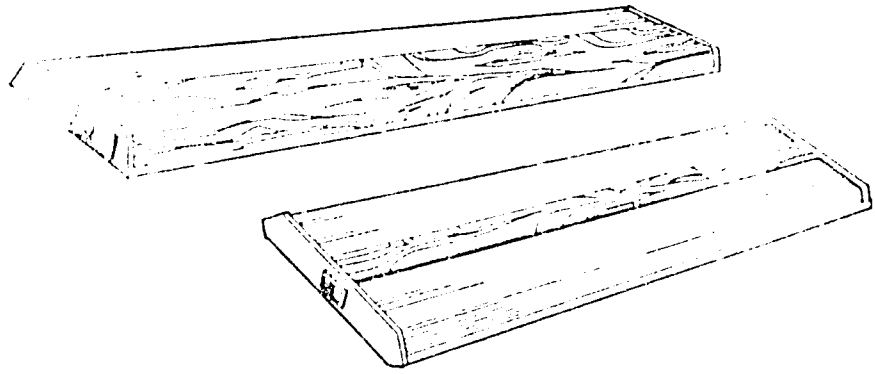
115 15 watt 12VDC 1.4 amps 18" x 4" x 1⅜" deep. Uses one F15T8/CW fluorescent tube. Light output: 880 lumens

116 30 watt 12VDC 1.9 amps 18" x 5½" x 1⅜" deep. Uses two F15T8/CW fluorescent tubes. Light output: 1760 lumens



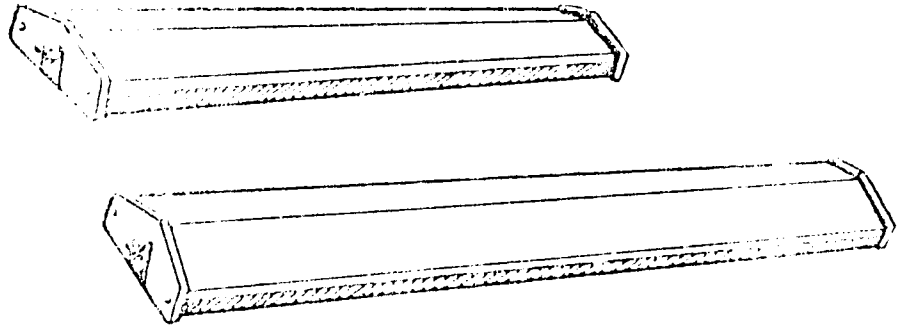
125 13 watt 12VDC 1.3 amps 21" x 4" x 1" thin. Uses one F13T5/CW fluorescent tube. Light output: 820 lumens

126 26 watt 12VDC 1.9 amps 21" x 5" x 1" thin. Uses two F13T5/CW fluorescent tubes. Light output: 1640 lumens

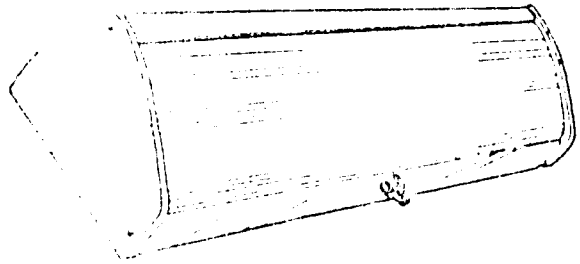


171 Anodized Aluminum: 8 watt 12VDC light 18" x 2⅜" x 1⅛" high 0.7 amps one F8T5/CW fluorescent tube. Light output: 400 lumens

173 Anodized Aluminum: 13 watt 12VDC 1.3 amps 27" x 2⅜" x 1⅛" high uses one F13T5/CW fluorescent tube. Light output: 820 lumens

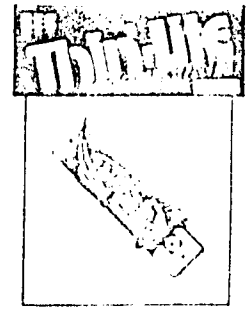


162 Anodized Aluminum: Weather-proof outdoor area light with amber lens (will not attract night flying insects such as mosquitos) 16 watt 12VDC 1.6 amps 12½" x 3¼" x 2¾" 800 lumens. Uses two F8T5/CW fluorescent tubes. (White lens optional)



Replacement Ballast Kit

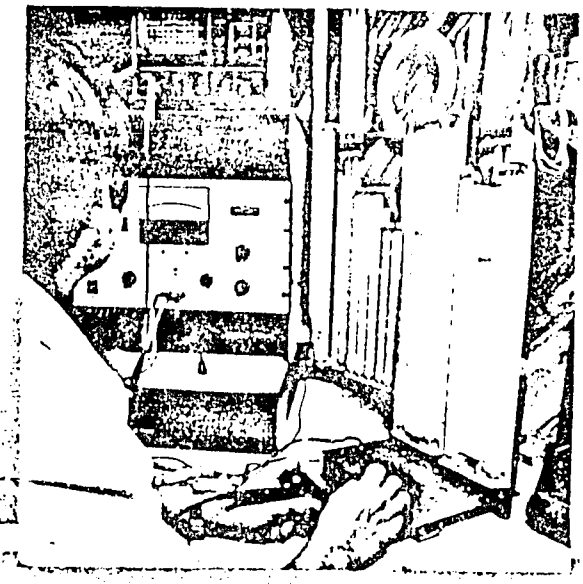
Part numbers IB-109, IB-110, IB-111, IB-112, IB-115, IB-116, IB 125, IB-126 (check model numbers for ballast applications)



Note: Fixtures and ballasts available in other voltages. Consult factory. Lumen ratings according to lamp manufacturers' 60Hz data for CW lamps. Specifications subject to change without notice.

Built to last by people who care.

Thin-Lites began as an innovative idea developed in a 200 square foot area. They are now built in a 25,000 square foot facility. Today this idea has been developed and technologically advanced to meet the exacting standards of Underwriters Laboratories. This advanced technology and experience has made REC Specialties, Inc. the largest manufacturer of low voltage fluorescent lighting for the marine and vehicular industries. Thin-Lites are the first, and only, U.L. Listed 12 volt DC fluorescent . . . for wherever dependable, bright and long-lasting lighting is required.

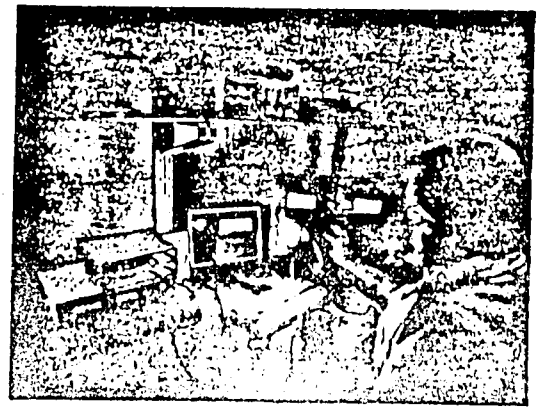


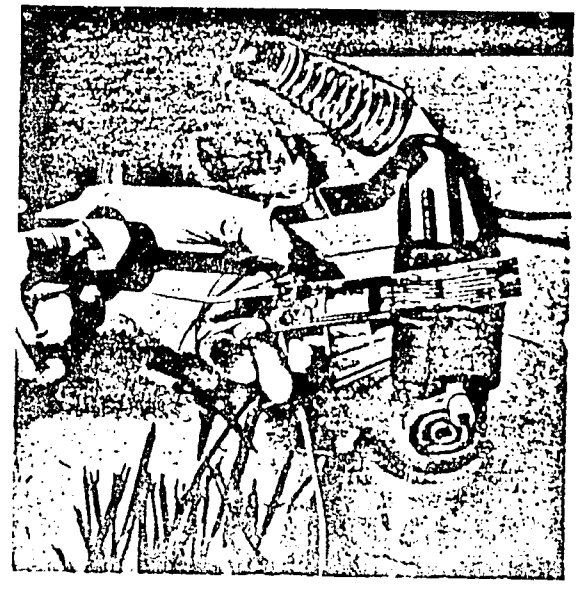
thin-lite™

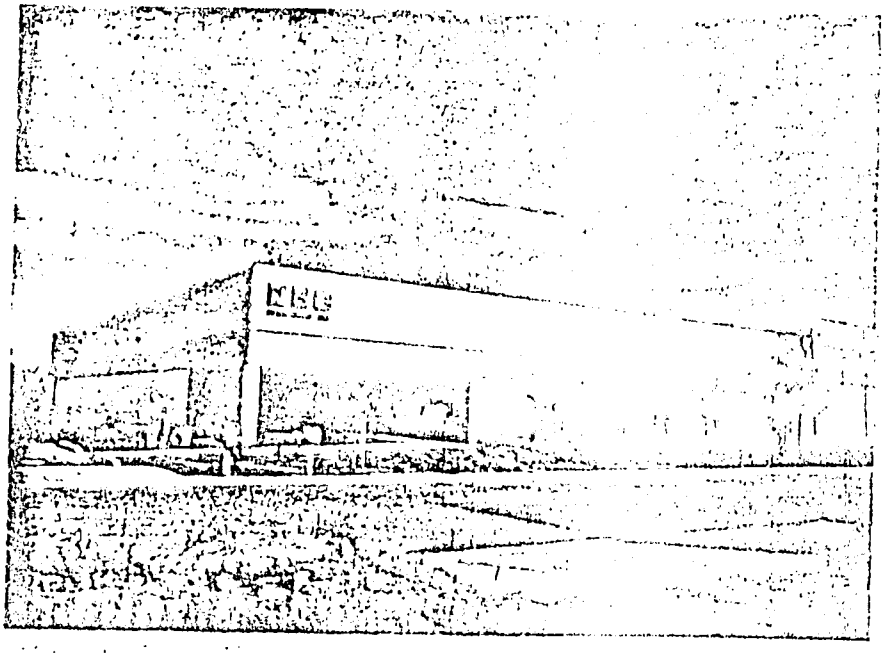
Manufactured by:

REC

SPECIALTIES, INC.
530 Constitution Avenue
Camarillo, Calif. 93010 USA
(805) 987-5021
Telex: 662203 RECSPEC CAMA
Printed in USA 1983







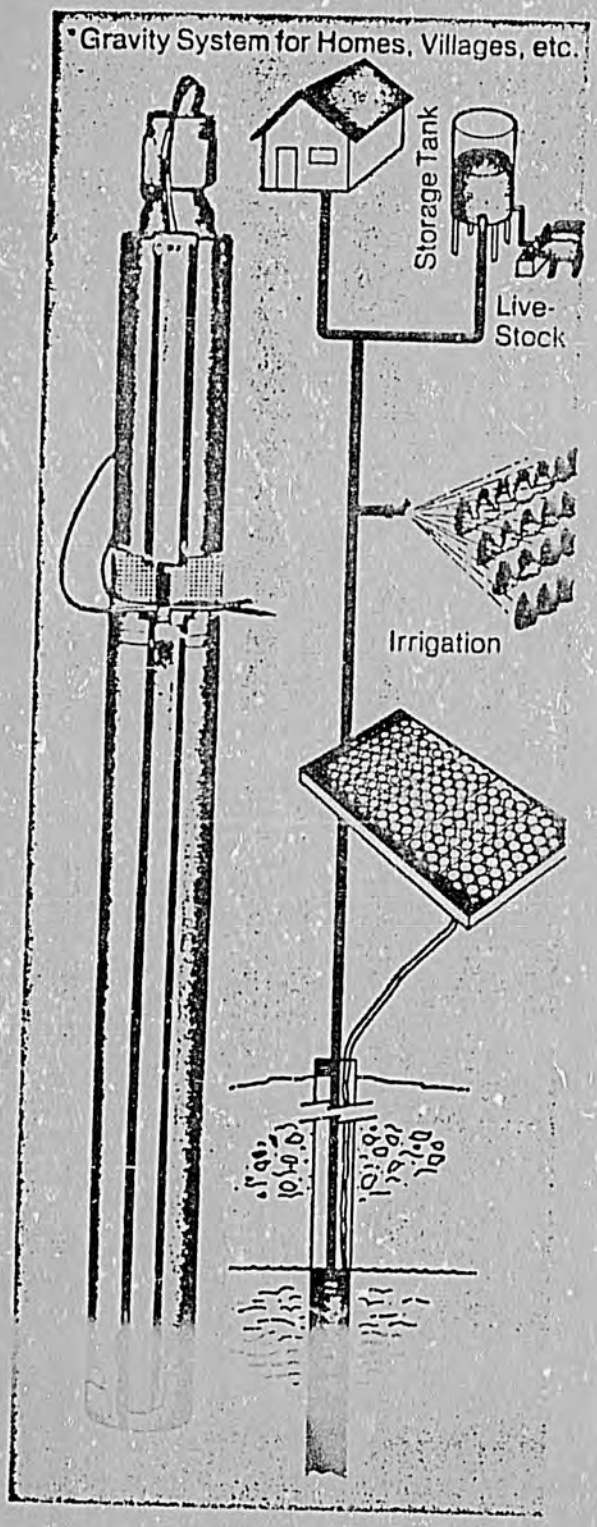
APPENDIX B

PRODUCT LITERATURE

A selection of manufacturer's product literature for PV Pumping Systems is provided in this Appendix. Additional manufacturer's product literature is available in the Technology Reference Notebook previously submitted under Task 2.2.4.

A.Y. McDONALD'S

"SOLAR SUB"



Complementing a highly successful line of solar jet pumps, McDonald now offers a variety of 4" solar submersible pumping systems that are also maintenance-free and ideal for livestock, village and remote-home water supplies, and many other needs.

Features:

Solar Sub Pumping Systems

- Easy to install and use
- Highly reliable technology and design
- Trouble-free with minimal maintenance
- Available in panel-direct models without inverters or special controls
- Also available for rechargeable battery installations with special controls
- Modular system design allows more water by simply adding panels
- Most efficient use of photovoltaics produce d-c electricity from sunshine and match with d-c pumps
- Available in nominal 300, 600, 900 & 1300 watt systems
- Submersible pump/motor combination FITS 4" DIAMETER WELLS or larger
- No priming required
- Built-in check valve prevents backspin on motor
- All corrosion resistant construction (stainless steel, brass & engineered plastic in pump end and motor)
- Pump connects directly to NEMA standard motor for positive torque without slippage
- Variable speed BRUSHLESS d-c permanent magnet motor construction
- Operates from 45 volts d-c or less to a maximum of 90 volts d-c
- Lightning protection built into motor
- Voltage and current limited to protect against electrical surges
- 2-wire color-coded connections
- Flow rates to 4000 U.S. gph (15,000 lph)
- Total dynamic head (lift) to 450 feet, (140 meters) or more w/multiple pumps

*Also available in pressurized systems

(Over for specifications and performance)

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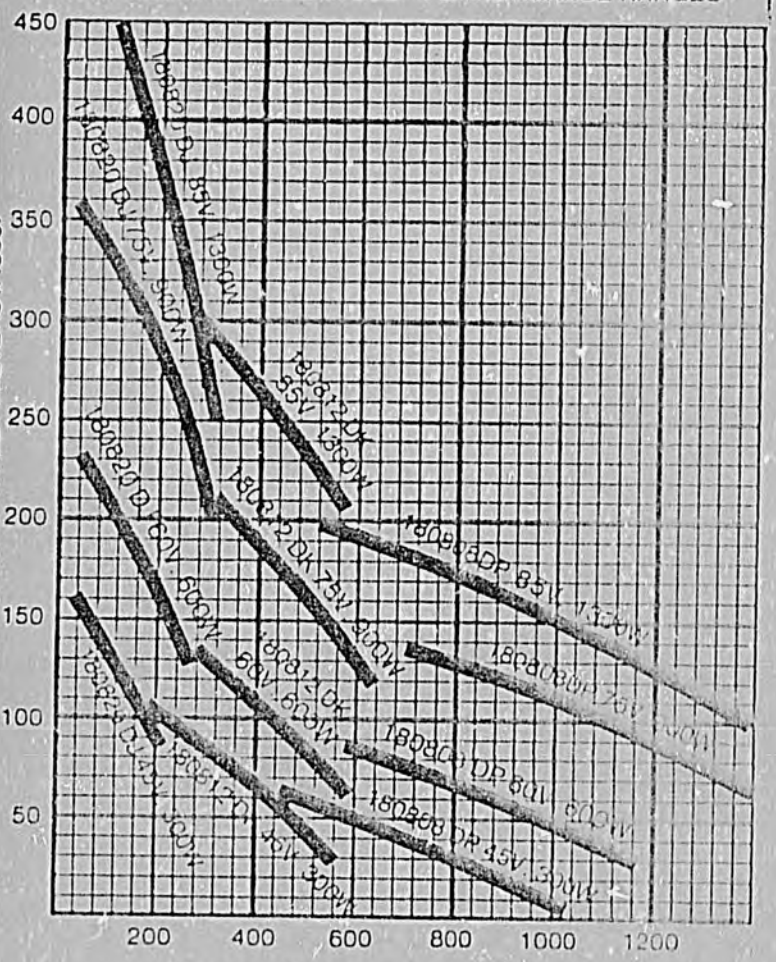
Specification Data

FOR WELL DIAMETERS 4" ID (100MM) AND LARGER

Model No.	Nom. Voltage	Nom. Watts	Discharge Size	Lgth.	Weight
180808DP	84 V d-c	1100	1-1/4" NPT	44"	51#
180812DK	84 V d-c	1100	1-1/4" NPT	45"	51#
180820DJ	84 V d-c	1100	1" NPT	52.5"	56#

(For higher capacity models, consult factory)

APPROXIMATE "SOLAR SUB" PERFORMANCE RANGES



Brushless D-C Submersible
Average Performance at Various Voltages
Expressed In: U.S. Gph at Feet of Lift*/D-C Watts Required

45 VOLTS D-C

20 Stage "J" Series	12 Stage "K" Series	8 Stage "P" Series
Gph @ Feet/Watts	Gph @ Feet/Watts	Gph @ Feet/Watts
90 @ 145/310	180 @ 100/300	480 @ 50/260
120 @ 125/320	240 @ 85/300	660 @ 35/265
	300 @ 75/310	1080 @ 10/250
	360 @ 65/310	
	420 @ 55/310	

60 VOLTS D-C

20 Stage "J" Series	12 Stage "K" Series	8 Stage "P" Series
Gph @ Feet/Watts	Gph @ Feet/Watts	Gph @ Feet/Watts
120 @ 215/535	300 @ 130/510	780 @ 70/510
180 @ 180/540	360 @ 125/520	1020 @ 50/510
240 @ 140/545	420 @ 110/530	1140 @ 35/500
	480 @ 90/530	
	540 @ 75/530	
	600 @ 50/530	

75 VOLTS D-C

20 Stage "J" Series	12 Stage "K" Series	8 Stage "P" Series
Gph @ Feet/Watts	Gph @ Feet/Watts	Gph @ Feet/Watts
120 @ 335/855	360 @ 200/825	720 @ 130/800
180 @ 300/885	420 @ 185/840	840 @ 115/830
240 @ 240/895	480 @ 170/865	960 @ 105/840
300 @ 200/910	540 @ 150/880	1080 @ 95/840
	600 @ 130/880	1200 @ 80/840
		1320 @ 65/830

85/87 VOLTS D-C

20 Stage "J" Series	12 Stage "K" Series	8 Stage "P" Series
Gph @ Feet/Watts	Gph @ Feet/Watts	Gph @ Feet/Watts
120 @ 425/1105	300 @ 275/1050	720 @ 160/1050
180 @ 375/1160	360 @ 250/1090	840 @ 150/1080
240 @ 325/1175	420 @ 240/1105	960 @ 140/1090
300 @ 260/1180	480 @ 220/1105	1080 @ 130/1105
	540 @ 200/1120	1200 @ 115/1105
	600 @ 180/1130	1320 @ 100/1105
		1560 @ 65/1080

* For liters X's 3.785
For meters X's .3048

EST. 1856 McDonald

A.Y. McDonald MFG. CO.
P.O. Box 508, Dubuque, Iowa 52001
Phone 319-583-7311
Telex 43-9020 AYMCD DUQU
Cable AYMCD DUBUQUE, IOWA, U.S.A.

5/84/7M

Printed in U.S.A.

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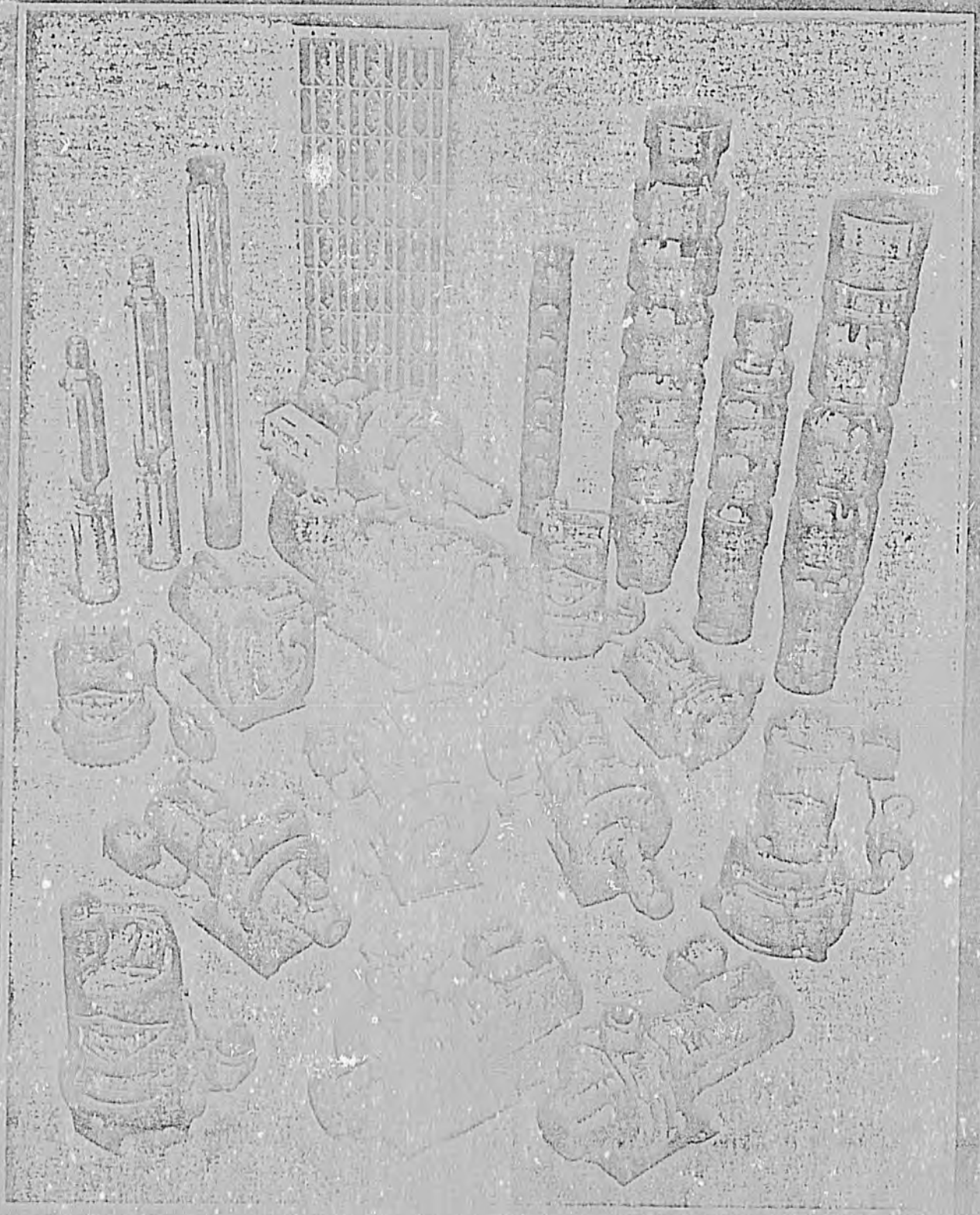
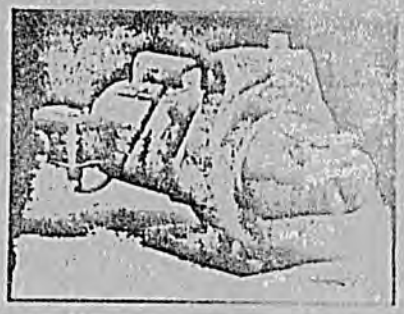
GO WITH THE FLOW

AYA McDonald
The Complete Line



8100 SERIES SHALLOW WELL JET

McDonald's 8100 Series shallow well jet pumps are ideal when suction lift is less than 25 feet. These self-priming units are available in ⅓, ½, ¾ and 1 H.P. models and will provide capacities to 1600 GPH, pressures to 70 P.S.I. Pumps are powered by 3450 RPM 60-cycle motors built to the latest NEMA specifications and employ extended threaded stainless steel shafts for positive alignment. Your choice of impeller material: engineered thermoplastic or time-proven bronze. Ideal for drive points, cisterns and drilled, driven or dug wells.



8200 SERIES CONVERTIBLE JET

McDonald's 8200 Series convertible jet pumps can be used for shallow or deep well applications. Shallow well capacities to 1600 GPH, pressures to 70 P.S.I. Deep well capacities to 1200 GPH and depths over 120 feet. Available in ⅓, ½, ¾ and 1 H.P. models with your choice of impeller material: engineered thermoplastic or time-proven bronze. Pumps are powered by 3450 RPM 60-cycle motors built to the latest NEMA specifications and each pump comes with a built-in regulating valve.

1000 & 1500 SERIES MULTI-STAGE JETS

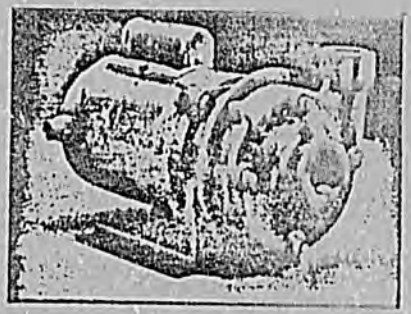
McDonald's 1000 (Vertical) and 1500 (Horizontal) Series multi-stage jet pumps can be used in either deep well or shallow well applications. Deep well models are available with ½, ¾ and 1 H.P. capacitor start motors. Shallow well pumps are available in ¾, 1 and 1½ H.P. models and can deliver up to 2500 GPH.

4600 SERIES CONVERTIBLE JET

McDonald's 4600 Series deluxe units are completely convertible to shallow well operation. Available in ½, ½, ¾ and 1 H.P. models, these units will provide capacities up to 1600 GPH and to depths beyond 120 feet. These models feature backhead construction allowing removal of the motor without loss of system pressure. Diaphragm type automatic regulating valves are employed on ¾ and 1 H.P. models to ensure maximum performance.

9000 SERIES CENTRIFUGALS

McDonald's 9000 Series centrifugal pumps are ideal for lawn sprinkling, booster systems, and many other transfer applications. Available in ⅓, ½, ¾, 1 and 1½ H.P. models, incorporating NEMA standard single or three phase motors. Pump housing and adaptor are made of heavy duty cast iron and impellers are either thermoplastic or bronze. Capacities to 3300 GPH.



84000 SELF-PRIMING CENTRIFUGALS

The McDonald 84000 Series self-priming centrifugals are ideal for garden irrigation, pool filling and can be used as standby pumps for fire protection as well as other commercial uses. These pumps are suitable for installation where the vertical distance from the pump to the water level does not exceed 25 feet. Available in ¾, 1, 1½, 2 and 3 H.P. models these pumps can deliver up to 8300 GPH or pressures up to 60 P.S.I. Individually balanced impellers handle silt and muddied water with a minimum of effort. Complete unit includes pump, motor and suction check valve for positive priming.

From 1856 To Today

The founding of A. Y. McDonald Mfg. Co. typifies the mystique of the free enterprise system.

Andrew Young McDonald, an apprentice plumber from Scotland, came to America in 1854 and worked his way to the Midwest. He settled permanently in Dubuque, Iowa in 1856 and opened a small plumbing shop. As development of the country moved westward and the prairies were turned into agricultural lands, a need for water was created and [illegible] added the manufacture of a line of hand pumps and well supply items to his plumbing business.

He consistently offered the highest level of excellence in product and service.

Today, McDonald is a leading manufacturer of products for water utilities, gas utilities, the petroleum industry, and the pump and water system fields.

The company is still wholly owned by the McDonald family. Their new plant and office complex located in the Dubuque Industrial Center, hundreds of McDonald employees are striving to maintain the same high standard of excellence in products and service established long ago by Andrew Young McDonald.

Distributed by:

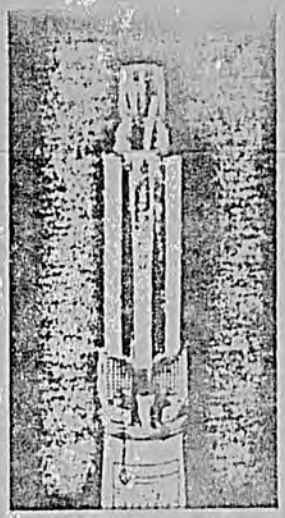
GO WITH THE FLOW

A. Y. McDonald MFG. CO.

P.O. BOX 508, DUBUQUE, IOWA 52001
PHONE: (319) 583-7311
TELEX: 43-2000 AYMCD DUQU
CABLE: AYMCD DUBUQUE IOWA USA

4" SUBMERSIBLES

McDonald's offers a full line of 4" submersibles ranging in size from ½ to 15 H.P. Our submersible line offers peak capacity performance and is available in 5, 10, 13, 18, 25, 30, 50, 80 and 90 GPM models. We also incorporate a one-piece replacement cartridge in most models which makes our submersible line easier than ever to service. Pumps are powered by NEMA approved stainless steel motors with built-in lightning protection. Available in two-wire models up to 1½ H.P.

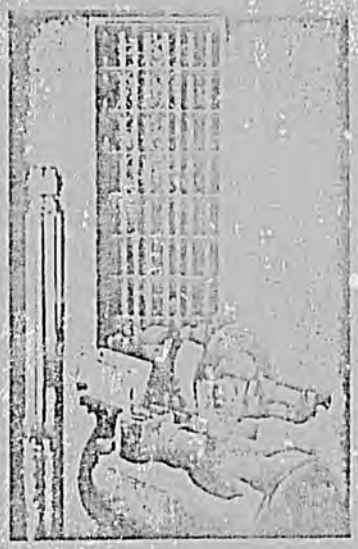


6-7-8" SUBMERSIBLES

McDonald's 6-7-8 inch submersibles bring together quality materials, precision machining and strict control of assembly and testing to provide service and dependability. Available in sizes ranging from 5 to 100 H.P. and capacities of 110, 140, 250, 450 and 600 GPM. These pumps are designed to meet any industrial, municipal or agricultural application.

SOLAR PUMPING SYSTEMS

A. Y. McDonald Mfg. Co. began research and testing of solar powered pumping systems in 1977. Applications include: remote village water supply, livestock watering, drip or trickle irrigation, remote home water supply and many others. These systems are available with either surface models or submersible D.C. powered pumps and can be tailored to your specific pumping needs.



SUMP PUMPS

McDonald's compact submersible sump pumps are available in ⅓, ½ and 1½ H.P. models and can handle capacities up to 120 GPM. All models include capacitor start motors with built-in thermal protection. The polypropylene pump housing and components ensure reliable, corrosion proof service and the removable intake screen allows portable pump down to ⅛" standing water level.

EFFLUENT PUMPS

McDonald's effluent pumps are designed for residential and light commercial applications. All models feature a 2" discharge and are capable of handling ¾" solids. Available in 4/10, ½, 1 and 2 H.P. models, these pumps can deliver heads up to 85 feet or 138 GPM. Single phase units feature a high torque, capacitor start motor with built-in thermal protection.

SEWAGE EJECTORS

McDonald's sewage ejectors are designed for home and light industrial applications. All models feature a 2" discharge and high torque capacitor start motors with built-in thermal protection. Available in 4/10, ½, 1, 1½ and 2 H.P. models, these pumps can deliver heads up to 46 feet or 350 GPM.

A.Y. McDonald MFG. CO

COMMERCIALLY AVAILABLE McDONALD SOLAR-POWERED PUMPS

NON-SUBMERSIBLE/CENTRIFUGAL PUMPS WITH OR WITHOUT JET

PANEL-DIRECT (NO BATTERY) SYSTEMS:

Capacity: 250 to 25,000 gallons per day

Depth to Water: Surface to 75 feet below the pump or ground

Total Lift or Head: To 300 feet

Well Requirements: As small as 1" diameter - usually 2" or larger or pumping is from a stream, river, cistern, etc.

Cost: Complete system from $1,495 with PV panels etc.
Pumps only from $495

Best Applications: Livestock and wildlife watering, low pressure irrigation, village or residential water or any gravity water supply

SOLAR-RECHARGED BATTERY SYSTEMS

Capacity: 50 to 5,000 gallons per day

Depth to Water: To 100 feet below the pump or ground level

Total Lift and Well Requirements: Same as panel-direct systems.

Cost: Complete systems from $995 with one module, battery, etc.

Best Applications: Same as panel-direct systems plus these units can supply pressurized water for on-demand use day or night for any remote location.

SUBMERSIBLE PUMPS (Panel-Direct or Battery Systems)

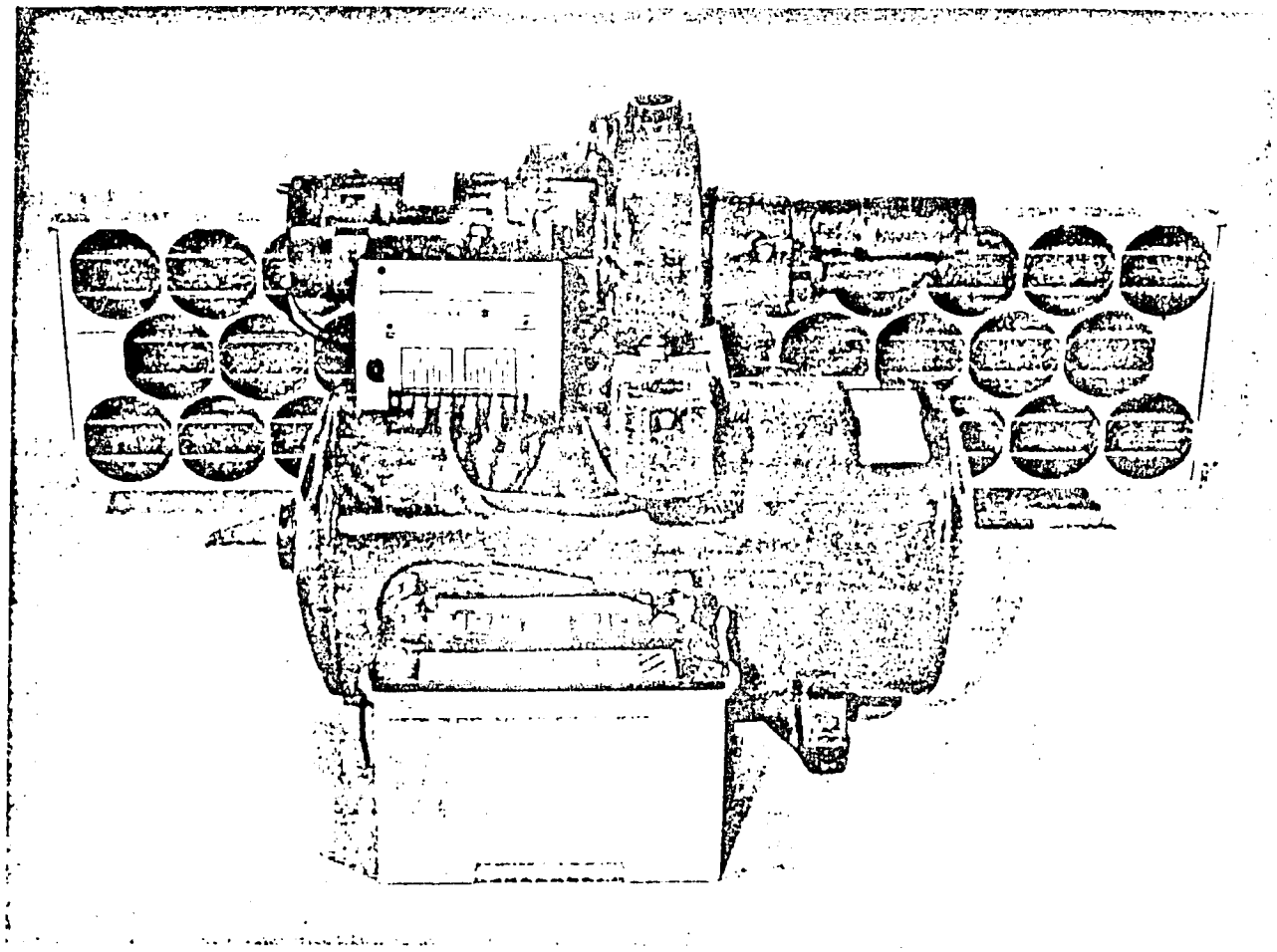
Capacity: to 10,000 gallons per day

Depth to Water: 20 to 400' below ground level

Well Requirements: Minimum of 4" diameter or larger

Cost: Complete system from $3,995 with PV panels etc.
Pumps only from $1,595

McDONALD'S SOLAR JET II



COMPLETE and VERSATILE SYSTEM

The package system on McDonald's "Solar Jet" colored brochure includes a 55-Watt panel and two batteries plus other top-of-the-line equipment.

For smaller quantity needs, consider this system: (One 35-Watt panel and one battery)

(Pumps from 60′ or less to water)

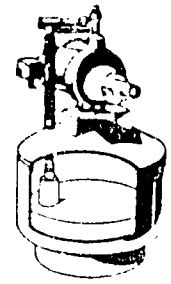
1. Same Model 150103D Pump with jet fitting, foot valve and pressure switch but now with 30-gallon captive-air tank and connecting fittings.
2. One 35-Watt PV panel (for 100–150 GPD depending on conditions).
3. One 12-Volt deep cycle battery (for 225–350 gallons reserve pumping per charge).
4. One indoor-type power controller with mounting bracket.
5. Complete instructions for assembly and installation of packaged system (less piping and wiring).

List Price $2,395.00

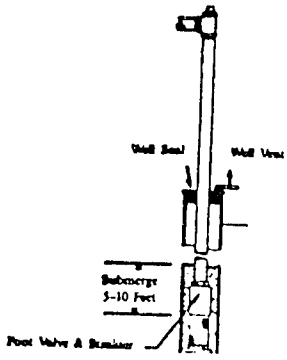
If more water is required later, simply add solar panels as needed.

(Over For Specifications)

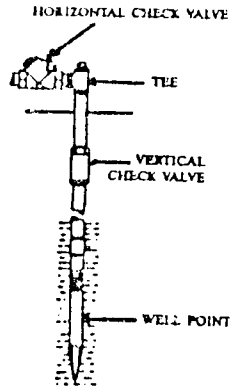
TECHNICAL SPECIFICATIONS

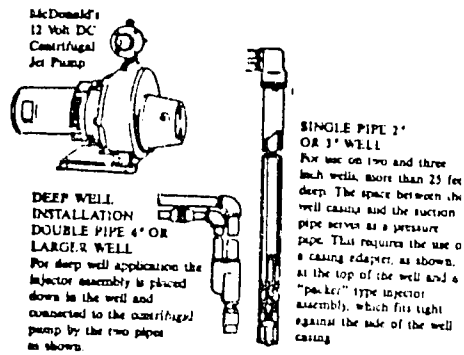


McDONALD "JET-PAK" WITH CAPTIVE AIR TANK



TYPICAL SHALLOW WELL INSTALLATION





DEEP WELL INSTALLATIONS

ONE PUMP USED THREE WAYS

1. SHALLOW WELL PERFORMANCE WITHOUT JET EJECTOR (For Higher Capacity)

Nom. Watts Required (12V)	Dept to Water/Ft.	GPH Capacity @ Discharge Pressure @ 12V 0	5	10	15	Shutoff Pressure*
300W	5	1400	1100	840	400	19 PSIG
	15	1200	900	500	—	14 PSIG

2. SHALLOW WELL PERFORMANCE WITH JET BOLTED ON THE PUMP (For Higher Pressure)

Nom. Watts Required (12V)	Dept to Water/Ft.	GPH Capacity @ Discharge Pressure @ 12V 0	5	15	22.5	30	Shutoff Pressure*
240W	10	330	300	270	180	100	40 PSIG
	20	220	210	200	120	80	36 PSIG

3. DEEP WELL PERFORMANCE WITH JET IN THE WELL (Lifts Water From 60' Below Ground)

Nom. Watts Required (12V)	Dept to Water/Ft.	GPH Capacity @ Discharge Pressure @ 12V 0	5	15	22.5	30	Shutoff Pressure*
270W	20	410	360	150	100	—	32 PSIG
	30	375	275	130	40	—	29 PSIG
240W	40	240	180	100	—	—	26 PSIG
	50	180	140	—	—	—	21 PSIG
	60	120	90	—	—	—	16 PSIG

*PSIG × 2.31 for equivalent feet of head.

A fully-charged battery will produce more than 12 Volts DC, resulting in greater GPH capacity than shown above.

For higher capacity and higher pressure systems, A. Y. McDonald provides standardized solar pumps through 1300 watts (1¾ HP DC). Contact factory for details.

EST. 1856 McDonald ®

A.Y. McDonald MFG. CO.
P.O. Box 508
Dubuque, IA 52004-0508
Telephone: 319/583-7311
Telex: 43-9020 AYMCD DUQU
Cable: AYMCD DUBUQUE, IOWA U.S.A.

SOLAR-POWERED WATER PUMPING SYSTEMS

SOLAR JETS — SOLAR SUBS

ALL CENTRIFUGAL PUMPS

CONDENSED CATALOG AND PRICE LIST

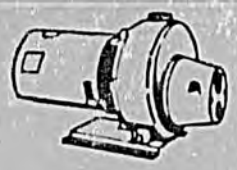
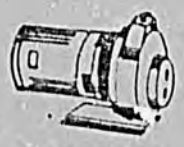
EFFECTIVE JANUARY 1, 1985

EST. 1856 McDonald

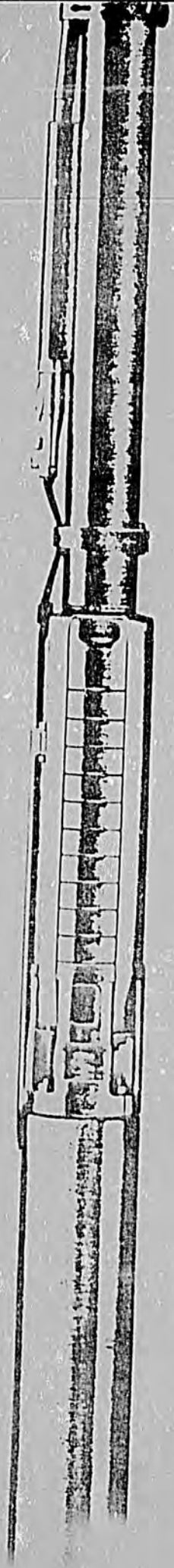
A.Y. McDonald MFG. CO.

P.O. BOX 508, DUBUQUE, IA 52004-0508 U.S.A.
Phone 319 583-7311
Telex 43 9020 AYMCD DUQU
Cable AYMCD DUBUQUE, IOWA U.S.A.

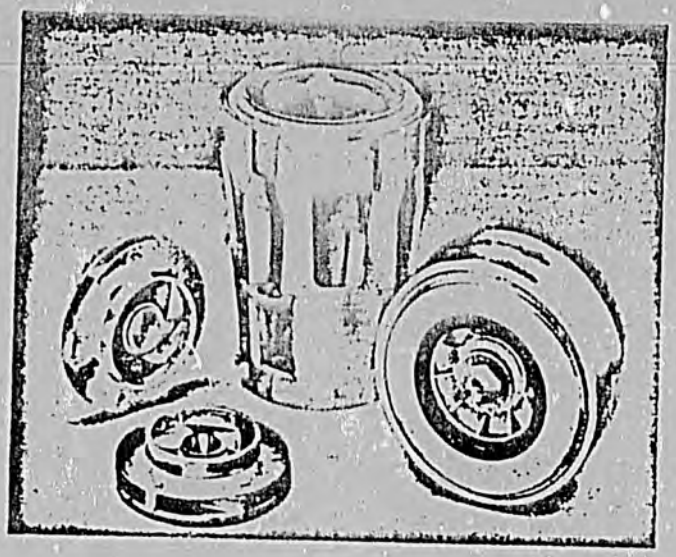
A.Y. McDonald D.C. Pumps and Solar-Recharged Battery System

	DESCRIPTION	MODEL NO.	RETAIL	WT/CUBE
 1500 SERIES Convertible/Centrifugal Pump	1500 BASIC PUMP FOR USE THREE WAYS 1500DS without Jet Ejector for 600 to 2100 GPH (2200 to 8000 LPH). Lifts water from 16' (5M) to 150' (45M). Water must be within 20' below the pump. 1500DJ with Jet Ejector bolted on for higher pressures. Water must be within 25' below the pump. 1500DD with Jet Ejector in the well. See Performance in Jet Ejector Section, Page 2. Sizes: 250, 500, 700, 900 and 1300 Watts (¼ to 1½ HP DC).	150103DS (300 Watt)	$995.00	55# 2.1 Cu. Ft.
		150305DS (500 Watt)	$965.00	53# 2.1 Cu. Ft.
		150307DS (700 Watt)	$1070.00	56# 2.1 Cu. Ft.
		150309DS (900 Watt)	$1125.00	64# 2.1 Cu. Ft.
		150813DS (1300 Watt)	$2035.00	80# 2.1 Cu. Ft.
 8200 SERIES	8200DS CENTRIFUGAL PUMP FOR HIGHER CAPACITIES 900 to 3000 GPH (3400 to 11,300 LPH). Lifts water from 10' (3M) to 100' (30M). Water must be within 20' below the pump. Sizes: 500, 700, 900 and 1300 Watts (½ to 1½ HP DC).	820305DS	$750.00	41# 2.1 Cu. Ft.
		820307DS	$835.00	45# 2.1 Cu. Ft.
		820309DS	$895.00	52# 2.1 Cu. Ft.
		820813DS	$1850.00	69# 2.1 Cu. Ft.
McDonald Jet-Pak with Captive Air Tank	COMPLETELY AUTOMATIC SOLAR PUMPING SYSTEM BEST — Includes McDonald 150103DJ 12-Volt DC Solar-Jet Pump with Ejector, Foot Valve and Pressure Switch for 15 to 30 PSIG On/Off Cycle. Also Includes 30-Gallon Captive Air Tank with Connecting Fittings Package, 1 - 43-Watt Solar (PV) Panel, Outdoor-Power Controller and 1 - H.D. Deep-Cycle Battery. Simply add pipe and wiring to pump an average 150 GPD. For more water, add additional panels.	150103DJK2	$2795.00	224# 11.5 Cu. Ft.
	GOOD — Completely Automatic System like 150103DJK2 except with 35/37-Watt Solar (PV) Panel and Indoor-Power Controller. (Does not include tank or fittings package.)	150103DJK3	$2250.00	175# 7.0 Cu. Ft.
Photovoltaic Panel PV Batteries Power Controller	COMPLETE MANUAL SYSTEM Includes 150103DS Pump with Foot Valve, 1 H.D. Deep-Cycle Battery and Self-Regulating Solar (PV) Panel. (Does not include pipe and wire.) (Operate for average ½ hour/day.)	150103DSK	$1595.00	135# 4.6 Cu. Ft.
	PUMPING PACKAGE ONLY Same as 150103DJK2 except less Solar (PV) Panel, Battery and Power Controller.	150103DJKL	$1195.00	111# 9.0 Cu. Ft.
18000 SERIES	BRUSHLESS DC SUBMERSIBLE PUMP FOR USE IN 4" DIAMETER OR LARGER WELLS High-Head Pump — 90 to 300 GPH (340 to 1100 LPH). Lifts to 400+ feet (120M).	180820DJ	$2600.00*	56# .7 Cu. Ft.
	Medium-Head Pump — 200 to 600 GPH (750 to 2300 LPH). Lifts to 300+ feet (90M).	180812DK	$2500.00*	51# .7 Cu. Ft.
	Medium-Capacity Pump — 500 to 1400 GPH (1900 to 5300 LPH). Lifts to 200+ feet (60M).	180808DP	$2500.00*	51# .8 Cu. Ft.
	High-Capacity Pump — 1200 to 3000 GPH (4500 to 11,300 LPH). Lifts to 70+ feet (21M).	180803DS	$2750.00*	

See Catalog For Full Item Descriptions. *Subject to availability later in 1985.



GRUNDFOS submersible pumps entirely of stainless steel



Throughout the world, GRUNDFOS submersible pumps have a reputation for maximum reliability as well as minimum maintenance and power consumption. Complicated individual parts are made from stainless steel plate correctly shaped and welded together to form complete impellers and intermediate chambers with guide vanes — the basic components in GRUNDFOS submersible pumps.

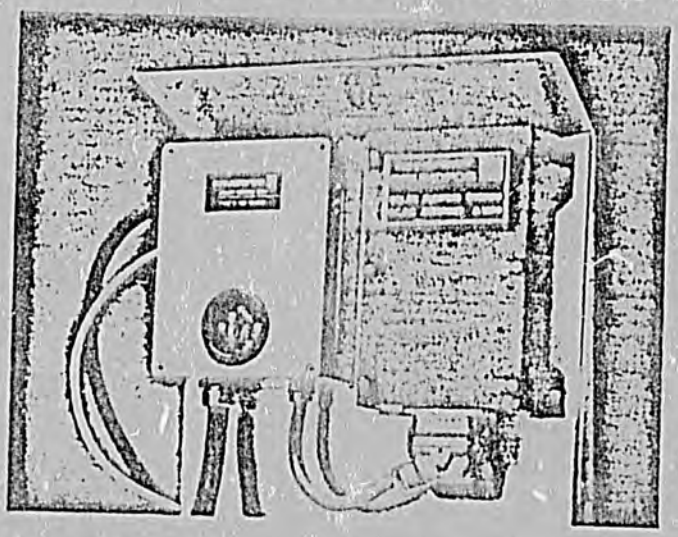
Stage by stage, the components are assembled into a complete pump with suction interconnector and discharge chamber.

The GRUNDFOS motor, which forms an important part of the unit, has, from many years' experience in operation and production of submersible pumps, been developed and constructed for operation under extreme conditions.

The GRUNDFOS pump/motor unit offers the following advantages:

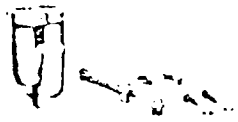
- Simple installation — threaded pump end for pipe-work connection and push-in cable plug and socket.
- Priming screw at suction interconnector protects against dry-running.
- Manufactured entirely from stainless steel.
- No supervision — pump and motor are water-lubricated.
- Low initial cost and low operating expenses.

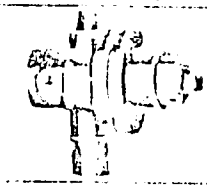
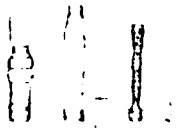
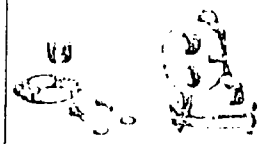
DC-AC inverter Switch box-terminal box

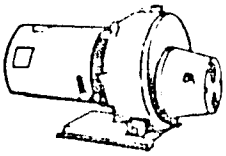
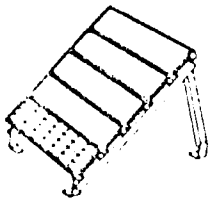
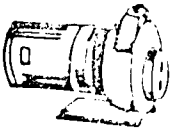
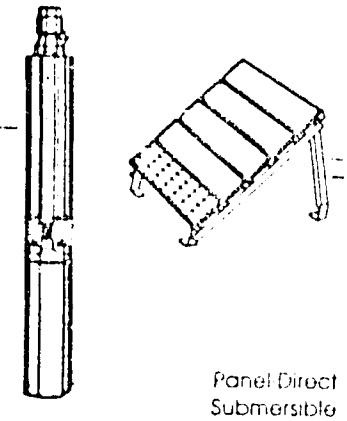


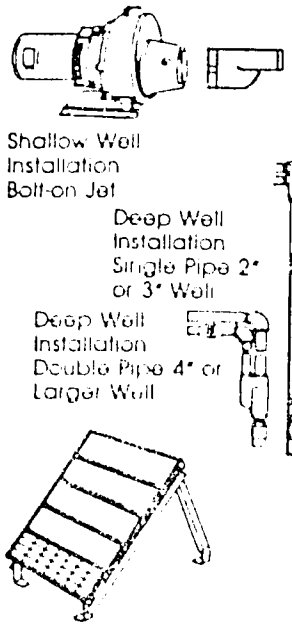
The DC from the solar array is transmitted to the inverter through a main switch - terminal box.
The GRUNDFOS inverter converts the DC power produced by the ARCO SOLAR panels into a three-phase AC voltage to run the pump unit. It is a fully electronic, compact unit which incorporates the latest technology and meets the severest demands for reliability, extremely long life, and high efficiency. The conversion of DC power into AC power is performed at an efficiency higher than 95%.
The built-in control loops of the inverter ensure that all the power available from the solar panels is drawn continuously.
If the irradiation is intensified, the inverter will automatically increase the frequency and the voltage. As a result, the pump speed is increased.
In practice, this means that the system is capable of delivering water even at very low irradiation values, e.g. immediately after sunrise or in cloudy periods.
Thanks to the automatic control system of the inverter, the available solar energy will all the time be utilized to its maximum. A maximum system efficiency is thereby achieved.
The inverter is equipped with a multi-plug which makes it possible to fit/remove the inverter without disturbing the electrical connections.

A.Y. McDonald Accessories and Panel Direct Systems

SHALLOW WELL	JET PACKAGES SHOWN CONVERT DS PUMPS TO DJ PUMPS		MODEL NO.	RETAIL	WEIGHT
	SP-115/150103DS	[illegible] pumps with bolt-on Jet Ejectors for higher pressure. 50' (15M) to 200' (60M) lift with flow from 120 GPH (450 LPH) to 800 GPH (3000 LPH). Water must be within 25' below pump.	150103DJ	Add $58.55 to DS Pump	Add 6 #
	SP-100/150305DS		150305DJ		
	SP-101/150307DS		150307DJ		
	SP-104/150309DS		150309DJ		
	SP-102/150813DS		150813DJ		

DEEP WELL	JET PACKAGES SHOWN CONVERT DS PUMPS TO DD PUMPS			
TWO PIPE	For Use In 4" Diameter or Larger Wells		RETAIL	NO. 105
	SP-115/150103DS SP-105 for All Other Pumps except 150813DS - Consult Factory	[illegible] pumps with Jet Ejectors in [illegible] for pumps from 50' (18M) or [illegible] the pump. Lifts to 250' [illegible] from 120 GPH (450 LPH) [illegible] (3000 LPH)	Two Pipe Jets - Add $58.55 plus $34.14 for 105 Regulating Valve.	
SINGLE PIPE	For Use In Small Diameter Wells			NO. 101
	2" MP-124/3" MP-140 for 150103DS 2" MP-123/3" MP-139 for All Other Pumps except 150813DS - Consult Factory.	[illegible] pumps with Single Pipe Jet Ejector in the well. Most practical [illegible] for small diameter deeper [illegible] for convenience, use 101 Cas-[illegible] Add $50.09 retail for 2" 101 Casing Adaptor.	Single Pipe Jets - Add $59.54 for 2"; $61.35 for 3" plus $34.14 for 105 Regulating Valve.	

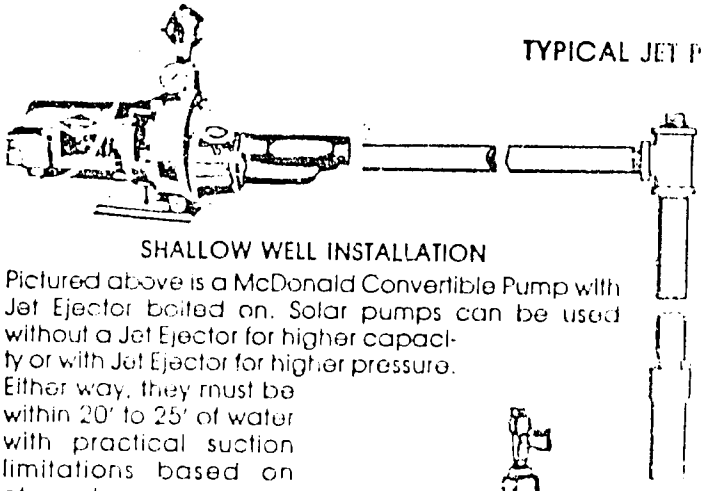
PANEL-DIRECT SYSTEMS	DESCRIPTION	RETAIL	WT./CUBE
	A) 150305D-8 — Minimum recommended functional demonstration system for pumping from shallow wells, lakes, rivers or streams. Includes 8 - 43-Watt Solar (PV) Panels, Mounting Rack, Interconnect Wires and McDonald Centrifugal Pump with Foot Valve for Average 3400 GPD (13 Cu M/D) at 33' (10M) Lift with Standard Solar Day of 5 KWH/Square Meter.	$6750.00	185# 15.5 Cu. Ft.
	B) 150309D-24 — Most popular Medium-Head Pumping System from shallow water (within 20' below the pump). Includes 24 - 43-Watt Solar (PV) Panels, Mounting Rack, Interconnect Wires and McDonald Centrifugal Pump with Foot Valve for Average 10,700 GPD (40 Cu.M/D) at 50' (15M) Lift with Standard Solar Day of 5 KWH/Square Meter.	$19,500.00	450# 42 Cu. Ft.
	C) 820305D-8 — Minimum Shallow Water Pumping System (within 20'). Same system as Item A above except use 820305DS pump for higher capacity. Average 6000 GPD (23 Cu M/D) at 16' (5M) Lift with Standard Solar Day of 5 KWH/Square Meter.	$6500.00	180# 15.5 Cu. Ft.
Panel Direct Surface Mounted Pumping Systems	D) 820309D-1-24 — Most popular Low-Head System for water within 20' of pump. Same system as Item B above except use 820309DS pump for higher capacity. Average 16,000 GPD (60 Cu M/D) at 33' (10M) Lift with Standard Solar Day of 5 KWH/Square Meter.	$19,250.00	445# 42 Cu. Ft.
	18000D-9 — Minimum recommended functional demonstration system for 4" diameter and larger wells includes 9 - 43-Watt Solar (PV) Panels, Mounting Rack, Interconnect Wires and McDonald Solar Submersible Pump. With Standard Solar Day of 5 KWH/Square Meter, Model 180820DJ pumps [illegible] (3.8 Cu.M/D) at 100' (30M) Model 180812DK pumps [illegible] GPD (4.1 Cu.M/D) at 85' (26M), and Model [illegible] pumps 1800 GPD (6.7 Cu.M/D) at 50' (15M).	$8950.00*	210# 15 Cu. Ft.
Panel Direct Submersible Pumping Systems	18000D-30 — Larger [illegible] includes 40 - 43-Watt Solar (PV) Panels, Mounting Rack, Interconnect Wires and McDonald Solar Submersible Pump [illegible] Standard Solar Day of 5 KWH/Square Meter. [illegible] 180820DJ pumps 330 GPD (1.2 Cu.M/D) at 330' (100M) [illegible] 180812DK pumps [illegible] Cu.M/D) at 200' (60M), and Model [illegible] pumps 3700 GPD (14 Cu.M/D) at 130' (40M).	$25,900.00*	600# 55 Cu. Ft.

PANEL-DIRECT SYSTEM	DESCRIPTION	RETAIL	WT./CUBE
 Shallow Well Installation Bolt-on Jet Deep Well Installation Single Pipe 2" or 3" Well Deep Well Installation Double Pipe 4" or Larger Well	150305DJ-8 — Minimum recommended functional demonstration system for shallow wells, booster systems, etc. to pressurize the water. Includes 8 - 43-Watt Solar (PV) Panels, Mounting Rack, Interconnect Wires and McDonald 150305DS Pump with SP-100 Jet Package and Foot Valve for 325 GPD (1200 LPD) at 16' Suction Lift and 20 PSIG* with Standard Solar Day of 5 KWH/Square Meter.	$6800.00	190# 16 Cu. Ft.
	150305DD-8 — Minimum recommended system for deep wells to 50' (15M) below ground level. Same solar array and pump as above except use SP-106 Jet Package in well for 1000 GPD (3800 LPD) at 50' (15M) Lift with Standard Solar Day of 5 KWH/Square Meter.	$6800.00	190# 16 Cu. Ft.
	150309DD-16 — Popular deeper well system to 50' (15M) below ground level. Includes 16 - 43-Watt Solar (PV) Panels, Mounting Rack, Interconnect Wires and McDonald 150309DS Pump with SP-106 Jet Package in well for 2400 GPD (9000 LPD) at 50' Lift with Standard Solar Day of 5 KWH/Square Meter.	$13,200.00	330# 30 Cu. Ft.

*PSIG x 2.31 for equivalent feet of head.

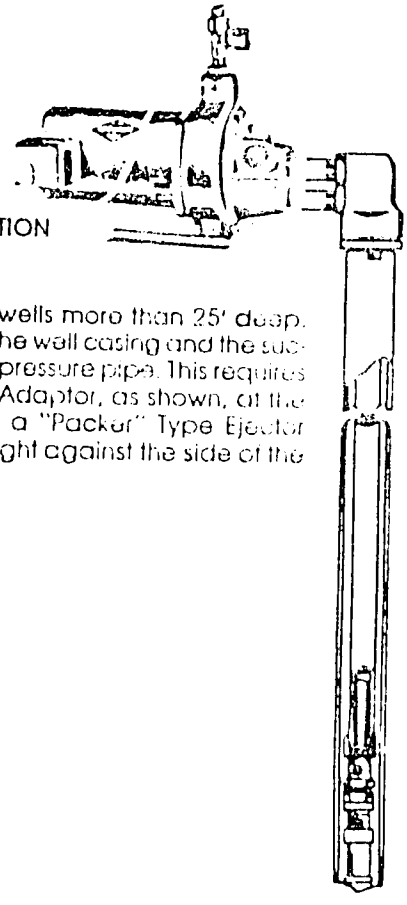
Request catalog for full line of Solar-Powered Pumps to 1300 W[illegible] provide application details as follows for sizing assistance from McDonald: 1) Depth to Water, 2) Required Gallons Per Day, 3) Type and Size of Well, 4) Location - Including Elevation Above Sea Level.

TYPICAL JET PUMP INSTALLATIONS



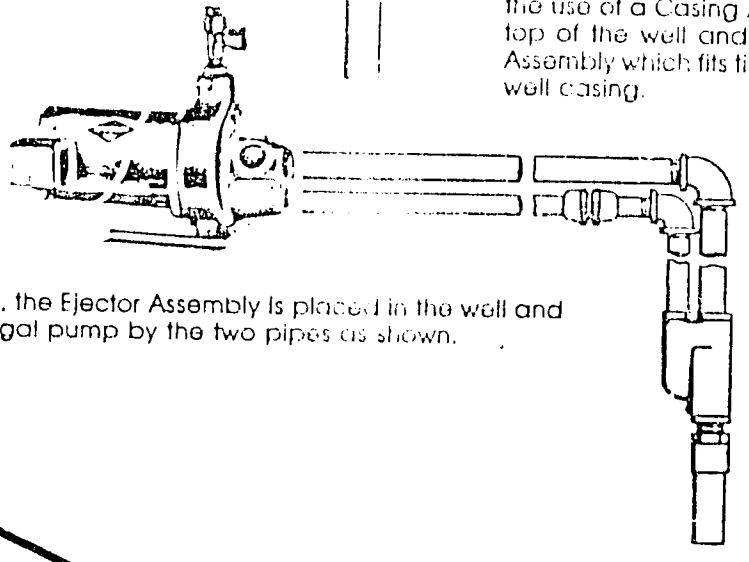
SHALLOW WELL INSTALLATION

Pictured above is a McDonald Convertible Pump with Jet Ejector bolted on. Solar pumps can be used without a Jet Ejector for higher capacity or with Jet Ejector for higher pressure. Either way, they must be within 20' to 25' of water with practical suction limitations based on atmospheric pressure.



DEEP WELL INSTALLATION SINGLE PIPE 2" OR 3" WELL

For use in 2" and 3" wells more than 25' deep. The space between the well casing and the suction pipe serves as a pressure pipe. This requires the use of a Casing Adaptor, as shown, at the top of the well and a "Packer" Type Ejector Assembly which fits tight against the side of the well casing.



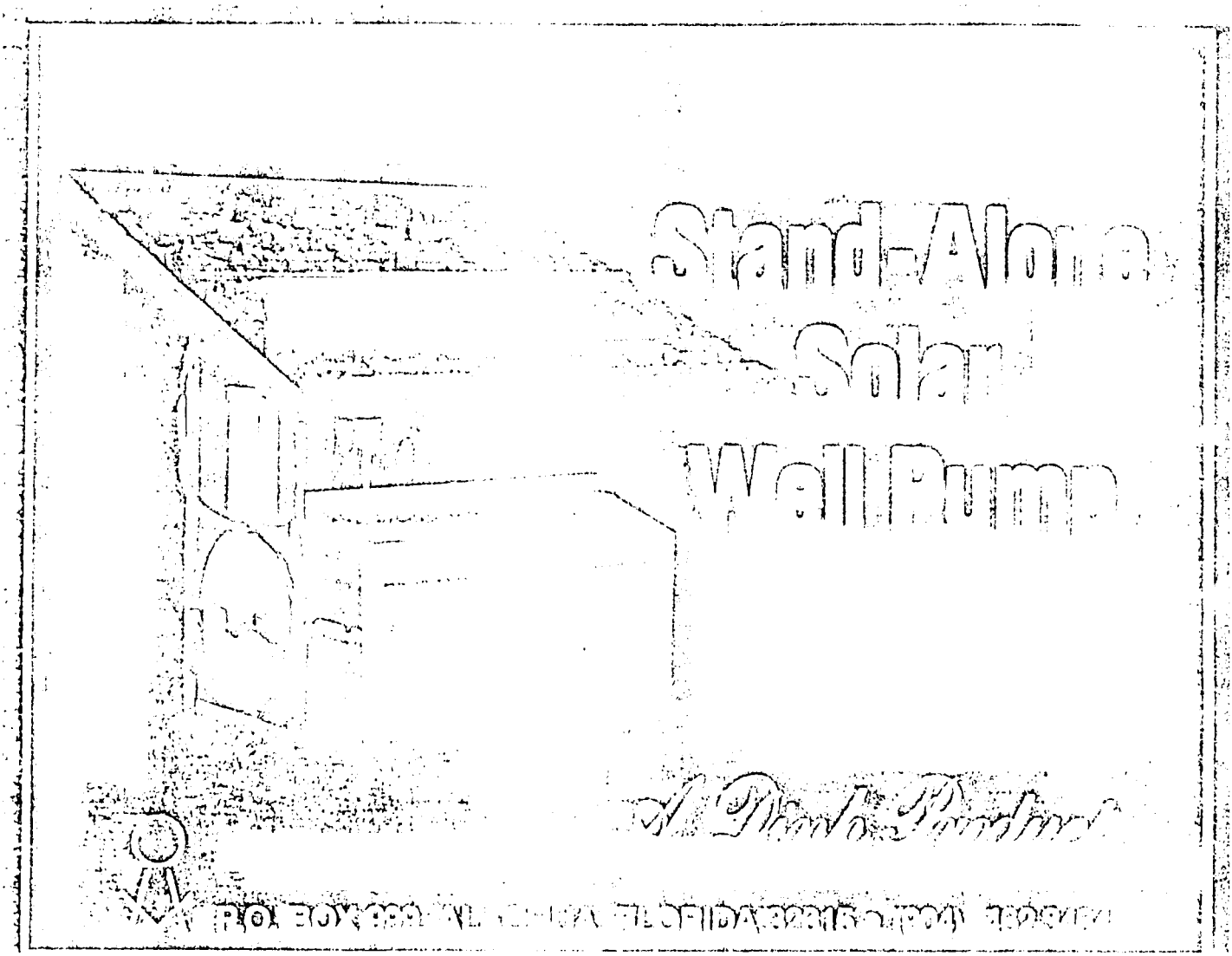
DEEP WELL INSTALLATION DOUBLE PIPE 4" OR LARGER WELL

For deep well application, the Ejector Assembly is placed in the well and connected to the centrifugal pump by the two pipes as shown.

EST. 1856 McDonald

A.Y. McDonald MFG. CO.

P.O. Box 200, DUBUQUE, IA 52004-0508 U.S.A.
Phone: 319 583 7311
Telex: 43 5020 AYMCD DUQU
Cable: AYMCD DUBUQUE, IOWA U.S.A.



The Lowest Cost Quality Solar Pump

- 500 Gallons of Water per Day
- Designed for Lower Rainfall Areas
- Highly Economical [illegible] Remote Locations for Drinking Water [illegible]

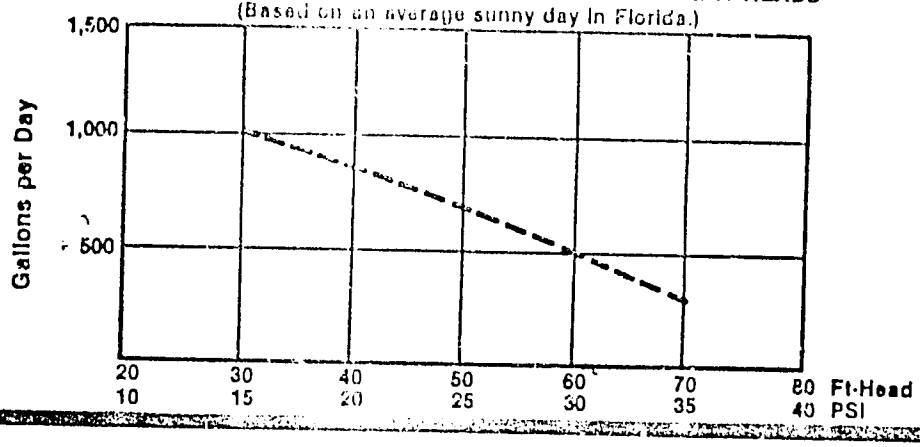
The Stand-Alone Solar Well Pump

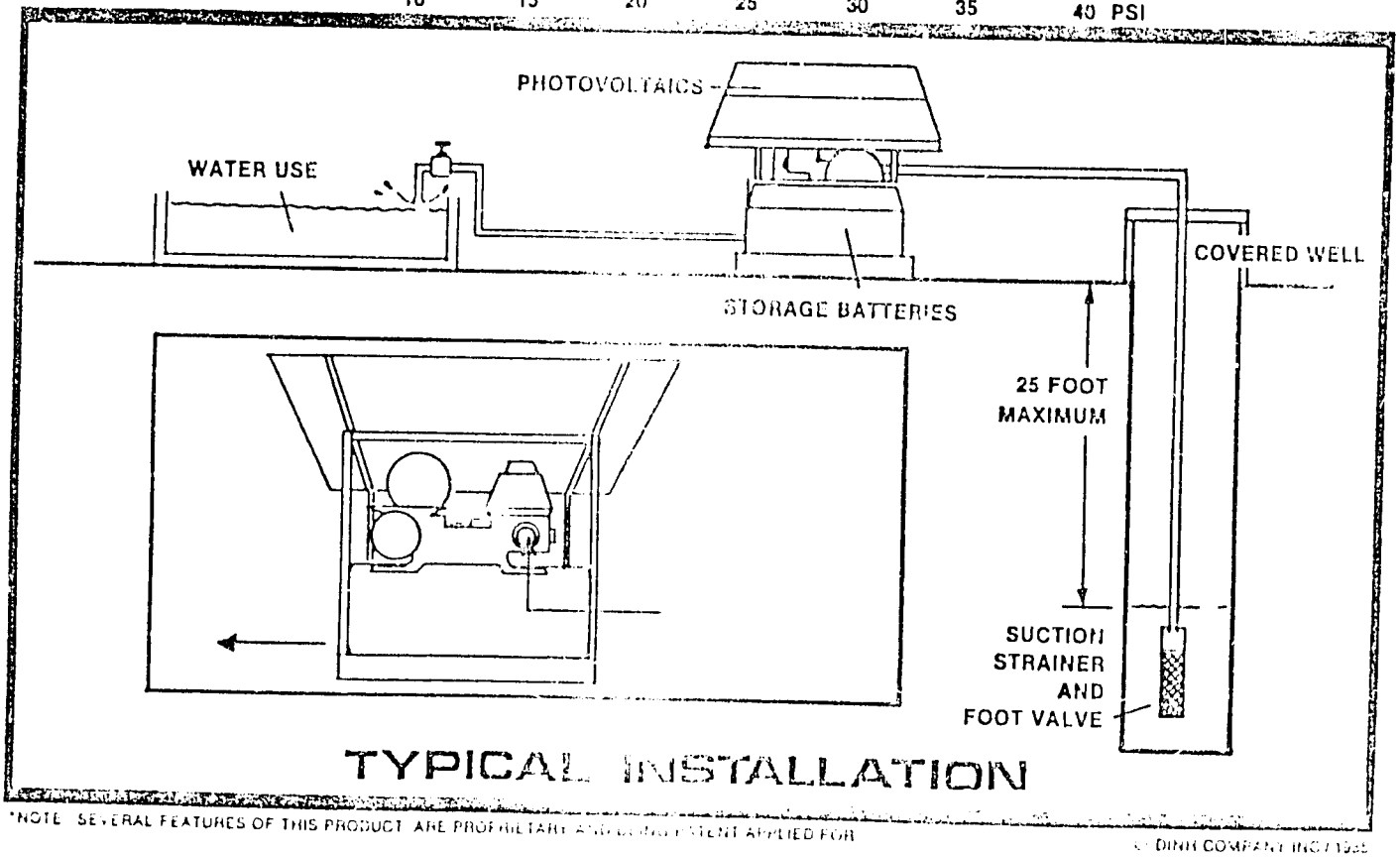
The Series 500 pumps are shallow well pumps designed for stand-alone operation. Two Photovoltaic modules charge storage batteries with enough energy every day to run the permanent magnet DC motor for about 100 minutes to pump a minimum of 500 gallons per day. The fully charged batteries have enough reserve capacity for 7 days of normal use. The operation is entirely automatic, a pressure switch turns the motor on and off according to demand. The storage reservoir holds water between 20 and 40 PSI pressure. In case of continuous bad weather, the pump can be "jumped" from a regular car battery or recharged with a battery charger.

SPECIFICATIONS

CAPACITY	500 GALLONS / DAY
MAXIMUM LIFT	25 FEET
WORKING PRESSURES	20 TO 40 PSI
PIPE CONNECTIONS	1" NOMINAL
PHOTOVOLTAICS	2 x 38 WATT MODULES
STORAGE BATTERIES (Deep Charge Cycle)	2 x 12 VOLT, 105 AH
RESERVE CAPACITY	7 DAYS

AVERAGE PUMPING CAPACITY PER DAY AT DIFFERENT HEADS
(Based on an average sunny day in Florida.)





TYPICAL INSTALLATION

*NOTE: SEVERAL FEATURES OF THIS PRODUCT ARE PROPRIETARY AND PATENT APPLIED FOR

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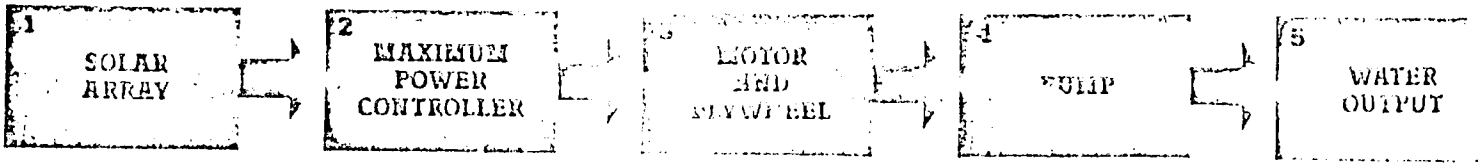
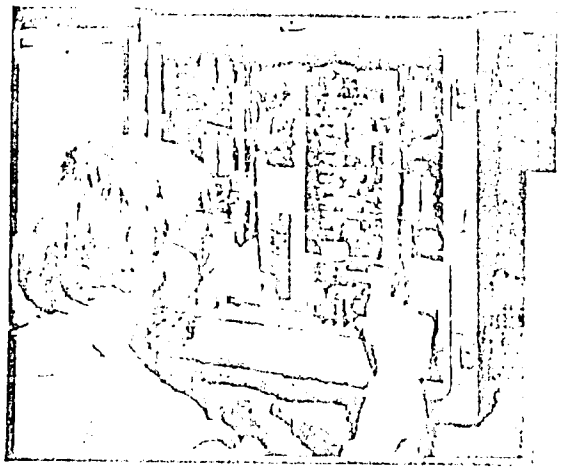


SYSTEM COMPONENTS

1. The solar array of silicon PV cells, laminated between tempered glass and coated metal in an aluminum frame, produces DC electric power when the sun shines on it. The size of the array depends on the desired capacity of the pumping system. The array is installed to face the midday sun, at a fixed tilt to capture maximum sun for the site latitude. Universal tilt adjustments are also available.



2. The Maximum Power Controller* (MPC) is TriSolarCorp's unique solid state current/voltage regulator. By varying circuit impedance, it helps match power to demand . . . as the output of the PV array varies with temperature and the angle and intensity of sunlight . . . and as the pump load varies on start-up and acceleration. Thus the MPC operates the motor at whatever voltage, and resultant speed, will deliver the most pumping hours and the most water in any given day — with earlier morning starts and more continuous operation in partial sun.

3. [illegible] motors are specially adapted [illegible] of splashproof and dust[illegible] construction, with long-life brushes for minimum maintenance. A thermal [illegible] protects against overl[illegible]

Various [illegible] configurations* store [illegible] during the low-power phase of the [illegible] pump stroke, then [illegible] energy to meet the demand of the high-power phase. By leveling the load, the flywheel increases [illegible] output while [illegible] electrical and [illegible] for the system.

[illegible] is a volumetric [illegible] lifts water from

the well with each stroke without relying on [illegible] atmospheric pressure. The weight of the water and pull rod are counterbalanced by weighting the free end of the [illegible] beam.

5. [illegible] to complete the water output system include the pumping cylinder and plunger, drop pipe and pump rod (for various well depths and diameters), stuffing box, well seal and discharge tee.

SYSTEMS OPTIONS

The Maximum Power Controller may be ordered with meters to display both the

electrical output of the PV array and the demands of the pump motor.

Controls may include automatic shutdown, operated by a float switch in the water storage tank, to stop pumping when the tank is full. The system can also be equipped with a water flow meter to measure output.

Power trains, including the MPC, motor and flywheel, are available for retrofitting existing installations.

Note: For other conditions of flow and/or head, TriSolarCorp offers PV pumping systems using either turbine or self-priming centrifugal pumps.

*Patents applied for.

TriSolarCorp
10 DeAngelo Drive, Bedford MA 01730
(617) 275-1200 Telex 940536 BOSTLX (TSC)

. . . putting the sun to work

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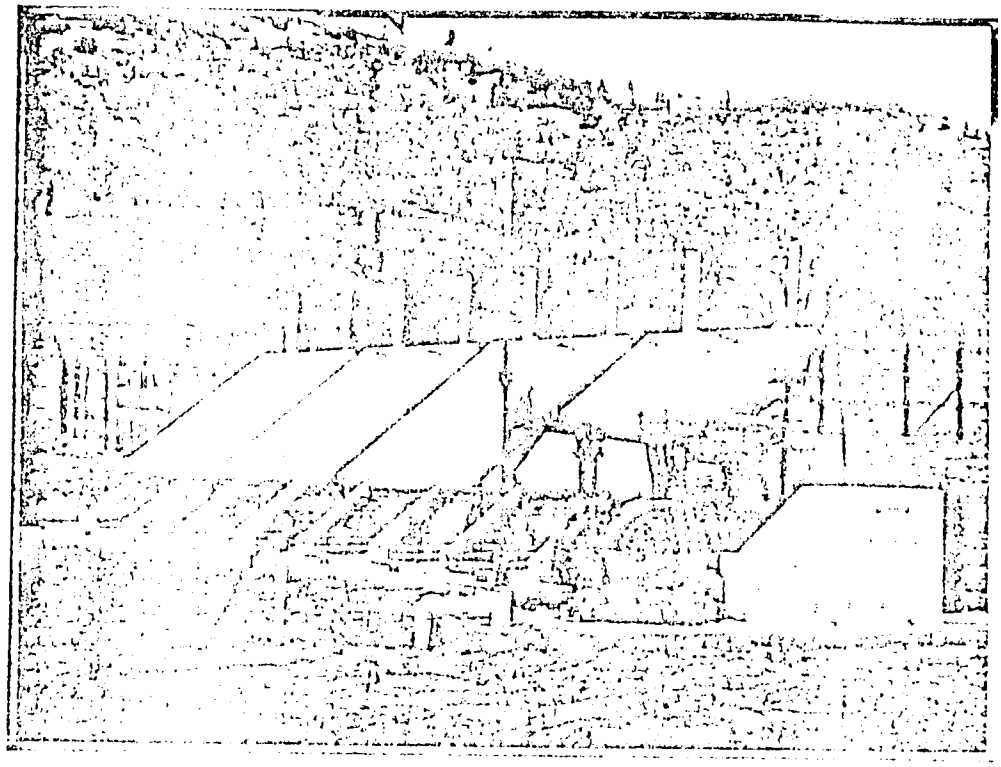
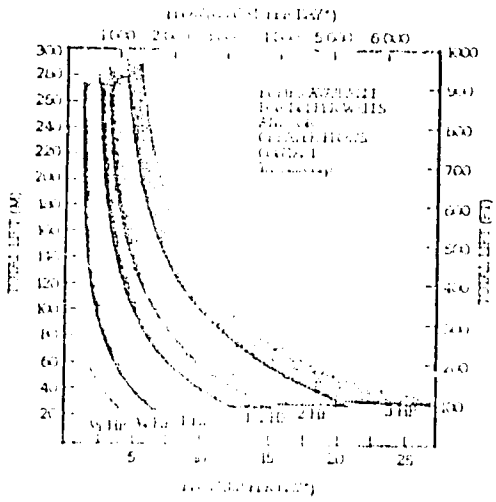
PHOTOVOLTAIC JACK PUMP SYSTEMS

...for low flow rates or deep wells



- Powered by solar cells — needs no fuel.
- Handles low flows, with automatic on/off operation.
- Lifts up to 300 meters (1,000 feet).
- Automatic power regulation for more hours of pumping with minimum sun.
- Flywheel levels cyclical demand — eliminates batteries.
- All components developed for minimum maintenance.
- Engineered by world's most experienced solar-pumping team.

Sometimes called "rod", "donkey" or "grasshopper" pumps, these volumetric pumps are ideally suited for relatively low flow rates combined with lifts of 15 to 300 meters (50-1,000 feet), as shown in the graph on this page. They are characterized by a counterbalanced rocker beam that lifts a piston (and a volume of water) inside a submerged cylinder by means of a rod and connecting linkages.

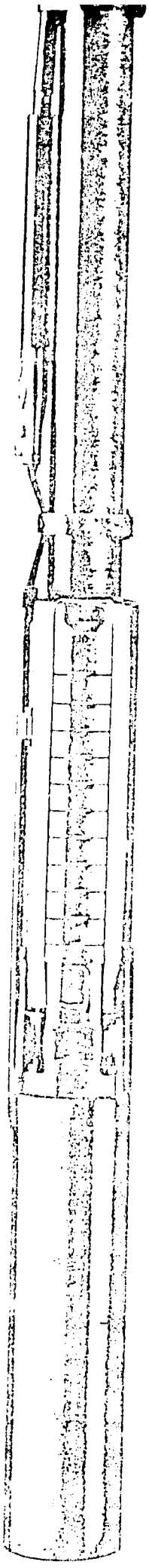


These capabilities ideally match the potable or livestock water delivery needs of many semi-arid regions, where the water table may be deep and the flow minimal. However, they present an engineering challenge in matching the uneven load to the constant power typically available from a PV array. Rather than burdening the system with the costs and maintenance of battery packs to even the load, TriSolarCorp developed new technology: Flywheel inertia levels the cyclical load, while the Maximum Power Controller adjusts voltage and current to match the starting load and provide more pumping hours per day.

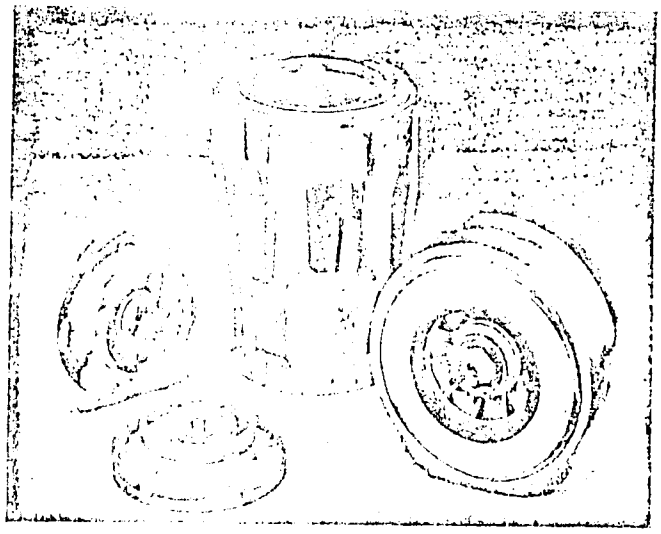
By these innovations, the TriSolarCorp system is independent of both batteries and auxiliary power supplies, for maximum reliability at minimum operating cost. The above system characteristics recommend such applications as livestock watering, drinking water supply and low-volume irrigation in remote locations.

GRUNDFOS

Solar Pumping Systems



GRUNDFOS submersible pumps entirely of stainless steel



Stage by stage, the components are assembled into a complete pump with suction interconnector and discharge chamber.

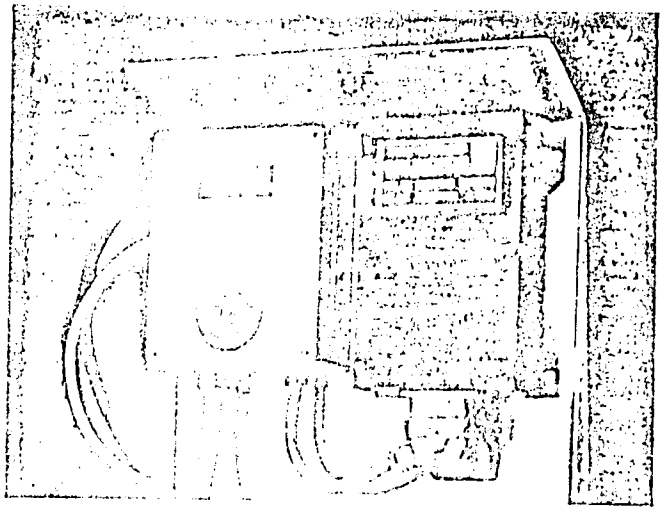
The GRUNDFOS motor, which forms an important part of the unit, has, from many years' experience in operation and production of submersible pumps, been developed and constructed for operation under extreme conditions.

The GRUNDFOS pump/motor unit offers the following advantages:

- Simple installation — threaded pump end for pipe-work connection and push-in cable plug and socket.
- Priming screw at suction interconnector protects against dry-running.
- Manufactured entirely from stainless steel.
- No supervision — pump and motor are water-lubricated.
- Low initial cost and low operating expenses.

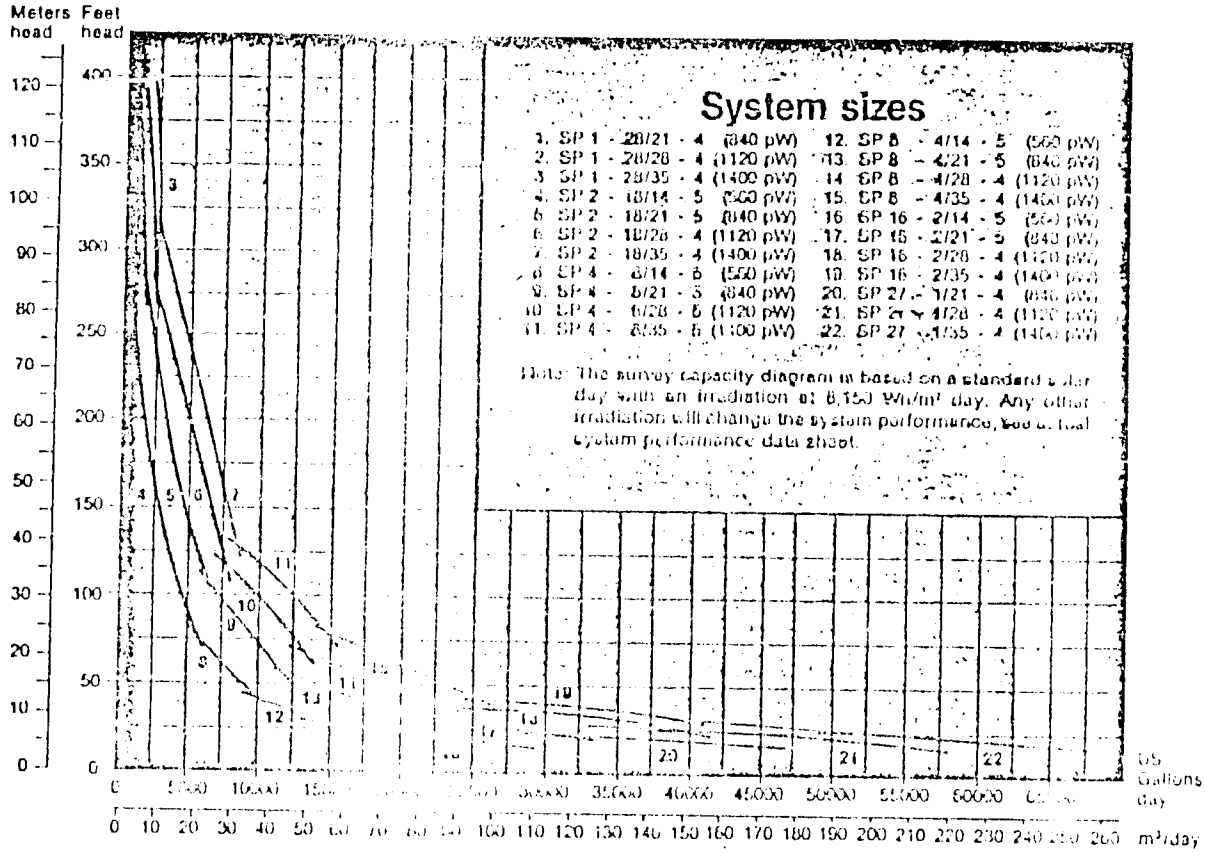
Throughout the world, GRUNDFOS submersible pumps have a reputation for maximum reliability as well as minimum maintenance and power consumption. Complicated individual parts are made from stainless steel plate correctly shaped and welded together to form complete impellers and intermediate chambers with guide vanes — the basic components in GRUNDFOS submersible pumps.

DC-AC inverter Switch box-terminal box

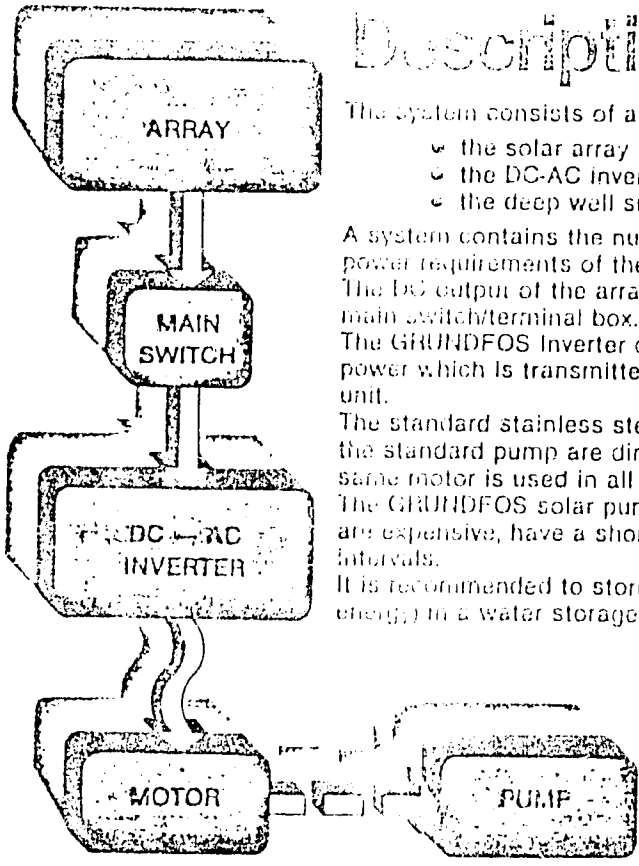


The DC from the solar array is transmitted to the inverter through a main switch - terminal box.
The GRUNDFOS inverter converts the DC power produced by the ARCO SOLAR panels into a three-phase AC voltage to run the pump unit. It is a fully electronic, compact unit and it incorporates the latest technology and meets the severest demands for reliability, extremely long life, and high efficiency. The conversion of DC power into AC power is performed at an efficiency higher than 95%.
The built-in control loops of the inverter ensure that all the power available from the solar panels is drawn continuously.
If the irradiation is intensified, the inverter will automatically increase the frequency and the voltage. As a result, the pump speed is increased.
In practice, this means that the system is capable of delivering water even at very low irradiation values, e.g. immediately after sunrise or in cloudy periods.
Thanks to the automatic control system of the inverter, the available solar energy will all the time be utilized to its maximum. A maximum system efficiency is thereby achieved.
The inverter is equipped with a multi-plug which makes it possible to fit/remove the inverter without disturbing the electrical connections.

Survey capacity diagram



The above diagram shows the statistical water output per day during periods of peak sunlight.
Utilizing arrays of photovoltaic solar modules and a standard GRUNDFOS stainless steel deep well submersible motor/pump unit, the system produces up to 1.5 kilowatts of electricity and is capable of pumping more than 60,000 gallons of water per day (230 m³/day) during periods of peak irradiation and depending on the well parameters.
At lower quantities of water, the system is able to lift the water up to 400 feet (120 meters).
The standard range includes 22 system sizes.



Description of the system

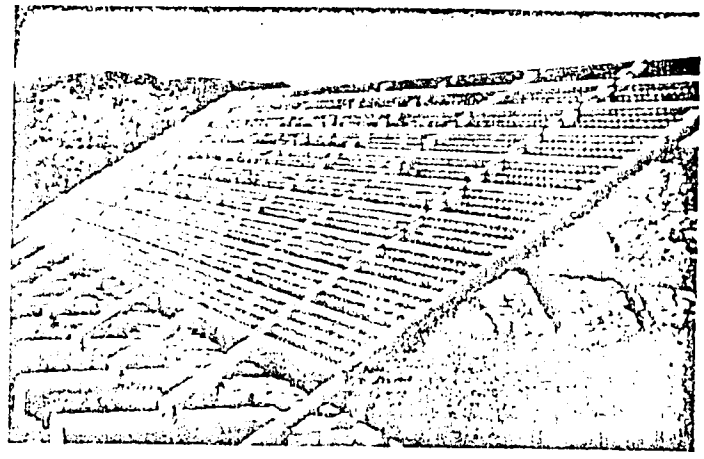
The system consists of a few main components only:

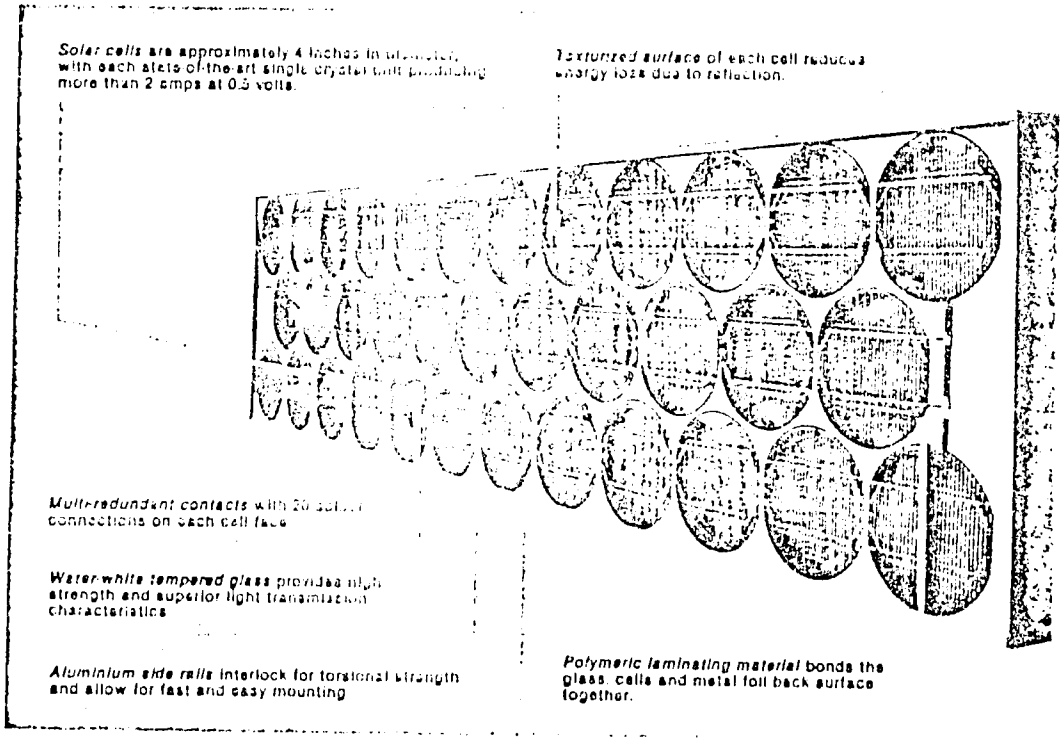
- the solar array
- the DC-AC inverter
- the deep well submersible pump/motor unit

A system contains the number of solar modules which meets the power requirements of the actual system size.
The DC output of the array is transmitted to the inverter through a main switch/terminal box.
The GRUNDFOS Inverter converts the DC power into three-phase AC power which is transmitted to the deep well submersible pump/motor unit.
The standard stainless steel high-efficiency submersible motor and the standard pump are direct coupled and form a complete unit. The same motor is used in all systems.
The GRUNDFOS solar pumping system requires no batteries. Batteries are expensive, have a short life, and require maintenance at regular intervals.
It is recommended to store the pumped water (and thereby the energy) in a water storage tank or a reservoir.

ARCO SOLAR array
Free-standing DC generating station

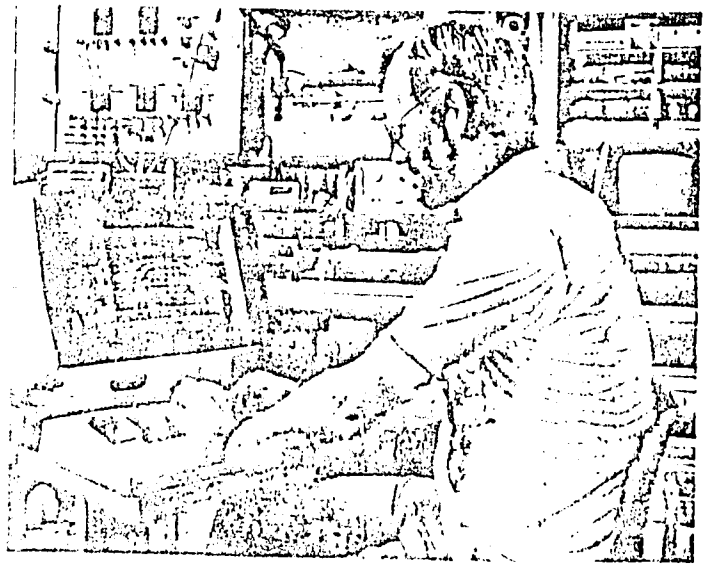
To ensure a uniform high quality of the whole system, GRUNDFOS has chosen ARCO SOLAR's latest module M51, which is the very [illegible] solar panel in the market today. The subarray consists of 7 [illegible]. Two, three, four, or five subarrays can be connected in parallel to meet the power requirements of the system in question.
Both the modules and the supporting structure are [illegible] can stand every conceivable weather condition. The modules have been tested at wind velocities of up to 125 mph (200 km/h).



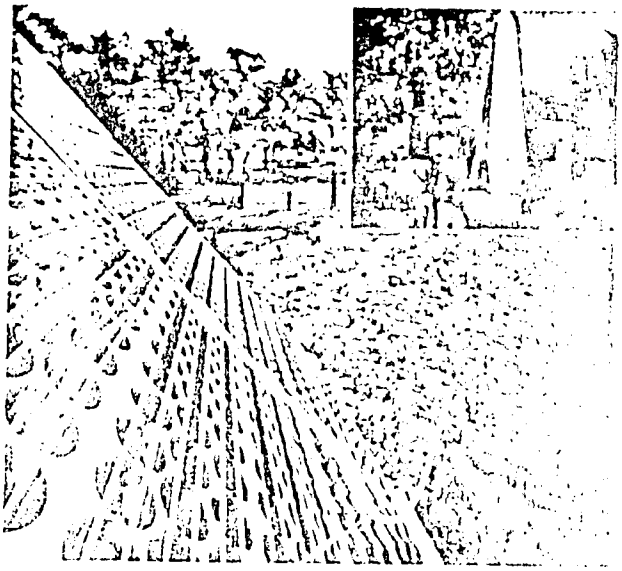


Computer calculations

The irradiation on a tilted surface in a given area on the earth is dependent on a number of factors such as geographic position, climatic conditions, atmospheric conditions, tilt angle, time of the year, etc.
Therefore, it is an extremely complex matter to calculate the irradiation on a given area at a given time.
From statistical weather observation data, etc., we are today able to dimension a GRUNDFOS solar pumping system for use anywhere in the world by means of a large computer in [illegible] research center.
GRUNDFOS has developed a [illegible] design manual which permits [illegible] simple selection of a GRUNDFOS solar pumping system, irrespective of the geographic position.



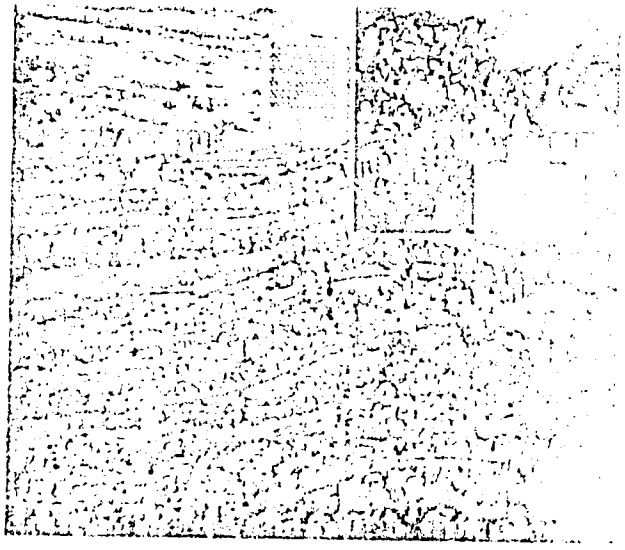
Water supply



In many parts of the world, surface water is available, but this water is very often contaminated and directly responsible for a number of infectious diseases.
A GRUNDFOS solar pumping system would make it possible to tap underground water which is generally clean.
The water can be pumped during the day and stored in community storage facilities.

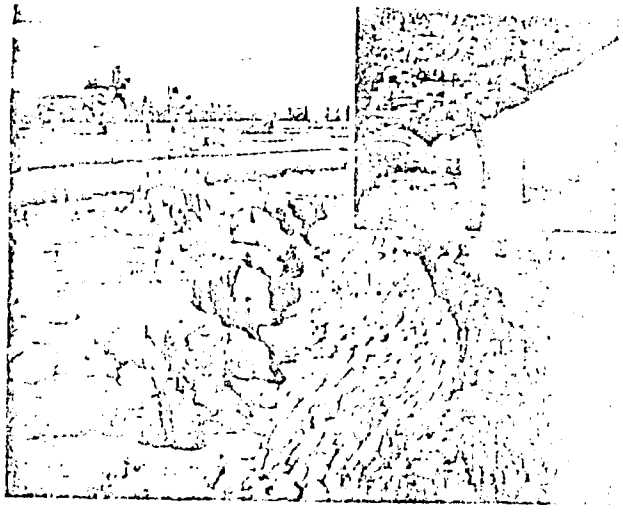
Drip irrigation

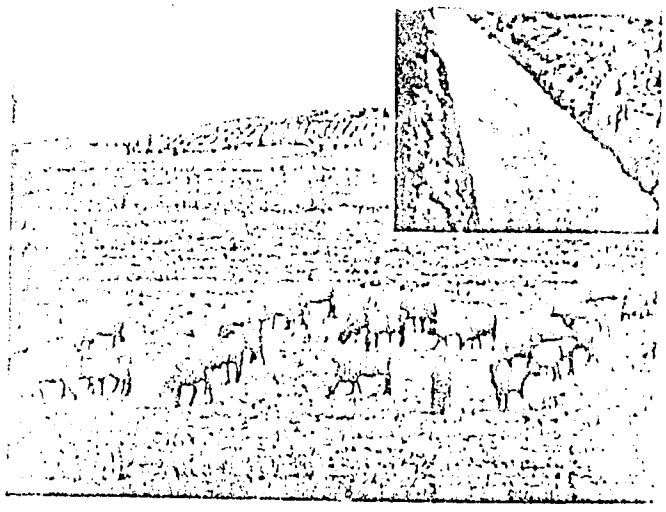
The GRUNDFOS solar pumping system is a commercially attractive to the irrigation systems known today and can be installed without expanding the utility power grid or developing new power plants. The free standing, independent solar pumping system can be installed anywhere without regard to energy costs and supplies.
In agricultural areas, the yield of the crops can be increased and the price per food unit decreased. Most agricultural areas can be developed at small cost.



Livestock watering

The availability of water permits an increase in the productivity of cattle grazing operations. An increased water supply per head will most certainly result in a higher forage intake.
An adequate supply of water for the cattle, sheep, goats etc. in remote areas can be ensured by installing a GRUNDFOS solar-powered livestock watering system, and new areas can be utilized as one does not have to think about fuel costs, fuel transport, and maintenance. The GRUNDFOS solar powered pumping system is reliable and will pump water from sunrise to sunset year in year out.





GRUNDFOS
GRUNDFOS Pumps Corporation
2555 Clovis Avenue • Clovis, California
Telephone (209) 299-9741 • Telex

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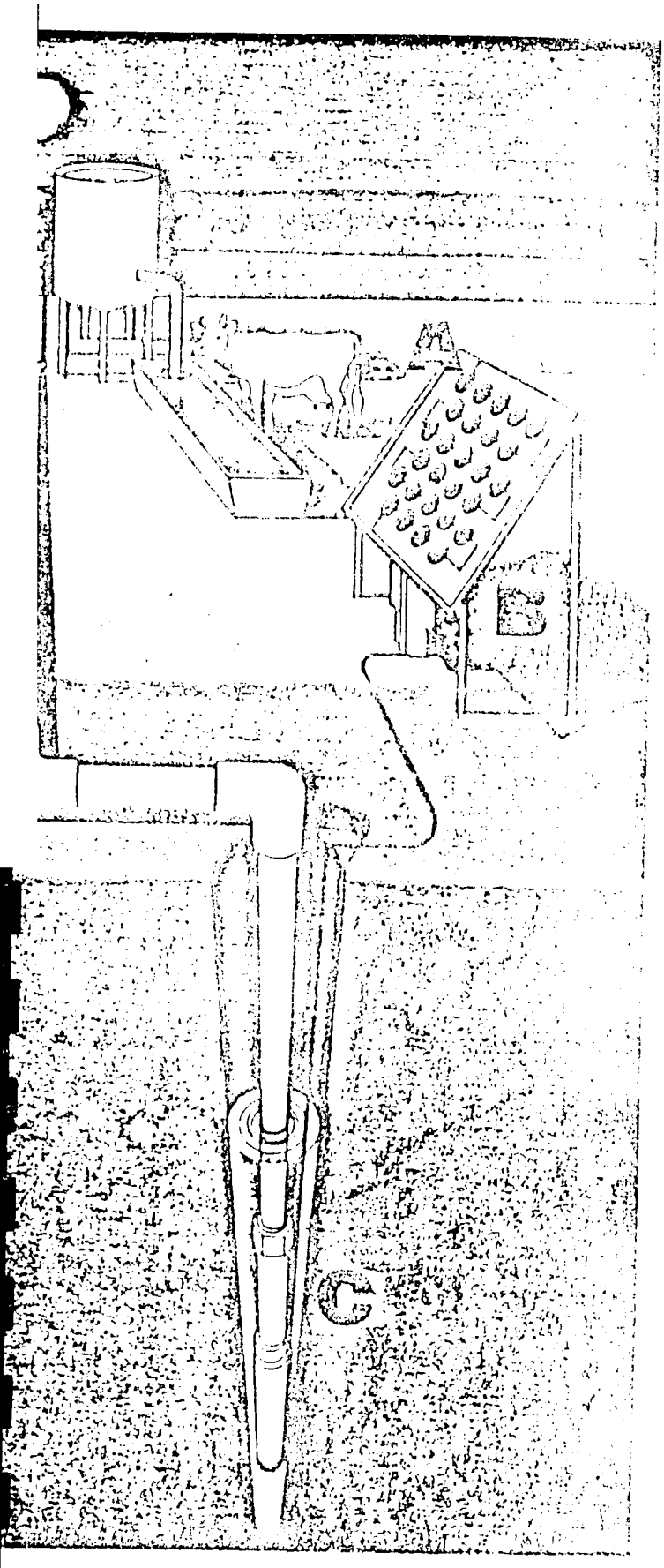
The Sun
The Pump
Powered by the Sun

The Simple Basics of Solar Pumping



A solar powered pumping system is an economical alternative to other methods of supply where small irrigation or drinking water requirements are beyond the availability of utility power. A typical system can be as simple as solar panels connected directly to a pump, or may include components to better receive the sun's rays and/or store the energy during periods of darkness.

A The photovoltaic cells are connected in multiples, both in parallel and in series, to produce direct current power which varies during the day in relation to the intensity of the sun.

B The array (several panels of photovoltaic cells) is sized to meet water requirements and mounted to maximize the incoming rays of the sun.

C Jacuzzi solar flow submersible pumps may be supplied with special direct current low voltage submersible motors to be connected directly to the solar array.

Additional components may be added included tracking devices to align the array to the sun, energy storage batteries, water storage tanks and interconnection to other electrical supplies.

To achieve maximum performance from systems using Jacuzzi solar flow pumps, the design and selection of equipment is critically important. An authorized Jacuzzi solar flow pump distributor is best qualified to engineer the system for the local environment, specify the components from various manufacturers and install the proper Jacuzzi solar flow submersible to meet requirements.

Jacuzzi Solar Flow Submersible Pumps

Jacuzzi engineers developed this equipment to provide optimum performance from the overall system as well as each component. The Jacuzzi solar flow pump achieves a new level of operating efficiency and reliability.

EFFICIENCY

PUMP designs include an impeller eye seal reducing backflow. Submersed pumping elements perform more efficiently and require no mechanical shaft seal.

MOTOR designs include direct current models. Jacuzzi motors do not require mechanical seal or power converters which absorb energy.

SYSTEMS can be sized for a smaller number of panels due to the wide selection of pumps and the direct connected, direct current brush-type motor (Pat. Pending).

RELIABILITY

PUMP elements are production units from Jacuzzi Inc., a worldwide water system pump manufacturer. Since the pump is submersed, it is self-priming.

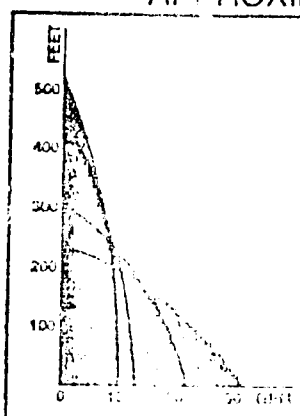
MOTORS are available with direct current brush design (Pat. Pending) providing years of operation between maintenance cycles. Models have a magnetic coupling which eliminates the shaft seal and disengages upon overload conditions.

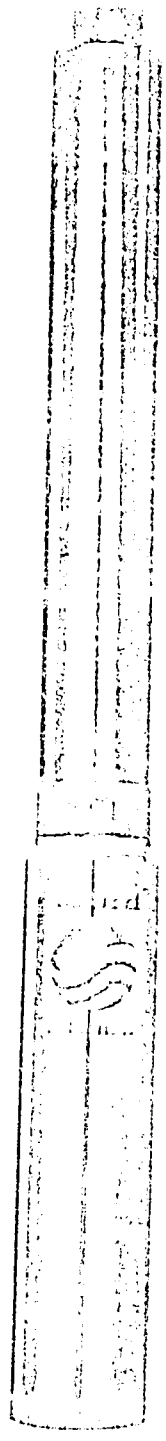
SYSTEMS can be provided in pure direct current eliminating electronic power converters. The pump and motor are installed underground away from vandals and the weather.

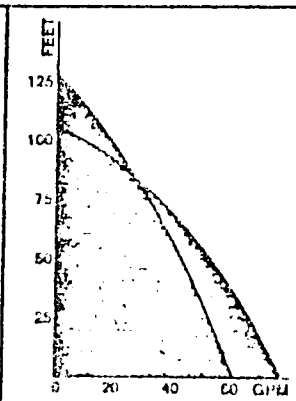
COST-EFFECTIVE

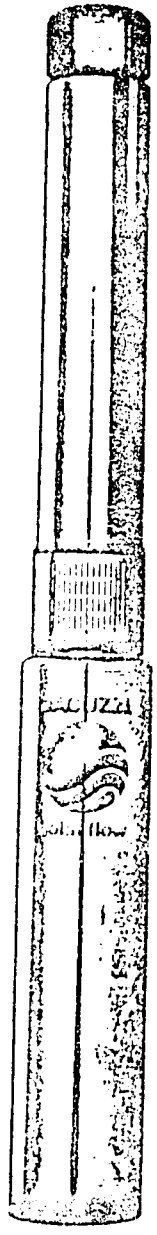
The efficiency and reliability of individual components results in new economies for solar-powered pumping. The extensive range of Jacuzzi solar flow pump models makes it possible to match solar pump systems to needs in the field.

APPROXIMATE PUMPING PERFORMANCE

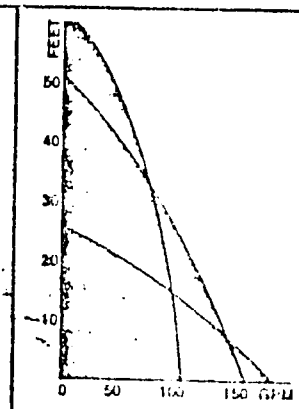


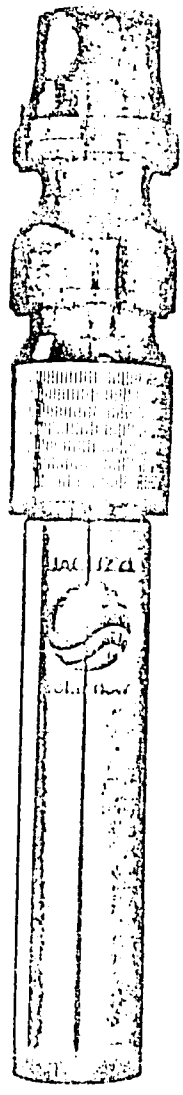






Capacity up to 60 GPM



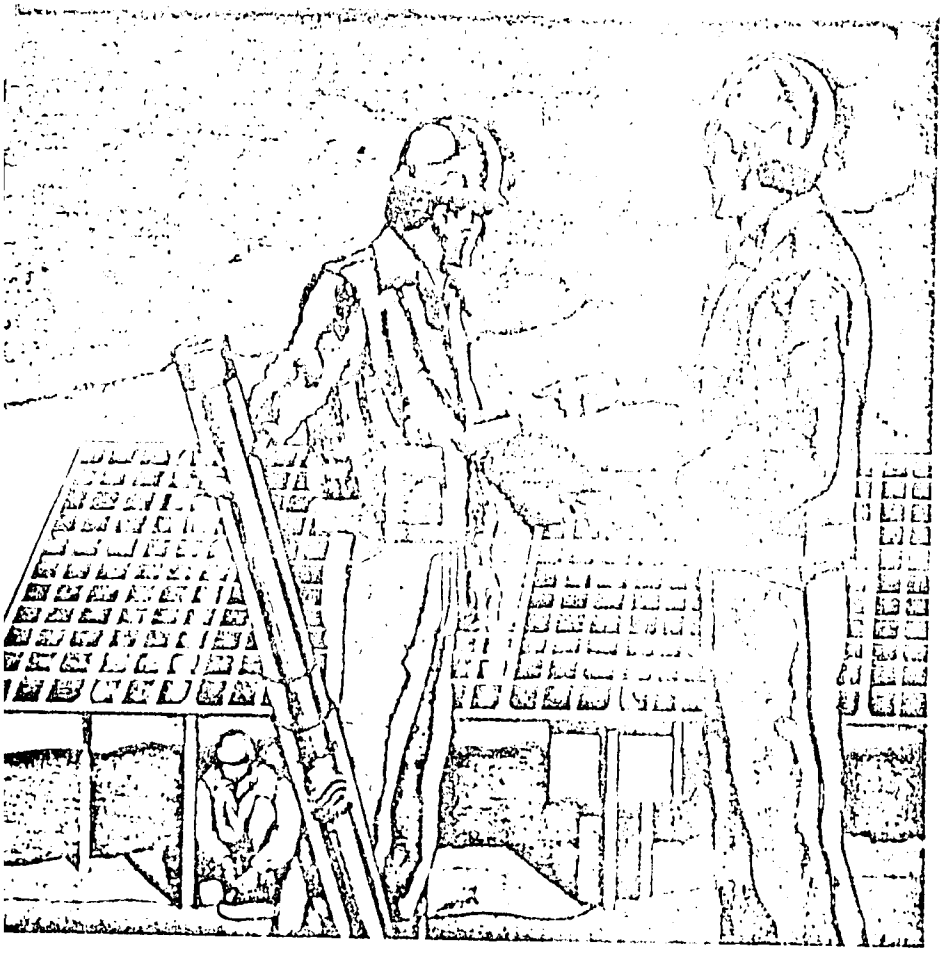


Jacuzzi Solar Flow Submersibles: Water for the World

It takes more than the power of the sun and Jacuzzi innovation to bring new solar water pumping advantages to the world. Energy available from the sun varies from country to country. The application of solar pumping technology requires experience beyond that needed for conventional water systems.

Jacuzzi solar flow pump distributors are available everywhere to design, engineer and install working sun-powered water systems. Solar panels, supporting structures, sun trackers, [illegible] current motors, and pumps must work together for maximum [illegible] efficiency.

For more information about solar pumping [illegible] and expert consultation [illegible] Jacuzzi solar flow pump to meet your needs, contact your local Jacuzzi distributor.



JACUZZI

solarflow

Contact any of the following Jacuzzi offices supporting the growing group of Jacuzzi solar flow pump distributors around the world.

CORPORATE HEADQUARTERS

JACUZZI INC.
12401 Interstate 30, P.O. Box 6503
Little Rock, Arkansas 72219-6503 USA
Telephone: (501) 455-1234
Telex: 53-6446

SUBSIDIARIES

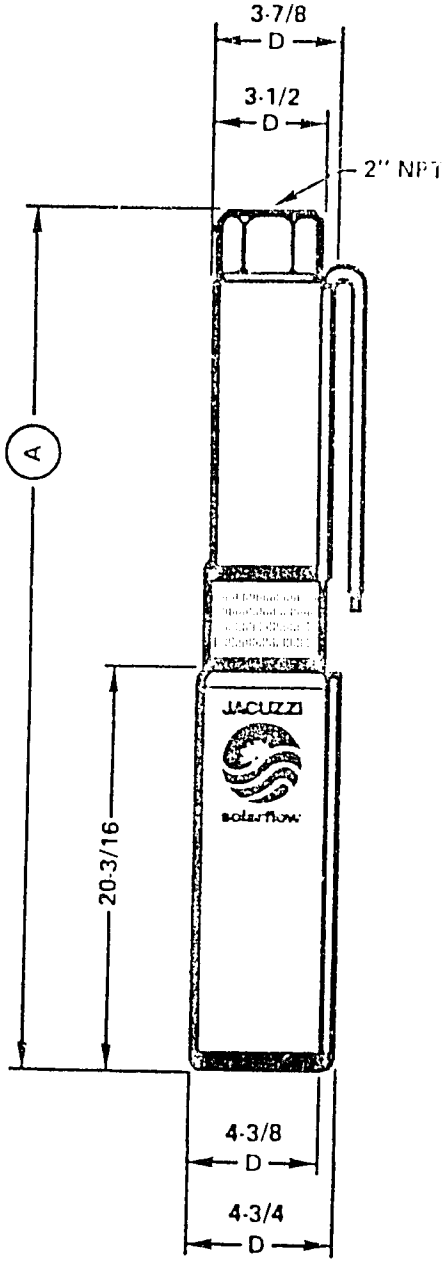
JACUZZI do BRASIL LTDA.
Caixa Postal 285
CEP 13.300 Itu
S.P. Brasil
Telephone: (011) 482-6711
Telex: 391-1135703

JACUZZI CANADA LTD.
330 Humberline Drive
Rexdale, Ontario, Canada M9W 1R5
Telephone: (416) 675-3333
Telex: 06989122

JACUZZI (CHILE) S.A.
Casilla 46
Cerillos, Santiago, Chile
Telephone: (011) 57-5403
Telex: 332-340260

JACUZZI EUROPE S.p.A.
33086 Vallenoncello
Pordenone, Italy
Telephone: (434) 85141
Telex: 450839

JACUZZI®
Subsidiary of Kidde, Inc
KIDDE

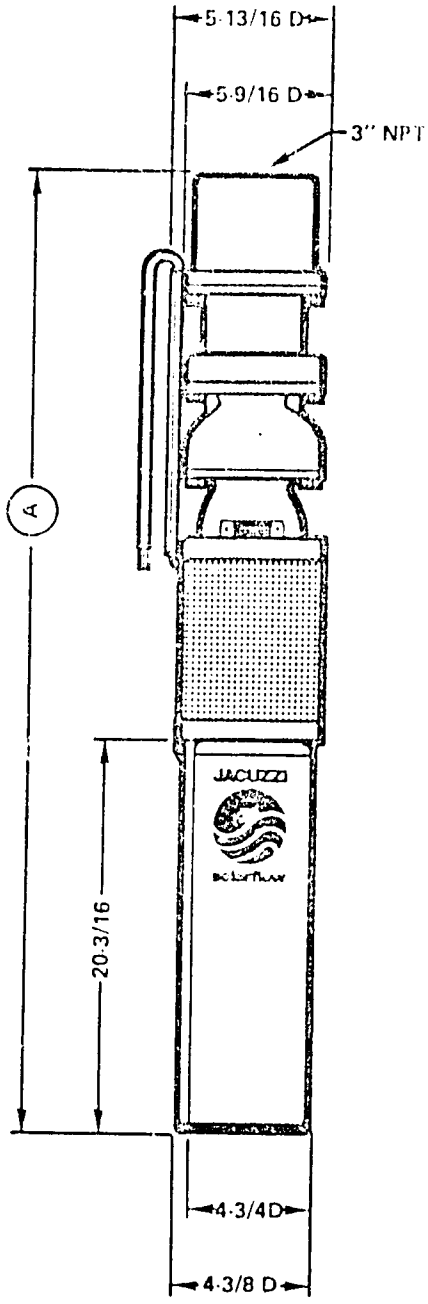


MODEL F-G SPECIFICATIONS

Jacuzzi solar flow pumps include hydraulic elements which are interchangeable with standard production units. Models F and G feature stainless steel shell, shaft, coupling and wire guard. The motor bracket and discharge piece are cast iron.

The impellers and diffusers are of glass reinforced molded thermoplastic which allows smooth and exact design shapes for consistent performance. Each impeller stage incorporates the exclusive Jacuzzi "floating seal". These seals, of bearing material, fit closely around the eye and hub of the impeller, but "float" within a seat and prevent water from recycling to low pressure areas. These features provide the high efficiency as indicated on the performance curves.

MODEL NO.		NO. OF	CAPACITY	WELL	(A)	DISCHARGE
Motor	Pump	Stages	GPM	Size		Pipe Size
SJ1	F 4	4	34	5"	36-11/16	2"
SJ1	G 3	3	42	5"	34-9/16	2"



MODEL M SPECIFICATIONS

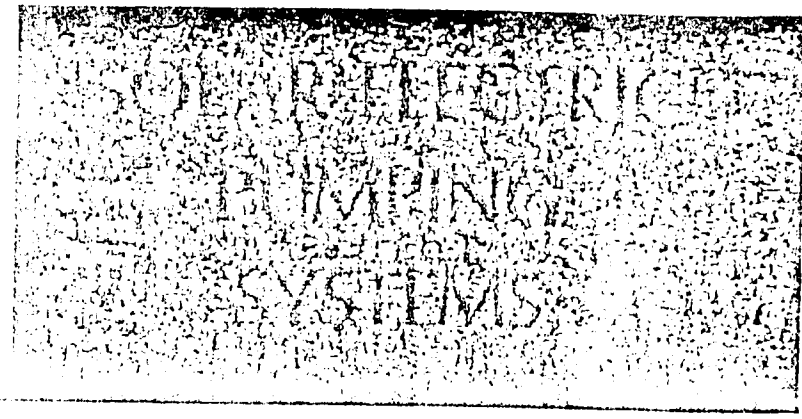
Jacuzzi solar flow pumps include hydraulic elements which are interchangeable with standard production units. Models M are of industrial turbine design and feature stainless shaft, wire guard and fastenings. The motor bracket, bowls, and discharge piece are cast iron. The interior passages are porcelain-coated for maximum efficiency. The impellers are cast bronze and hand-finished for consistent performance as indicated on the performance curves.

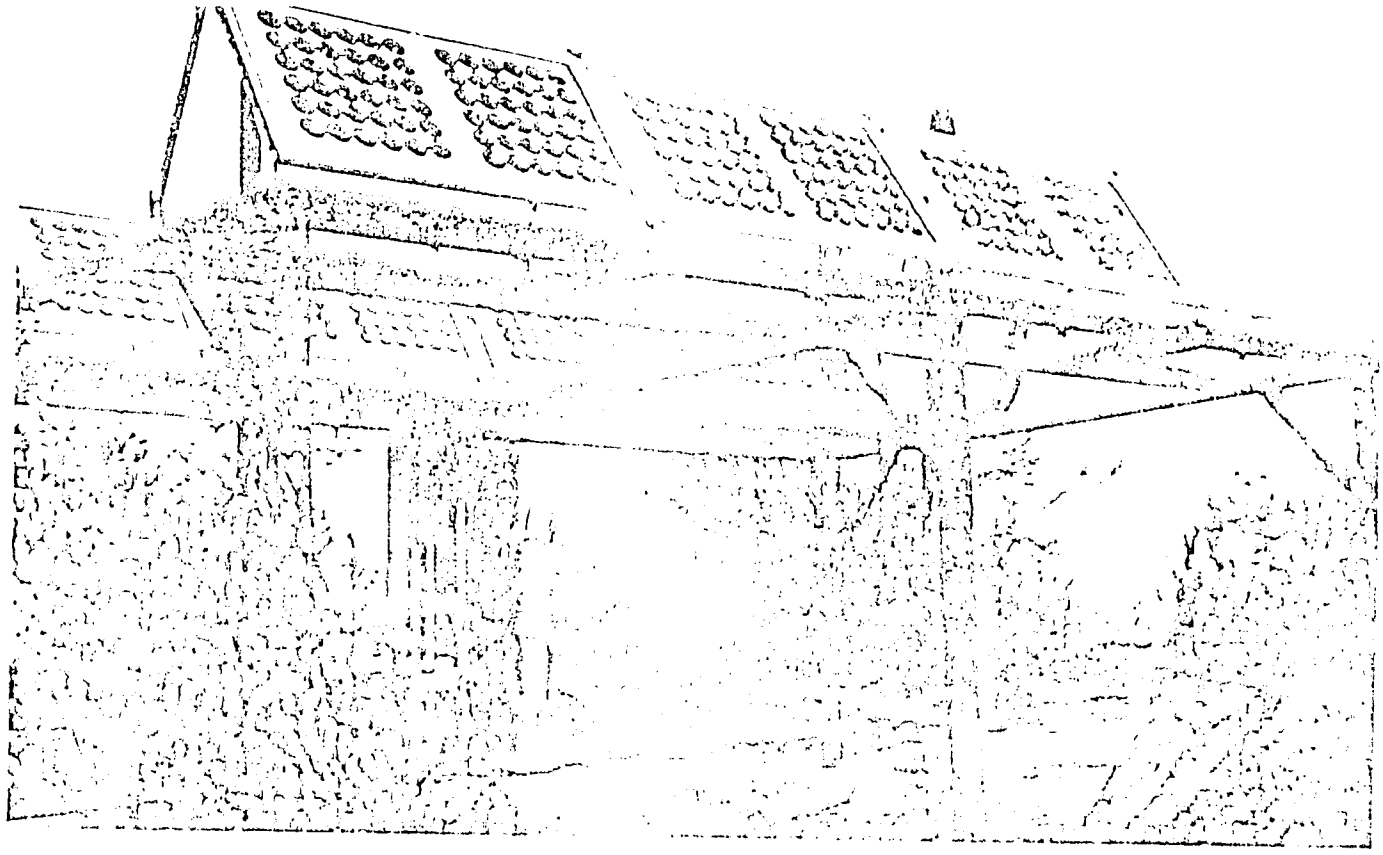
MODEL NO.		NO. OF	CAPACITY	WELL		DISCHARGE
Motor	Pump	Stages	GPM	Size	(A)	Pipe Size
SJ1	M1A	1	60	6"	43-7/16	3"
SJ1	M1B	1	65	6"	43-7/16	3"
SJ1	M1C	1	70	6"	43-7/16	3"

SOLAR
ENERGY
SYSTEMS

Solatherm Inc.

1312 Apple Ave., Silver Spring, Maryland 20910
(202) 882-4000



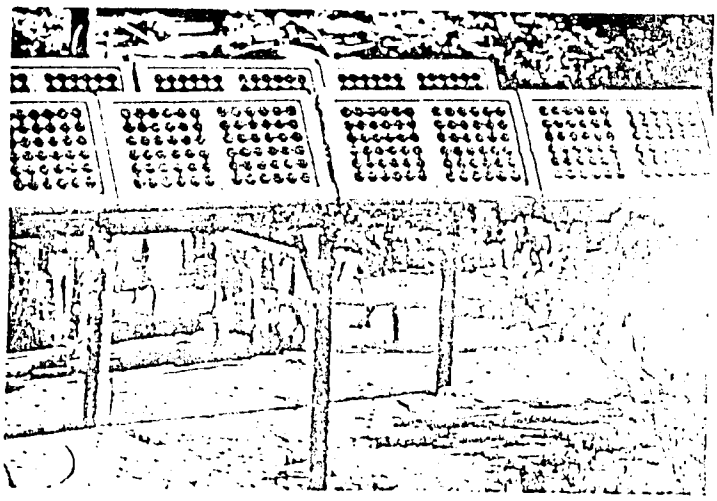


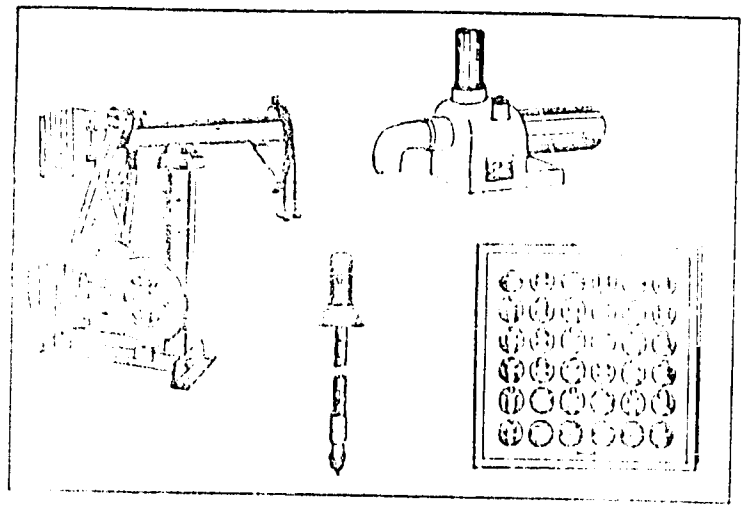
RELIABLE AND ECONOMICAL WATER PUMPING

- IDEAL FOR REMOTE LOCATIONS
- HIGHLY RELIABLE
- REQUIRES NO FUEL
- EASY INSTALLATION
- FULLY AUTOMATIC
- MAINTENANCE-FREE
- SILENT, SAFE, NON-POLLUTING

MONEGON Solar Powered Pumping Systems can provide fresh water for irrigation, livestock, or drinking. Solar electricity is the most reliable and economical of any remote power source and it is virtually maintenance-free. MONEGON Pumping Systems, powered completely by the sun, are ideal for new and replacement installations.

MONEGON Pumping Systems are designed specifically to your location requirements. We use only the most reliable positive displacement ("duck"), centrifugal, or jet pumps available. The maintenance-free electrical power equipment features tested solar panels and a specially designed power controller to extract maximum efficiency from the solar panel/water pump combination.





PHOTOVOLTAIC WATER PUMPING SYSTEMS TO MEET YOUR NEEDS.

Solar Panel Array, with:

- Panels
- Panel support structure (exclusive of footings or foundation)
- Array interconnect wiring, connectors, and junction boxes

Jack, Centrifugal, or Jet Pump:

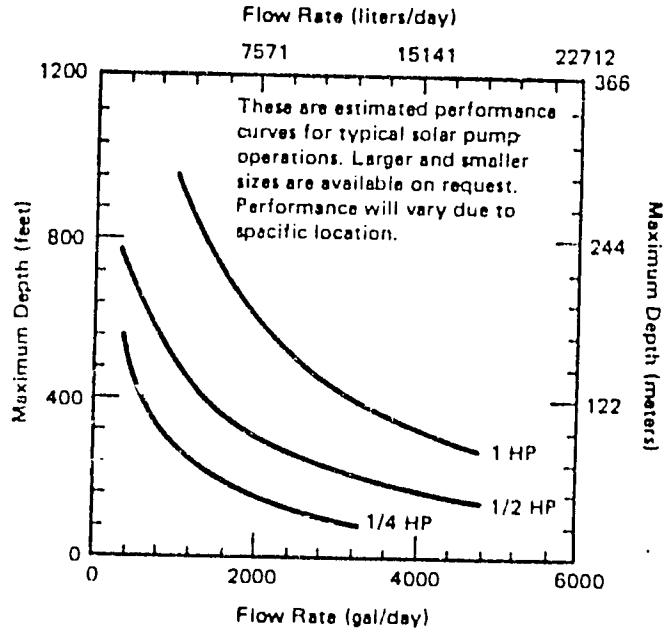
- Selected for your requirements
- High water production for less cost
- Years of proven reliability

DC Motor, featuring:

- Extremely high efficiency, approx. 85%
- Long brush life, over 5000 hrs. (approx. 3 years normal use)
- Low maintenance

Controls, including:

- Solar panel/motor interface electronics
- Small battery pack (as required)

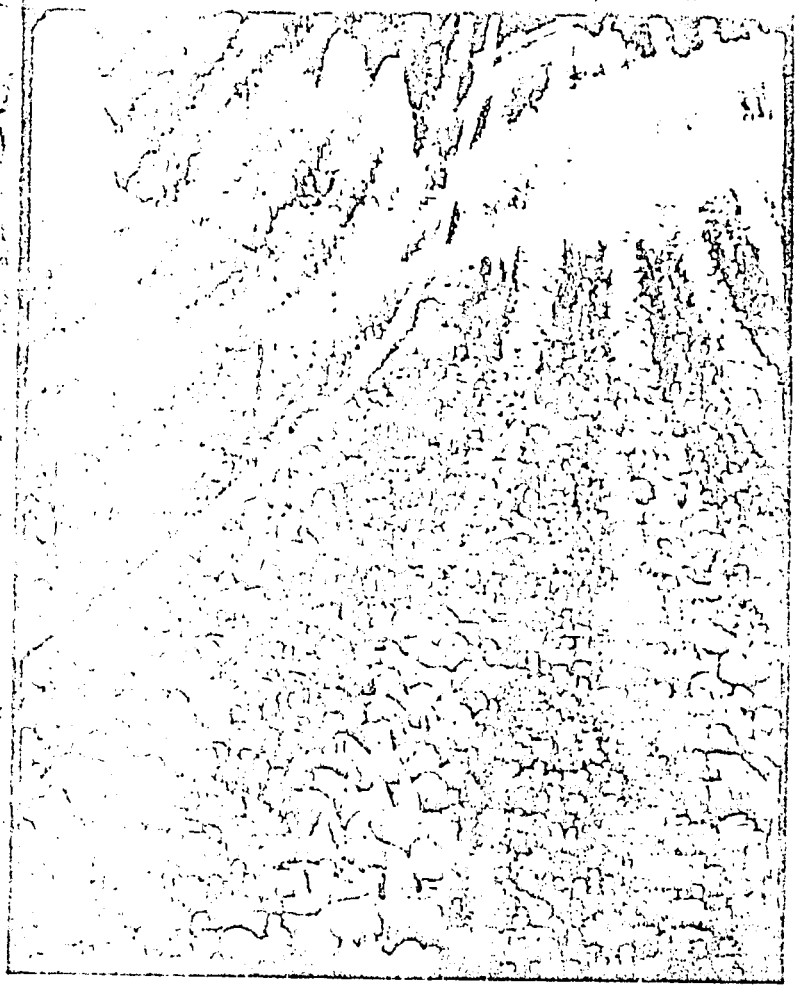


Fresh water is essential for crops, livestock and for community drinking water and is needed in many areas where commercial electricity is not available. In most cases water can be pumped during sunshine and stored for use at night and during cloudy periods. For this reason the basic pumping system does not include battery storage. Where required, storage batteries can be furnished to provide continuous uninterrupted pumping operation.

SOLAR
ENERGY
SYSTEMS

Solartherm Inc.

1315 Apple Ave., Silver Spring, Maryland 20910
(202) 882-4000



IRRIGATION/DRINKING/CLEANING/COOLING/PROCESSING

olar photovoltaic water pumping systems

solec

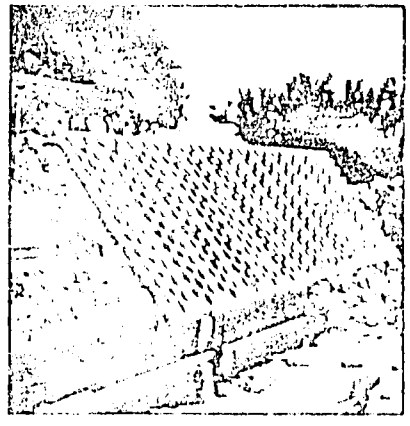
A Member of the Hanington Group

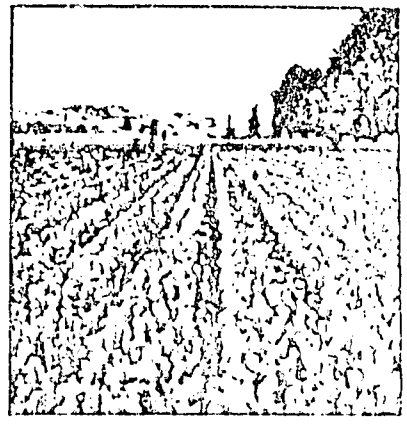
Solec: Systems to get pumped up about

Solec, a leader in the manufacture of photovoltaic solar cells, modules, and systems, now offers a broad variety of packaged water pumping components which run on reliable, efficient, and maintenance-free photovoltaic power.

To ensure trouble-free operation, Solec engineers have field-tested and analyzed every system component. You can be assured that these water delivery products (chosen from only established manufacturers) work as productively on photovoltaic electric power as they do on other power sources.

Solec components: A powerful solution





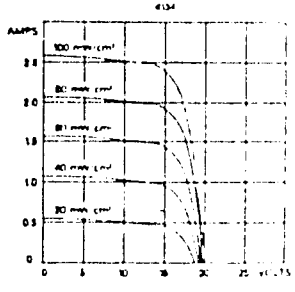
The Solar module at the heart of the system is the Solec S-4134, a solar cell module that meets all requirements of JPL Specification 5260-5. A similar module design currently being used by the United States Air Force at their Test Center in China Lake, California, has proven its durability in years of field operation.

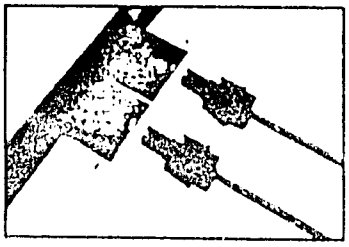
To deliver both higher dielectric strength and moisture resistance, the Solec S-4134 is encapsulated with a transparent plastomer called ethylene vinyl acetate (EVA). In tests conducted by JPL, it has proven to be a superior encapsulant to either PVB or silicone.

The Tedlar film back sheets used on the Solec module provide the best environmental protection of any available material, according to JPL tests. Sealants around module terminals and edges meet the exacting requirements of the U.S. Navy.

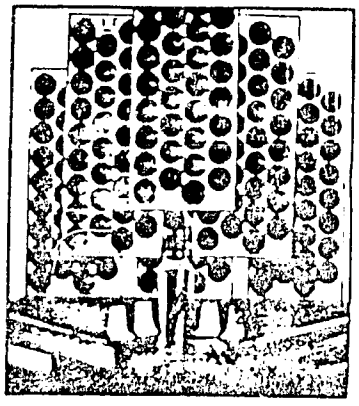
Peak Power Characteristics of the S-4134 Solar Module
(under solar insolation of 100mw/cm² @25° C)

Peak Power	35 Watts
Peak Power Current	15.7 Volts
Open Power Current	2.23 Amps
Open Circuit Voltage	20.5 Volts
Short Circuit Voltage	2.4 Amps





Solec's unique "Solarlok" Plug-In
Connectors deliver higher reliability in severe environments than conventional junction box connections with screw type terminals. This solution overcomes the common problems of seal breakage and moisture entry into the module encapsulant that are the result of over-torquing junction box connections during installation. For even greater protection, the Amp Solarlok connector with 600 volt @ #10 or #14 wire, has a positive locking device and an O-ring seal. Safety locking mating receptacles are also provided at the junction box.



Modular Design Arrays on Solec water pumping systems mean that all sub-arrays are identical and interchangeable.

Sub Arrays, mounting structures are capable of withstanding 125 mph winds, and consist of 3 solar modules each. These modules can be connected in parallel providing 105 watts of peak power at 15.7 VCD or 6.69 Amps. Each S-4134 module comes with dual AMP "Solarlok" connections at the back. Additional connectors on each of the sub-arrays allow for quick and easy changing of alternate batteries for those periods when the sub-array is not being used to drive the pump set.

For durability and safety, every Solec water pumping system includes a GE THN 22-61-RHDC Safety Switch mounted in a NEMA 4 rated junction box. This heavy duty enclosure is resistant to extremes in the environment. For added protection, a safety lock receptacle is also installed at the motor/pump set and sub-array connections.

Shallow well submersible pump set

Solec has selected a totally submersible self-priming centrifugal pump for its irrigation and water pumping systems. The pump and motor are constructed with a stainless steel screen and bronze impeller.

Pump Specifications

Pump Number	SWP-1A (16/10)	SWP-2A (16/40)
Pump Weight	13 lbs. (5.9 kg)	13 lbs (5.9 kg)
Impeller Diameter	2-1/8"	2-1/8"
Blade Width	3/4"	3/4"
Intake Orifice	1-5/16"	1-5/16"
Lift	16 feet (4.9 m)	16 feet (4.9 m)
Voltage	12 VDC	15.2 VDC
Current	15 Amps	26.2 Amps
Delivery Rate	10 GPM	40 GPM
Static Pressure	12 psi	12 psi
No. of Sub-Arrays	2	4
Array Power	175 Watts	420 Watts

To complete your system, Solec also delivers to your site approximately 50 feet of 2" reinforced plastic pipe with clamps and fittings, and pipe to go down the well. Discharge piping should be installed with a downward pitch so that it does not create additional lift on the pump.

System SWP-1A (16/10) (10 GPM @ 16') configuration

5 S-4134 Solar Modules

Lot Array Structures
10 Solarlok Interconnections
1 NEMA 4 Enclosure
1 Safety Switch (GE THN-22-61 RHDC)
2 Safety Lock Pairs
1 Array Interconnection
1 Motor/Pump Assembly
50 Feet of 2" PVC Reinforced Pipe
40 Feet of AWG #10 Wire
2 Pole Mount Structures
1 Lot of Miscellaneous Hardware (Couples, tees, ells, etc.)
1 Set of Installation Tools

System SWP-2A (16/40) (40 GPM @ 16') configuration

12 S-4134 Solar Modules

Lot Array Structure
24 Solarlok Interconnections
1 NEMA 4 Enclosure
1 Safety Switch (GE THN-22-61 RHDC)
4 Safety Lock Pairs
3 Array Interconnections
1 Motor/Pump Assembly
50 Feet of 2" PVC Reinforced Pipe
40 Feet of AWG #10 Wire
4 Pole Mount Array Structures
1 Lot of Miscellaneous Hardware (Couples, tees, ells, etc.)
1 Set of Installation Tools

Medium well vertical turbine pump systems

Sub-Arrays for this system are lightweight aluminum for easy transportability and installation on either concrete pads or anchored wood platforms. Each sub-array consists of (6) S-4134 solar modules.

Surface Mounted Dual Impeller Centrifugal or Vertical Turbine Centrifugal Pumps are ideally suited for tube wells, cisterns, and other reservoirs with moderate to high flows. You'll find them especially efficient at rates from 10 gallons/minutes/and up.

Pump/Motors in these Solec systems are specially designed to operate at 1800 or 3600 rpm and range from ½ to 3 horsepower. Solec systems utilize high efficiency permanent magnet D.C. motors. These systems utilize maximum power trackers to increase power during initial start-up and provide more pumping hours per day.

Pump Specifications

Pump Designation	SWP-3A (30/25)	SWP-4A (50/35)	SWP-5A (150/10)
Lift	30 feet (9.14 m)	50 feet (15.24 m)	150 feet (45.7 m)
Delivery Rate	25 GPM (1.58 l/s)	35 GPM (2.21 l/s)	10 GPM (.63 l/s)
Voltage	30 VDC	90 VDC	90 VDC
Current	13.4 Amps	20 Amps	27 Amp
# of Pump Stages	1 stage	9 stages	10 stages
Static Pressure	14.1 psi	14.1 psi	14.1 psi
# of Sub-Arrays	3	9	12
Array Power	630 Watts	1890 Watts	2520 Watts

Solec systems for your special needs

Solec can custom-design a photovoltaic system to your specifications. We suggest that you consult our Engineering Staff to discuss your specific application and to receive a price for your made-to-order system.

PILKINGTON
◄ Solar Technologies ►

Solec International, Inc., 12533 Chadron Avenue, Hawthorne, California 90250
Telephone (213) 970-0065 TWX 910-325-6215 SOLEC HWTH

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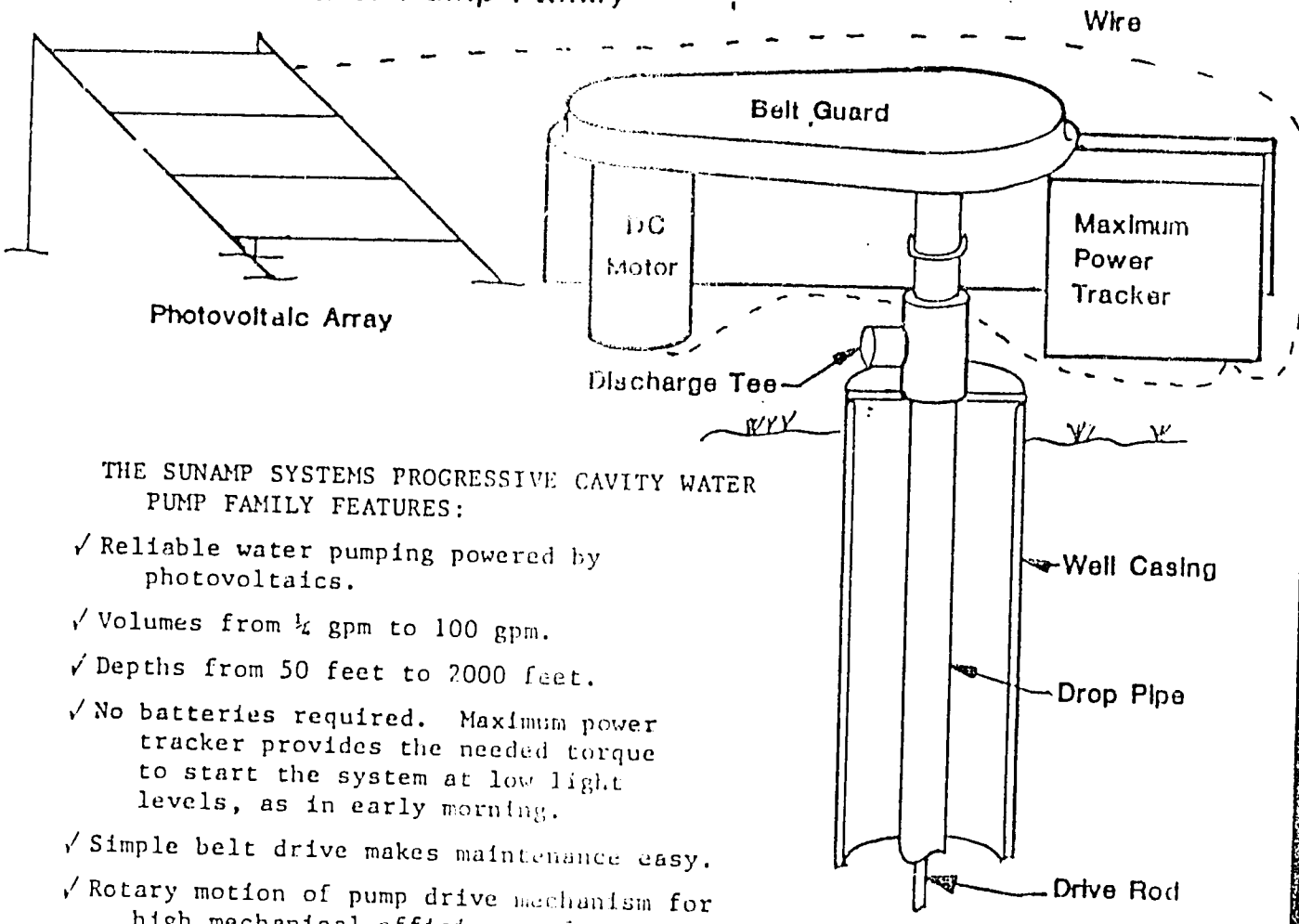
SunAmp Systems Inc

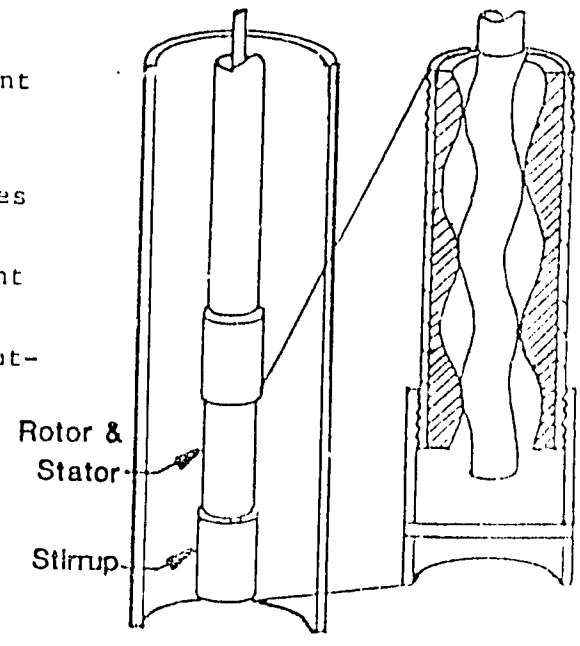
PHOTOVOLTAIC PRODUCTS

SunAmp Systems™ Progressive Cavity Water Pump Family



THE SUNAMP SYSTEMS PROGRESSIVE CAVITY WATER PUMP FAMILY FEATURES:

- ✓ Reliable water pumping powered by photovoltaics.
- ✓ Volumes from ¼ gpm to 100 gpm.
- ✓ Depths from 50 feet to 2000 feet.
- ✓ No batteries required. Maximum power tracker provides the needed torque to start the system at low light levels, as in early morning.
- ✓ Simple belt drive makes maintenance easy.
- ✓ Rotary motion of pump drive mechanism for high mechanical efficiency of system. (No losses due to gear reducers.)
- ✓ Precision engineered positive displacement pump rotor and stator give excellent hydraulic efficiency.
- ✓ Overall photovoltaic to water efficiencies over 40%.
- ✓ Long life D.C. brushes require replacement infrequently.
- ✓ Expandable system. May increase water output by adding more PV modules.
- ✓ Range of systems from 1/20 hp to 20 hp.



APPLICATIONS:

Domestic···Livestock···Irrigation

7702 East Gray Road Scottsdale, Arizona 85260 (602) 951-0699

STANDARD MODELS BY NUMBER

Nominal U.S. Gallons/Minute Delivered per 100 RPM

(Actual flow rate 10 to 20% less depending on pressure)

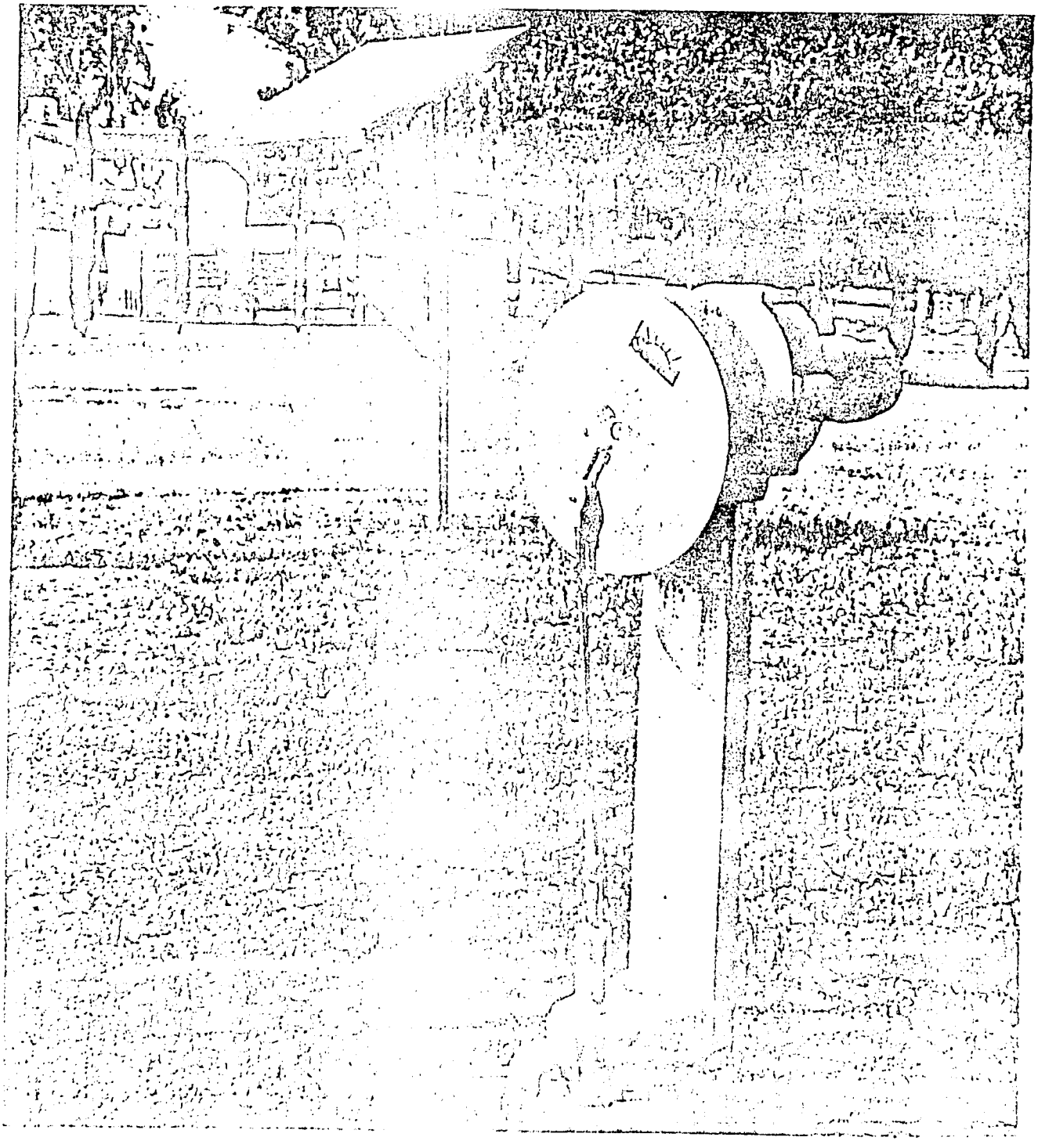
Total Delivered Head	.25	0.86	2.02	5.2	11.7	18.8	27.7	44.0
100'	¼A-1	1A-1	2B-1	SC-1	12D-1	18E-1	28F-1	44-G*
200'	¼A-2	1A-2	2B-2	SC-2	12D-2	18E-2		
300'	¼A-3	1A-3	2B-3	SC-3	12D-3			
400'	¼A-4	1A-4	2B-4	SC-4	12D-4			
500'	¼A-5	1A-5	2B-5	SC-5	12D-5			
600'	¼A-6	1A-6	2B-6	SC-6	*			

Other models may be special ordered. Call SunAmp Systems for non-standard requirements. (The 44-G series is not yet available.)

Model Type	Rotor Diameter	Drop Pipe Diameter	Minimum Well Casing Diameter
¼A	7/8"	1¼"	2"
1A	1-3/16"	2"	3"
2B	1-9/16"	2½"	4"
SC	1-7/8"	3"	5"
12D	2-½"	5"	7"
18E	2-½"	6"	8"
28F	2-½"	6"	8"
44G		8"	10"

Sunmill

Solar powered water pumps combining today's mature high technolloggy with time proven methods



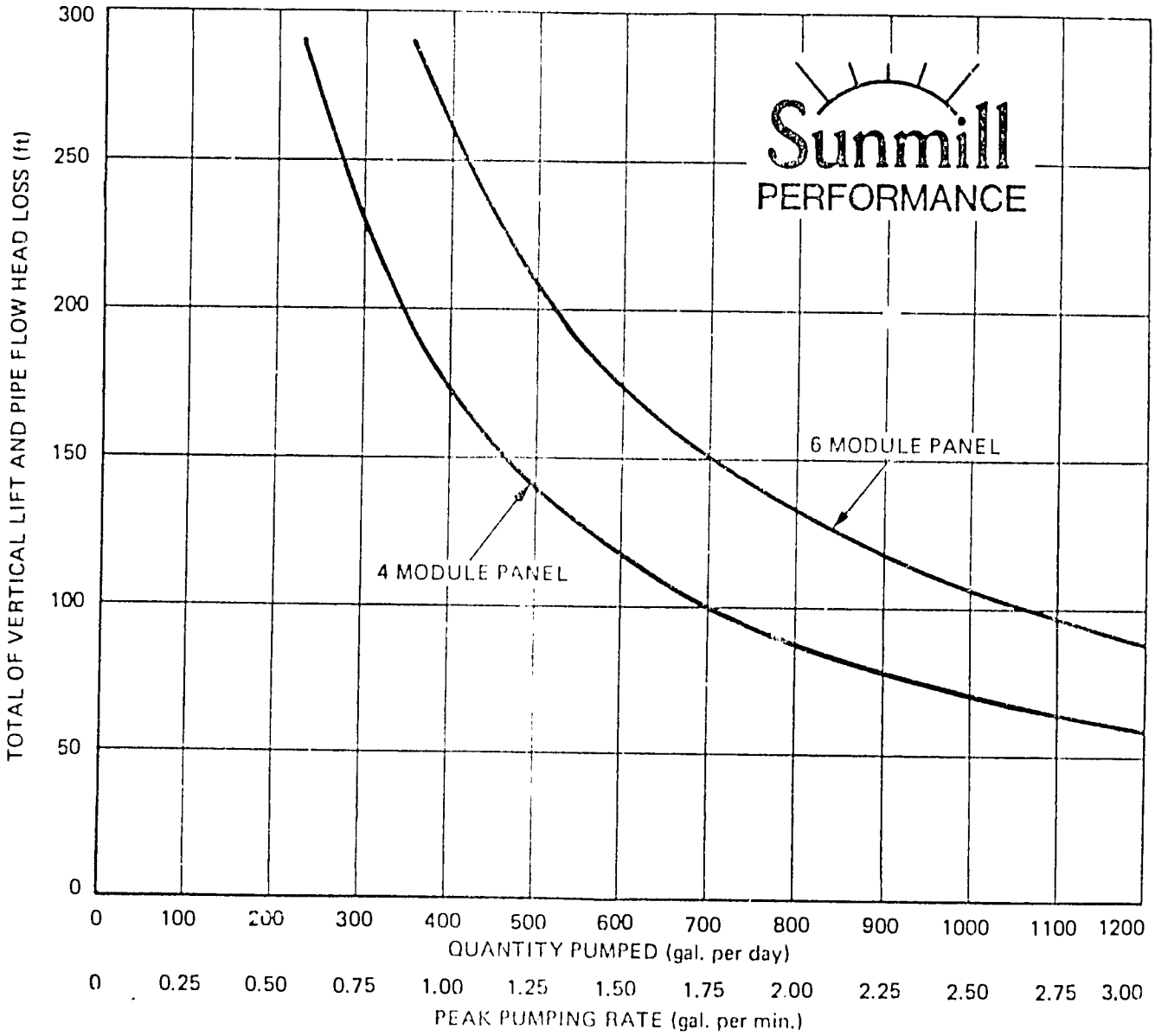
The Sunmill is today's solution to an age old water pumping dilemma. It is especially suited to low flow wells and spring boxes but will pump a generous supply for a normal dwelling or the stock-watering needs for hundreds of acres of grazing land. The Sunmill operates on solar energy and is independent of commercial power. A photovoltaic panel provides electrical energy, which is coupled by an electronic controller to a DC motor which is part of the Sunmill's jack pump. The jack is specially designed for this application. It includes a directly coupled, enclosed flywheel and a high efficiency gear box to drive a counterweight balanced crank.

The highest quality, most efficient components available are uniquely integrated to pump a maximum amount of water for your money. The Sunmill has no life limiting components such as batteries and with simple annual maintenance will last almost indefinitely.

Sunmill performance can be tailored to your particular needs. The total quantity of water pumped each day will depend on the location, as it effects available solar energy, the total lift and the number of photovoltaic modules selected for the panel. A typical Sunmill in the American South-west will provide about 700 gallons per day from 100 feet with a four module panel.

PERFORMANCE

Sunmill performance is specified in the figure below. It is the average to be expected at mid latitudes on a clear summer day. The two horizontal scales indicate the total amount of water pumped each day and the peak pumping rate at mid-day for four and six module Sunmills as a function of total lift.



MOUNTING

The Sunmill's jack pump is normally threaded directly to the 2″ top section of the drop pipe and rests on the well casing seal. — The photovoltaic panel is normally attached to a vertical section of 3½″ pipe. The length of the pipe or the height of the array is not important to the Sunmill performance, but the combination of location and height must result in no shadows on the array from 8 a.m. until 4 p.m. all year long. The pipe with the array may be adjacent to the well head and set in the concrete around the casing or up to several hundred feet away — The Sunmill jack pump vertical frame can be bolted directly to the side of a spring box. A bushing reducer, short section of drop pipe and sucker rod, and the pump cylinder complete the spring box installation.

INSTALLATION CONSIDERATIONS

LABOR

A Sunmill can be installed on a normally cased well by experienced and appropriately equipped workmen with as few as 6 man hours of labor.

MATERIAL

All materials required to install a Sunmill are provided except:

1) Drop pipe and sucker rod of appropriate length. The top section of drop pipe must be 2″ diameter and full 21′ long.
2) Pump cylinder of appropriate diameter and stroke
3) 12 gauge insulated wire, terminal lugs and wire nuts.
4) Well casing seal for 2″ pipe
5) Section of 3½″ pipe to support photovoltaic array.

MAINTENANCE

An annual lubrication of the grease fittings and a check on gear box oil level is recommended.

WARRANTY

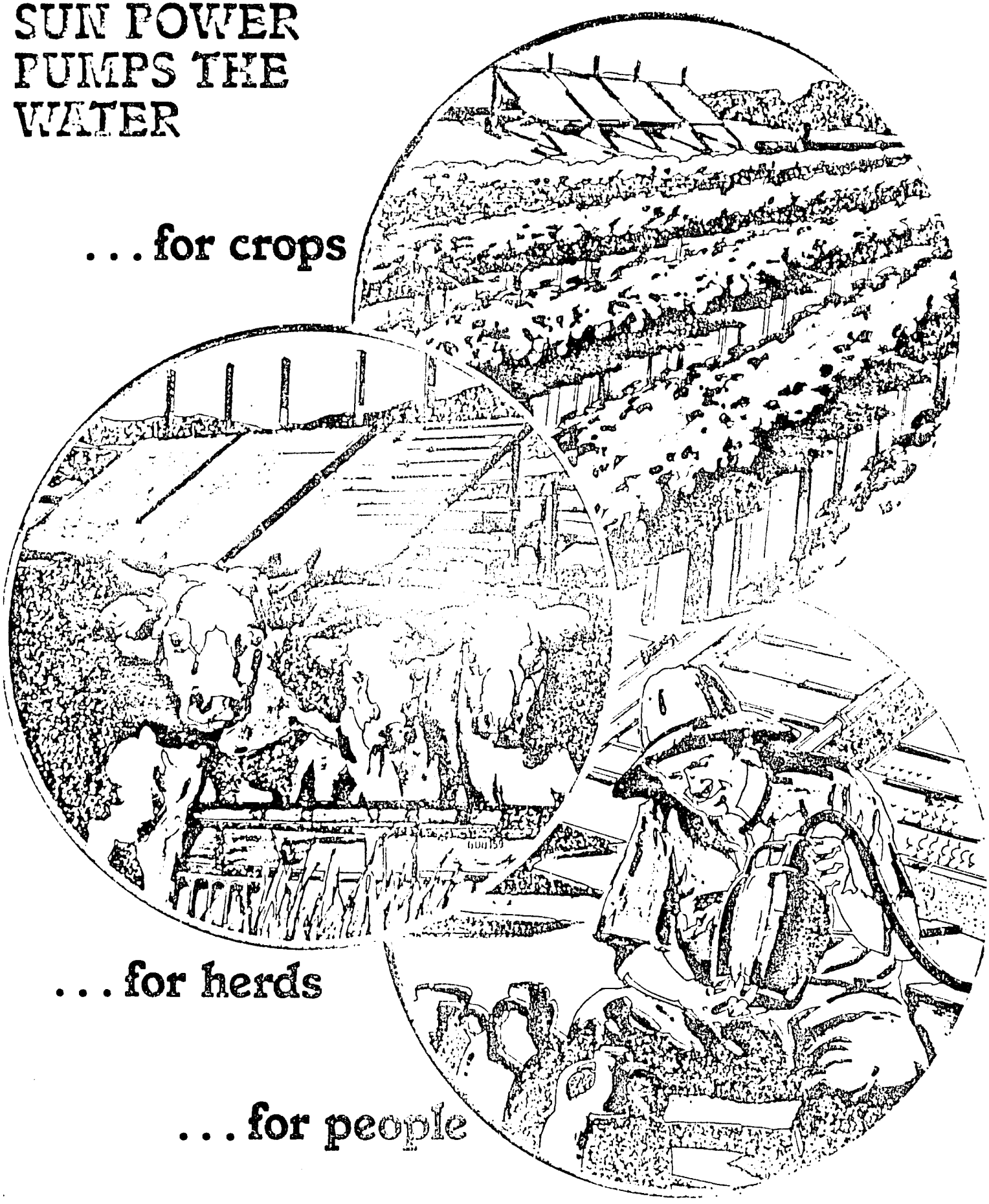
The Sunmill is guaranteed against defects in material or workmanship for 3 years.

LIFE EXPECTANCY

The Sunmill is designed to operate for 20 years with the maintenance described above and the possible replacement of minor parts such as pump leathers and motor brushes.

YOUR LOCAL Sunmill DEALER / INSTALLER IS:

SUN POWER PUMPS THE WATER



WaterPumpSystems

TriSolarCorp

PHOTOVOLTAIC PUMPING
. . matching the system o the need

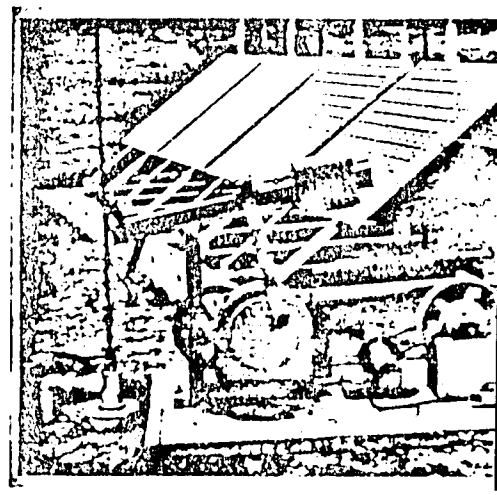
The earth's resource of livable and arable land can be greatly increased by solar power. It is now economic to develop many marginal rainfall areas, where some surface or subsurface water has been available but where the power to deliver it was not too far from the nearest utility line or diesel depot for conventional power, these sites have been impractical for pumping.

Now photovoltaic (PV) pumping systems, engineered by TriSolarCorp, are irrigating land and watering herds — and supplying potable water for people — in many remote areas in the western United States and in more than 30 other countries.

These PV systems range from 250-watt portable micro-irrigation packages to 12-kilowatt deep-well pumps. The founders of TriSolarCorp, while affiliated with MIT, were also responsible for the 100-kilowatt central utility system at Natural Bridges National Monument and the world's largest solar-powered irrigation system at Mead, Nebraska. For the present, however, the most cost-effective installations are at sites where water is needed, electricity is not otherwise readily available and power requirements are relatively modest.

ACK PUMP SYSTEMS
. . for low flow rates r deep wells

Sometimes called "rod", "donkey", or "grasshopper" pumps these volumetric pumps are ideally suited for relatively low flow rates combined with lifts of 15 to 300 meters (50-1,000 feet), as shown in the graph above. They are characterized by a counterbalanced rocker beam that lifts a piston (and a volume of water) inside a submerged cylinder by means of a rod and connecting linkages.



VERTICAL TURBINE SYSTEMS
. . for moderate to high-flow tubewells

Centrifugal turbine pumps can deliver a smooth flow of water at moderate to high rates in tubewells, or from cisterns or other reservoirs. They are most efficient at flow rates greater than 25 cubic meters (6,000 U.S. gallons) per day, and lifts up to 50 meters (150 feet) as shown in the graph above.

TriSolarCorp employs two different motor options in these high-performance systems. Below 15kW (20hp), surface-mounted DC motors usually prove most efficient. At higher ratings, 3-phase AC submersible motors become an economic alternative when

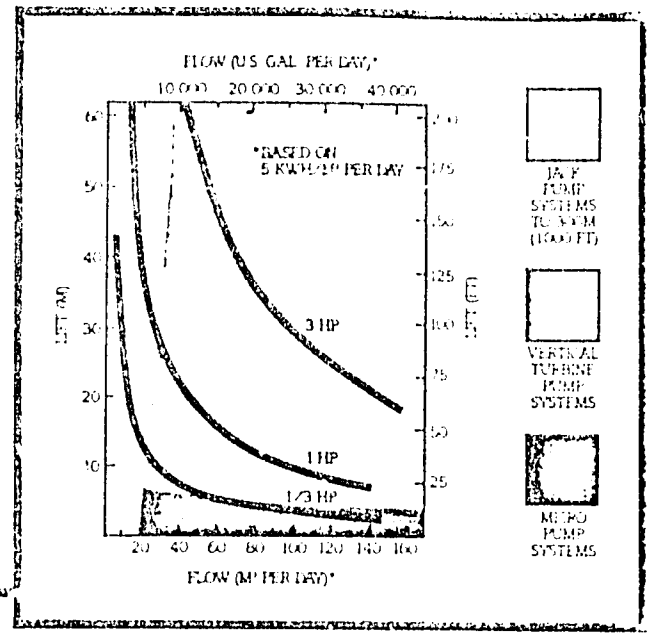
CENTRIFUGAL PUMP SYSTEMS
. . for low-lift crop r herd watering

Self-priming centrifugal pumps are the economic means of providing water for livestock or irrigation from ponds, rivers, canals, dug wells and shallow tubewells — wherever there is abundant water near the surface.

Systems pioneered by TriSolarCorp provide flows in excess of 25 cubic meters (6,000 U.S. gallons) per day with lifts up to 4 meters (13 feet) and discharge heads up to 30 meters (100 feet) as shown in the combined systen graph above. Even the smallest of these systems uses high-efficiency permanent-magnet DC motors, coupled to specially designed pumps and regulated by Maximum Power Controllers. To avoid clogging or jamming, foot valves are eliminated.

SolarCorp systems may employ face-mounted centrifugal pumps, rtical turbines or positive-displace-ent jack pumps. Each is engineered the world's most experienced ap-cations team and employs state-the-art technology, including high-iciency motors with permanent agnets and durable PV arrays — atched for optimum performance by SolarCorp's exclusive Maximum wer Controller (MPC: Patents applied).

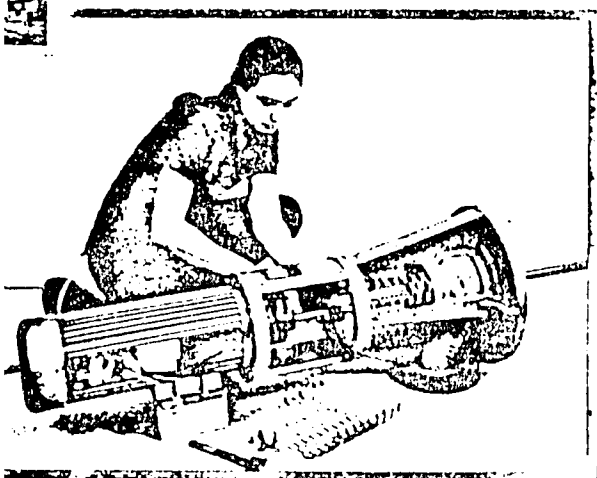
hally, each system is powered di-ctly by sunlight . . . without fuel costs or combustion . . . without waste or noise or pollution . . . and without reliance on batteries. While site and use conditions may vary widely and require system customization, the following graph and descriptions may serve as an introduction to basic system capabilities.



These capabilities ideally match the potable or live-stock water delivery needs of many semi-arid regions, where the water table may be deep and the flow mini-mal. However, they present an engineering challenge in matching the uneven load to the constant power typically available from a PV array.

Rather than burdening the system with the costs and maintenance of battery packs to even the load, TriSolarCorp developed new technology: flywheel inertia levels the cyclical load, while the Maximum Power Con-troller adjusts voltage and current to match the starting load and provide more pumping hours per day.

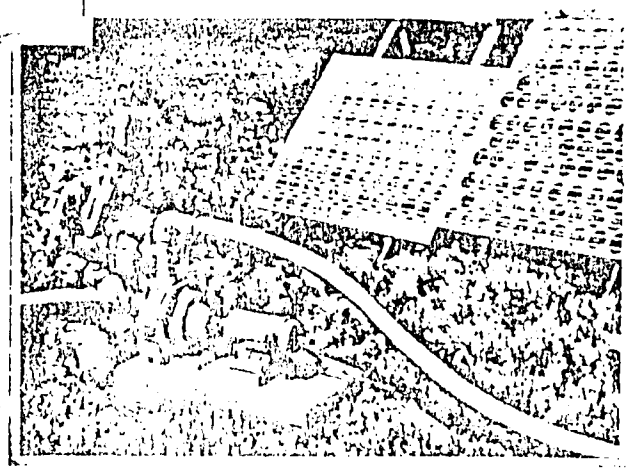
By these innovations, the TriSolarCorp system is independent of both batteries and auxiliary power supplies, for max-imum reliability at minimum operat-ing cost.



equipped with specially controlled DC-AC inverters.

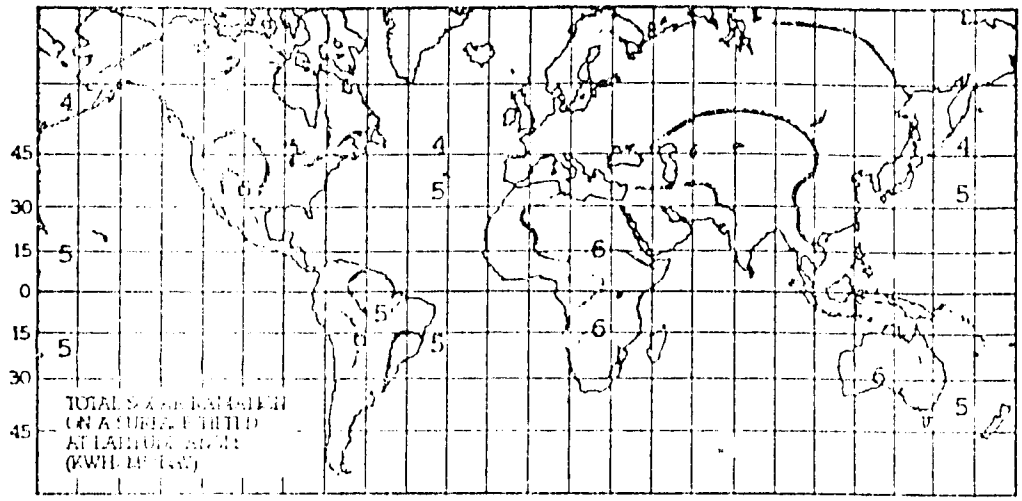
All TriSolarCorp turbine sys-tems employ the Maximum Power Controller for more continuous performance un-der conditions of marginal sunlight. The MPC also helps the system adapt itself to site variations, increasing installation flexibility and decreasing the cost of customization. Unlike the volumetric systems, they do not re-quire flywheels for load leveling.

e portable TriSolarCorp system is ntweight and completely self-ficient, without batteries, providing ny years of maintenance-free oper-on for remote locations. It is esti-ted that there are 50 million small ms, of four hectares (10 acres) or s, supporting a quarter-billion peo-in the world's major alluvial val-



leys. Developed to serve this population, TriSolarCorp portables are already in use in more than 25 countries.

POWER FROM SUNLIGHT
. . . wherever on earth the need may be



The photo-electric effect, discovered nearly a century ago, is the ability of photons of light energy to knock electrons out of their atomic orbits — in certain materials such as silicon — and force them to follow a wired path to get back, thereby creating an electric current.

But the technology to produce useful amounts of this photovoltaic (PV) power was not developed until the space program recognized the need for an inexhaustible power supply. The engineers who later founded TriSolarCorp were responsible for many developments involving solar arrays and internal power systems for both satellites and deep space probes.

Since the early days of space exploration, continuing progress in both the manufacture of solar cells and the engineering of PV systems have made this power source cost-effective for many applications here on earth. Water pumping and purification, residential electrification and the powering of medical and communications equipment, particularly in remote locations, are already practical with TriSolarCorp systems.

As the erratic costs and supplies of fossil fuels make solar energy more competitive — and as the ecological effects of combustion become more critical — these systems are taking their place among the world's significant energy sources.

Solar power is obviously most efficient in those areas of the world where sunlight is most abundant. But continuing reductions in the unit cost of PV arrays, and TriSolarCorp's continuing innovation in systems engineering, are bringing "free electricity" and a better quality of life to more and more people around the world.

TriSolarCorp

10 DeAngelo Drive, Bedford MA 01730 USA
(617) 275-1200 Telex 940536 BOSTLX (TSC)

. . . putting the sun to work

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WM. LAMB CO. Solar Systems

TWX: 910-499-2677 AMTURNER

P. O Box 4185, North Hollywood, Ca 91607
10615 Chandler Boulevard, North Hollywood, Ca. 91601 U.S.A.
(213) 980-6248
(213) 877-3901

SUBMERSIBLE TURBINE PV PUMP SYSTEMS

FOR LARGE WATER FLOWS, SUBMERSIBLE TURBINE PUMPS POWERED BY PHOTOVOLTAIC ARRAYS OFFER THE HIGHEST EFFICIENCIES AND EASY INSTALLATION. BELOW, WE LIST THE CHARACTERISTICS OF TWO TYPICAL PUMP SYSTEMS THAT USE A 12 MODULE (ARCO SOLAR M51) ARRAY.

THE PUMPS ARE OF NOMINAL 4" AND 6" SIZES, AND WEIGH ABOUT 60 POUNDS. INSTALLATION CONSISTS OF CONNECTING THE REQUIRED LENGTH OF CABLE BETWEEN THE PUMP AND ARRAY, ATTACHING THE FLEXIBLE OUTPUT HOSE, AND LOWERING TO A SUBMERGED LEVEL IN THE BOREHOLE OR POND.

THE MOTOR IS MAGNETICALLY COUPLED TO THE TURBINE AND THUS THERE IS NO LINE SHAFT. THE MOTOR IS DRIVEN DIRECTLY FROM THE PV ARRAY. THERE ARE NEITHER COMPLICATED ELECTRONICS OR BATTERIES TO CAUSE TROUBLE. THE ONLY PERIODIC MAINTENANCE REQUIRED IS REPLACEMENT OF MOTOR BRUSHES...APPROXIMATELY EVERY 3-5 YEARS...WHICH IS DONE IN THE FIELD WITH SIMPLE TOOLS.

	16' LIFT	50' LIFT
FLOW AT PEAK SUN	70 gpm	25 gpm
FULL SUN DAY'S PRODUCTION	33,000 gal. (125 M^3)	11,000 gal. (40 M^3)
EFFICIENCY*	to 60%	to 55%

*"WIRE TO WATER"

WM. LAMB CO. Solar Systems

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P.O Box 4185, North Hollywood, Ca. 91607
10615 Chandler Boulevard, North Hollywood, Ca. 91601 U.S.A.
(213) 980-6248
(213) 877-3901

Jan. '83

SOLAR PV WATER PUMPS

The following solar water pumps are now available from us. We suggest that you discuss your application with us if you don't see below just the pump characteristics required.

CATTLE WATERING PUMP -- 1 GPM ON ONE ARCO Solar M61

This diaphragm pump will draw from as much as 6 feet (2 meters) above the water source, and yields 1.15 gpm at 2 feet total head dropping to 0.94 gpm at 12 feet total head powered by one M61 at 85% insolation. As this is a positive displacement pump, total head to over 60 feet can be attained with efficiencies (wire to water) of typically 30%. Filter and motor included at price of $119.00

HOUSEHOLD WATER OR ? -- 5 GPM FOR UNDER $2000 INCLUDING SOLAR POWER

This is the smallest pump we know that yields efficiency over 50%. This rotating vane pump can be used for flows from 1 gpm through over 5 gpm, and heads to over 100 feet. Send us your required head and flow so we can supply system design. Using our 1/2 HP motor with 11,000 hour rated brushes -- $550 sans PV modules -- flow is approximately 1.2 times number of modules in series and current requirement is approximately given by $I=1+0.024H$ amperes, with H being the total head in feet. Use with filter to avoid wear due to grit in water.

SUBMERSIBLES -- "BIG WATER" AT THE LOWEST COST, EASILY INSTALLED

Major advances are being made in PV water pumping using submersible pumps. These pumps are easily installed in a borehole well in hours, and exhibit efficiencies from 40 to 60 %. They use fully sealed DC motors with a magnetic coupling to a multistage turbine. Price for pump alone is generally less than $1200. We have data available for many head-flow combinations, heads to several hundred feet and flows to well over 100 gpm. Example: A 12 module M51 array and pump that produce 15 gpm at 65 foot head-- rated at 60° C. cell temperature and 96 mw/cm^2 insolation. Efficiency (wire to water) of 55%.

THE WM. LAMB DEEP WELL PUMP -- PROVEN OVER THE YEARS

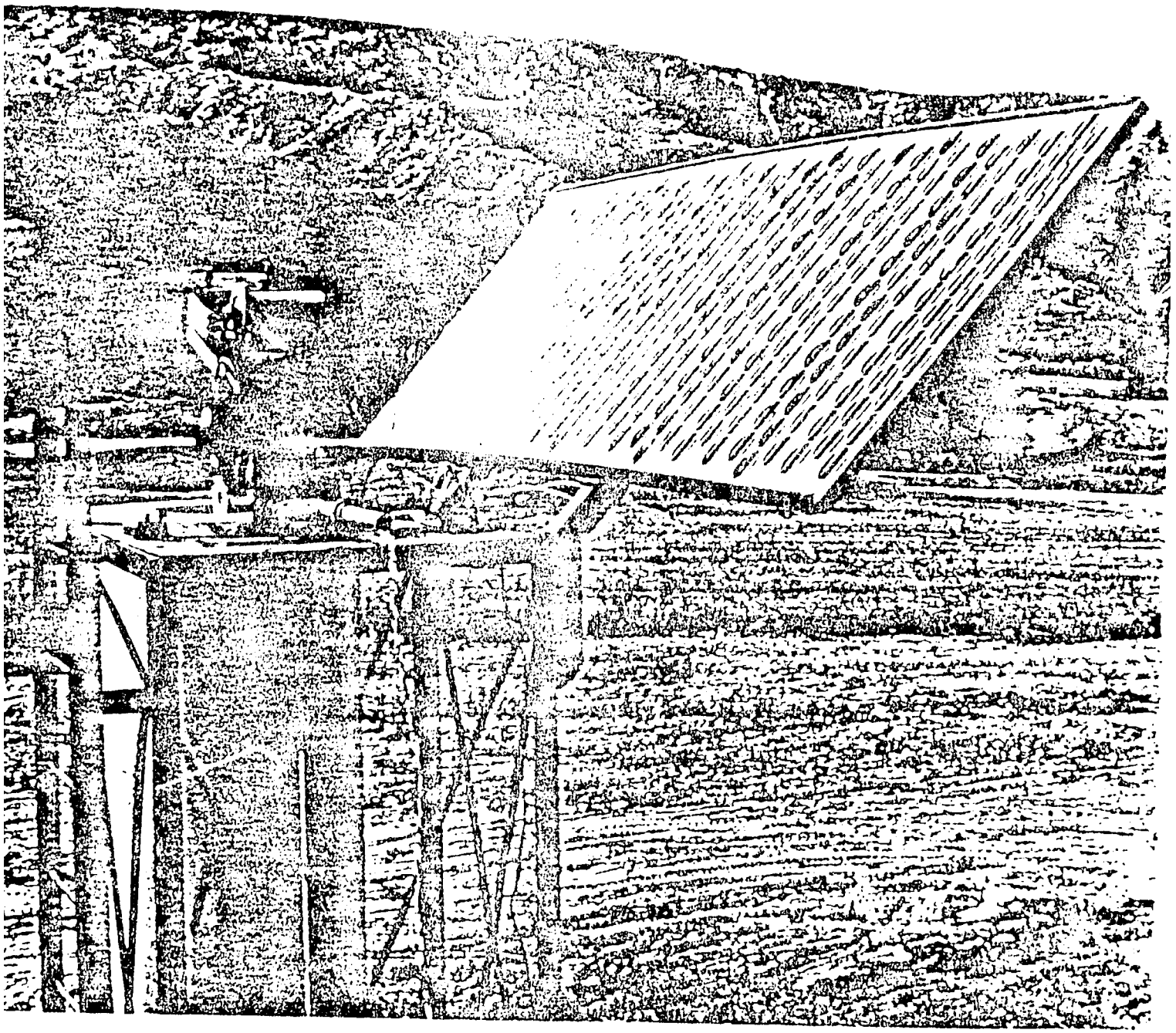
This dependable system is offered in many configurations for pumping from depths of sixty to hundreds of feet -- see our data sheet (with picture) for more detail. Selected by the World Bank to participate in thier solar pumping evaluation project. Electronic "max power tracker" may be used to extend hours of operation. This one is hardest to size, as one has the choice of several cylinder diameters and belt ratios. Call us with head and flow required.

SOLAR POWERED

PUMPING SYSTEM

#80 DEEP WELL PUMP

NO BATTERIES NEEDED



Wm. LAMB CO.

Solar Systems

P. O. Box 4155, North Hollywood, CA 91607
10615 Chandler Boulevard, North Hollywood, CA 91601 U.S.A.
TWX: 910-499-2677 LAMTURNER (213) 980-2[illegible]

#80 SOLAR PUMP

This pump is located near Yucaipa, California, U.S.A., on the Bill Merrill Ranch.

The water is being pumped from a depth of over 230 feet at about 190 gallons per hour. The solar arra delivers some 480 watts of power at peak sunlight. The pump does operate at about 25% overcast, at a reduced rat

For residents of California, a state and federal tax credit is available for installing a solar powered agricultural livestock water pump. This does apply to other states and should be handled by a qualified tax person.

The cost is about the same as a windmill, but the windmill does not qualify for the tax credits.

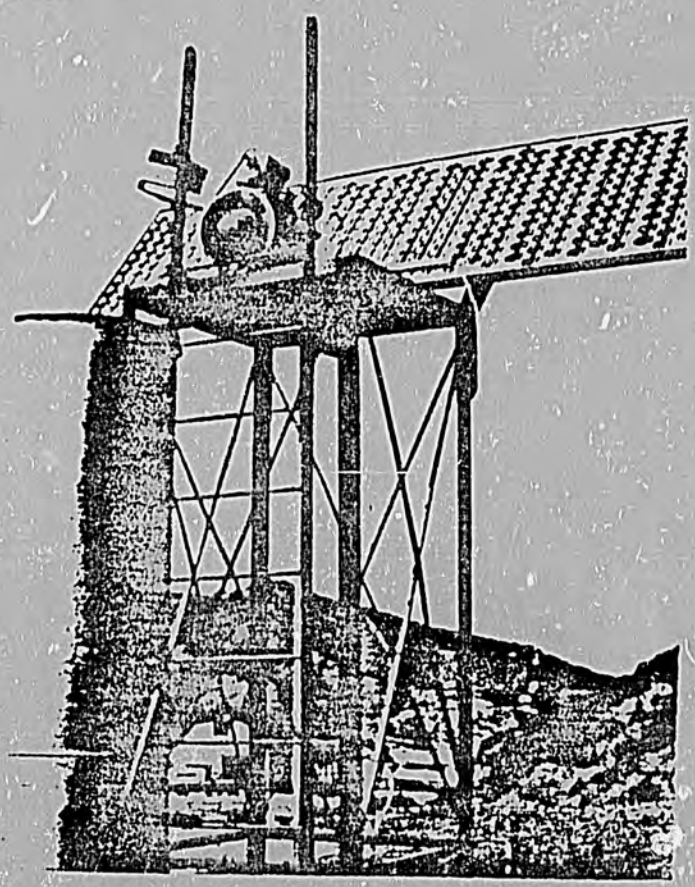
The installation costs vary with the depth of the well and the amount of water required, so for exact costs we suggest you contact the factory.

One of the plus factors of the solar installation, aside from the tax credits, is that the solar array can be use for many other things. For instance, to run a cooler, when not pumping, to charge batteries, to run smal appliances and on and on.

A number of people have put the solar array on top of their houses and run a line to the pump, or pum to the barn, or other out buildings. This would be to operate fans, or evaporative coolers in confined anin pens, chicken houses, and many other places where cooling, or circulating air is desirable.

Our factory trained salesmen are glad to answer any questions possible.

The package includes
Pump Weights
Special Motor
Pulleys, Belt,
Solar Panels,
Cylinder and
Full instructions
for assembly.



Shipping Weight
Approximately 400 lb
Tank and Tower
Not Included

LS EXPORT LTD WM LAMB CO

Solar News briefs

News

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World Bank Evaluates Solar Water Pumps

Data of dates but funding of failures

A solar-powered water pumping system, designed and assembled by an ARCO Solar distributor, is presently being evaluated as part of the United Nations Development Program's (UNDP) photovoltaic water pumping project.

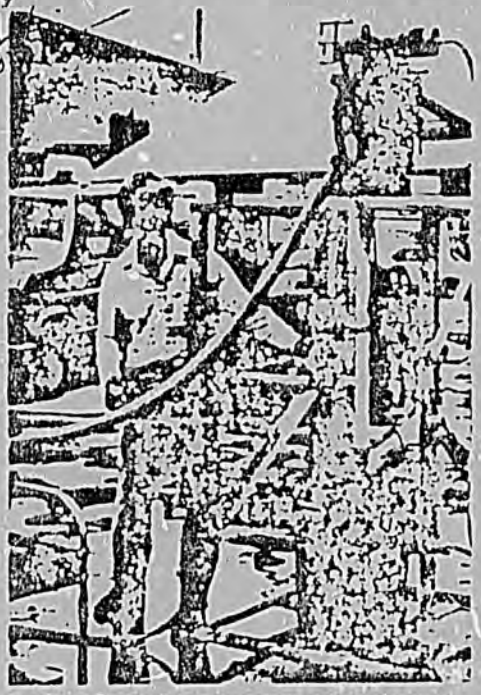
Organized by the World Bank, the project is aimed at providing an inexpensive and dependable method of pumping water to villages and farms in developing countries throughout the world.

Dr. Paul Scott, engineering consultant with the William Lamb Company in North Hollywood, Calif., designed the prototype system earlier this year. A representative from Sir William Halcrow Partners, subcontractors to the United Nations, will inspect and test the system this summer before it is shipped to London for further evaluation.

The system includes a modified jack pump able to move water from a 20-meter depth at a high flow rate (approximately 5,000 gallons per day). A one-half-horsepower motor, custom-made by Honeywell, is powered by 15 ARCO Solar photovoltaic modules.

Scott said he designed the system to meet World Bank specifications for high winds (150 kilometers per hour) and a desert climate. The system could easily pump water to support a five-acre garden, he added.

The solar electric modules are mounted on a 10-foot support structure that can be manually turned and tilted to optimize collection of sunlight. For demonstration purposes, the pump is hooked to a hose and tank that simulate water depth and pressure. Water is pumped from a barrel and recirculated through the hose.

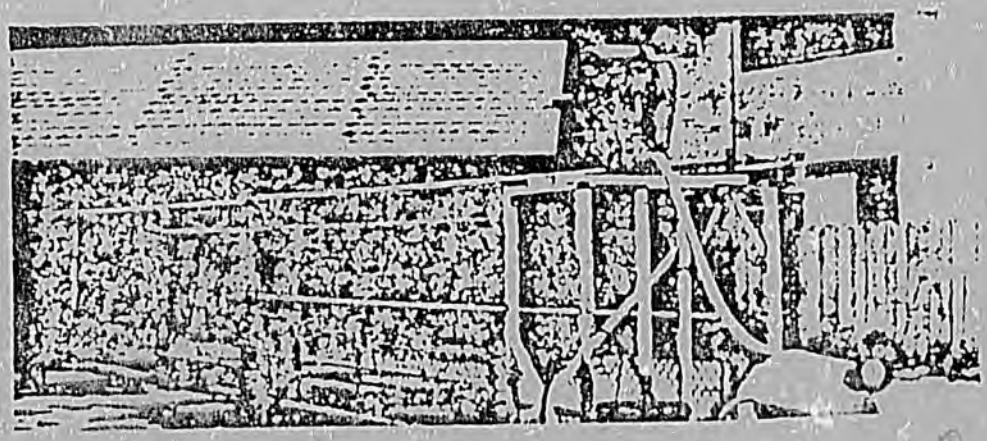


Dr. Paul Scott demonstrates solar-powered water pump.

The first phase of the UNDP photovoltaic water pumping project was completed last summer after a study was conducted comparing performance data from 12 solar pumping systems installed in Mali, the Philippines and Sudan.

During the 20-month intermediate phase, according to Dr. M.A.S. Malik, renewable energy specialist with the World Bank, 12 commercial photovoltaic water pumping systems, selected from 60 entries, are being evaluated.

In addition, countries in Asia, Africa and Latin America are being considered for their suitability as sites for all or some of these commercial systems during the second phase of the project, said Malik.



APPENDIX C

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PV MODULE QUALIFICATION TESTS SUMMARY

-JET PROPULSION LAB

The program of the Jet Propulsion Laboratory (JPL) Flat-Plate Solar Array Project (FSA) has included a series of competitive procurements, designated Block I through Block V, of various quantities of solar modules. The objectives of this procurement effort were to stimulate reduction in the cost of photovoltaic energy by encouraging technology advances and to make modules of advanced design available for field testing and for commerical applications.

Block I included the purchase from five contractors of a quantity of modules having a total power output of approximately 58 kW. These modules were procured to the contractors' specifications as a means of ascertaining the state of the art of commercial terrestrial solar cell modules and of providing modules for early test and applications programs.

Block II, consisting of the purchase of 123 kW of total power capacity from four contractors, introduced a degree of standardization by defining the module design specifications and by providing for a design qualification test program.

The Block III procurement consisted of 205 kW of total power capacity from five contractors. The design specifications and the qualification test program were essentially the same as those for Block II.

Block IV varied from the prior procurements in that: the design specifications and the qualification tests were more stringent; modules were categorized as either intermediate-load or residential; and the procurement was effected in the form of sequential development and production contracts. Each successful proposer was awarded a contract for development of about 1 kW of modules. For each design that completed the subsequent qualification tests successfully, a production contract was issued for 1 to 4 kW of modules. The seven contractors whose modules passed the tests supplied a total of 32 kW, including development and production modules.

Because the Block V procurement was initiated and carried out during a period of programmatic change, it was implemented in three phases. The first phase consisted of design only. The second phase consisted of the manufacture of 10 modules for qualification test, and the third phase consisted of the manufacture of additional modules, after correction of the deficiencies revealed by the foregoing qualification tests, plus various documentation. The contractors who were awarded the design phase contracts did not all participate in all of the subsequent phases.

The design and test requirements for Block V modules are more demanding than those for Block IV.

Modules of each Block V design were subjected to a series of qualifications tests to prove their ability to withstand the required ranges of environmental exposure. Typically, four modules were used for each of the tests. Qualifications of a design means that modules of that specific detailed design and processing have been shown capable of withstanding the stresses of the test program without more than 5% power degradation, without exhibiting open circuits or ground faults during the environmental tests, without failing of a hot-spot test, an electrical isolation test and a ground continuity test, and without visible degradation exceeding preselected criteria.

A simplified description of the Block V qualification tests is presented here.

The block diagram in Figure B-1 shows the qualification test sequence with the names of individual tests given in blocks that are alphabetically coded to key them to the descriptions below. Note that some tests occur more than once in the sequence. The description of each test is as follows:

A. VISUAL INSPECTION

This consists of detailed visual examination of the module for mechanical degradation exceeding preselected criteria for that module design. The criteria reflect a judgment of degradation that threatens continued successful performance of the module. Such degradation may appear as breaks, cracks, delamination, spalling, etc.

B. GROUND CONTINUITY

The procedure for the ground-continuity test was defined in the Block V specifications by reference to an internal JPL document. This procedure has since become available in the Underwriters Laboratories, Inc., "Proposed First Edition of the Standard for Flat-Plate Photovoltaic Modules, UL 1703." The procedure consists essentially of supplying current flow equal to twice the module short-circuit current through the module grounding path and measuring the voltage drop of 1 volt. The limit in the subsequent UL document, UL 1703, is 0.5 volt.

C. ELECTRICAL ISOLATION

This hi-pot test verifies that the insolation between the (shorted-together) output terminals of the module and the module ground point will not suffer dielectric breakdown when subjected to either 3000 Vdc for an intermediate-load module or 1500 Vdc for a residential module. The test is

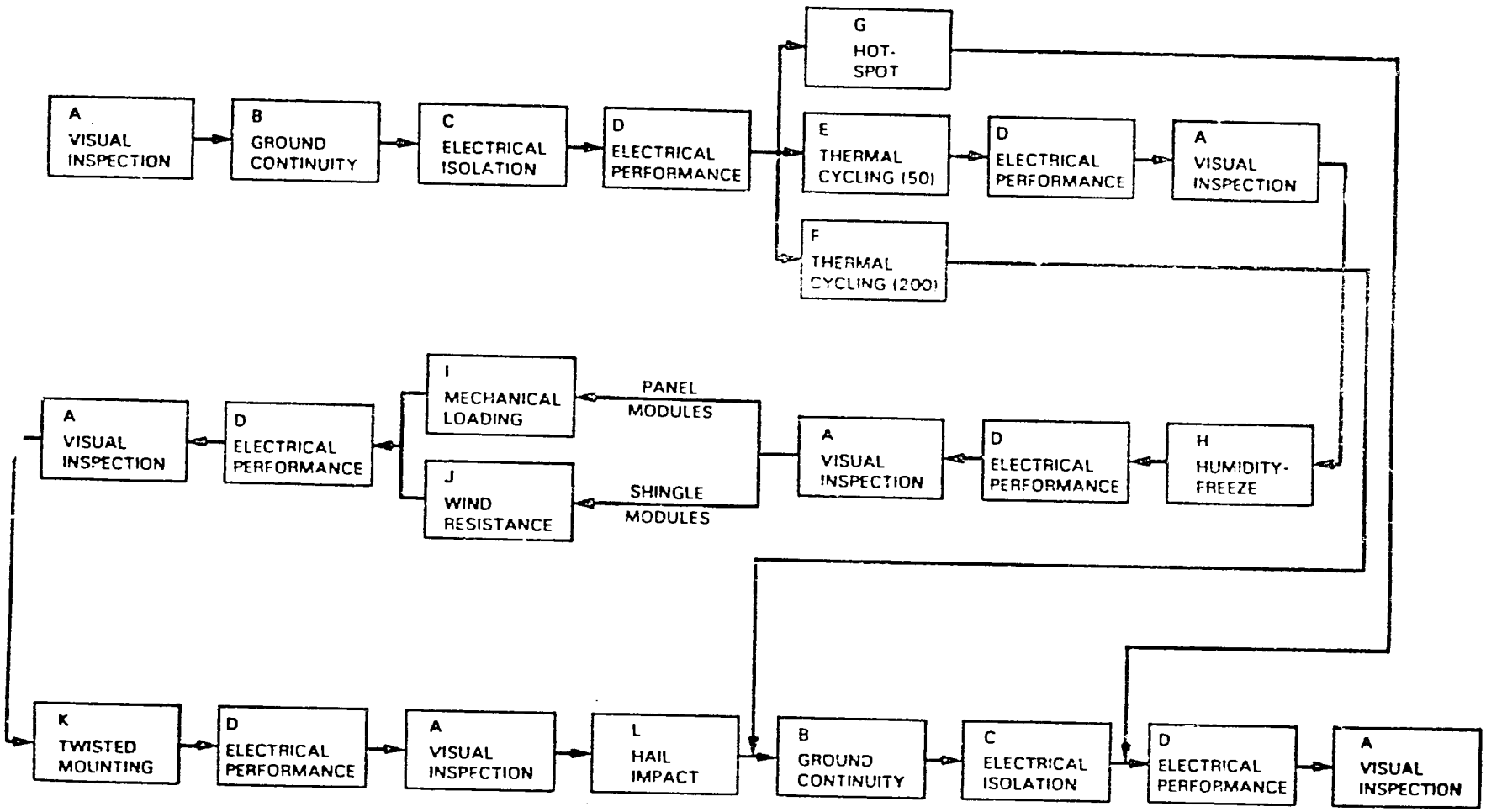

Figure B-1. Qualification Test Sequence

conducted twice, once with each polarity. The voltage is applied at a rate not exceeding 500 V/s up to the test value and then held constant for 1 minute. Failure is defined as arcing, flashover, or leakage current exceeding 50 microamperes. For modules not required to have a ground terminal, the mounting structure is used as the ground point. In the case of a module intended to be mounted in a non-conductive structure, this test does not apply.

D. ELECTRICAL PERFORMANCE

The purpose of this test is to obtain current-voltage (I-V) characteristic curves, first to establish a performance baseline, and subsequently to examine for performance degradation resulting from the stresses of the qualification tests. The criteria for excess degradation is a reduction in maximum power (measured at 100 mW/cm^2, AM1.5 irradiance and 25°C cell temperature) exceeding 5%.

E. THERMAL CYCLING (50)

This test requires that the modules be subjected to 50 cycles of cell-temperature variation between -40°C and +90°C. The variation is approximately linear, at a rate not exceeding 100°C per hour, with a period not exceeding 6 hours per cycle.

F. THERMAL CYCLING (200)

This test is identical to that in E except that 200 cycles are applied, and the modules (two minimum) undergoing this test are not subjected to subsequent environmental tests.

G. HOT-SPOT

Three individual, electrically isolated cells in the one module are heated to Nominal Operating Cell Temperature (NOCT) and then subjected to the maximum values of cell current and back-bias voltage that could occur in the field due to operating conditions, module faults, or cell shadowing, as determined by the frequency of bypass diodes in the module design. The current and voltage are maintained for 1 hour and are then reduced to zero until the cell temperature has dropped to approximately NOCT. This cycle is repeated until 100 hours have accumulated under the power-on condition. The module is not subjected to subsequent environmental tests.

H. HUMIDITY-FREEZE

This test requires that the module be subjected to the temperature-humidity regime depicted in Figure B-2. The important part of this test is the dwell time at 85°C and 85% RH.

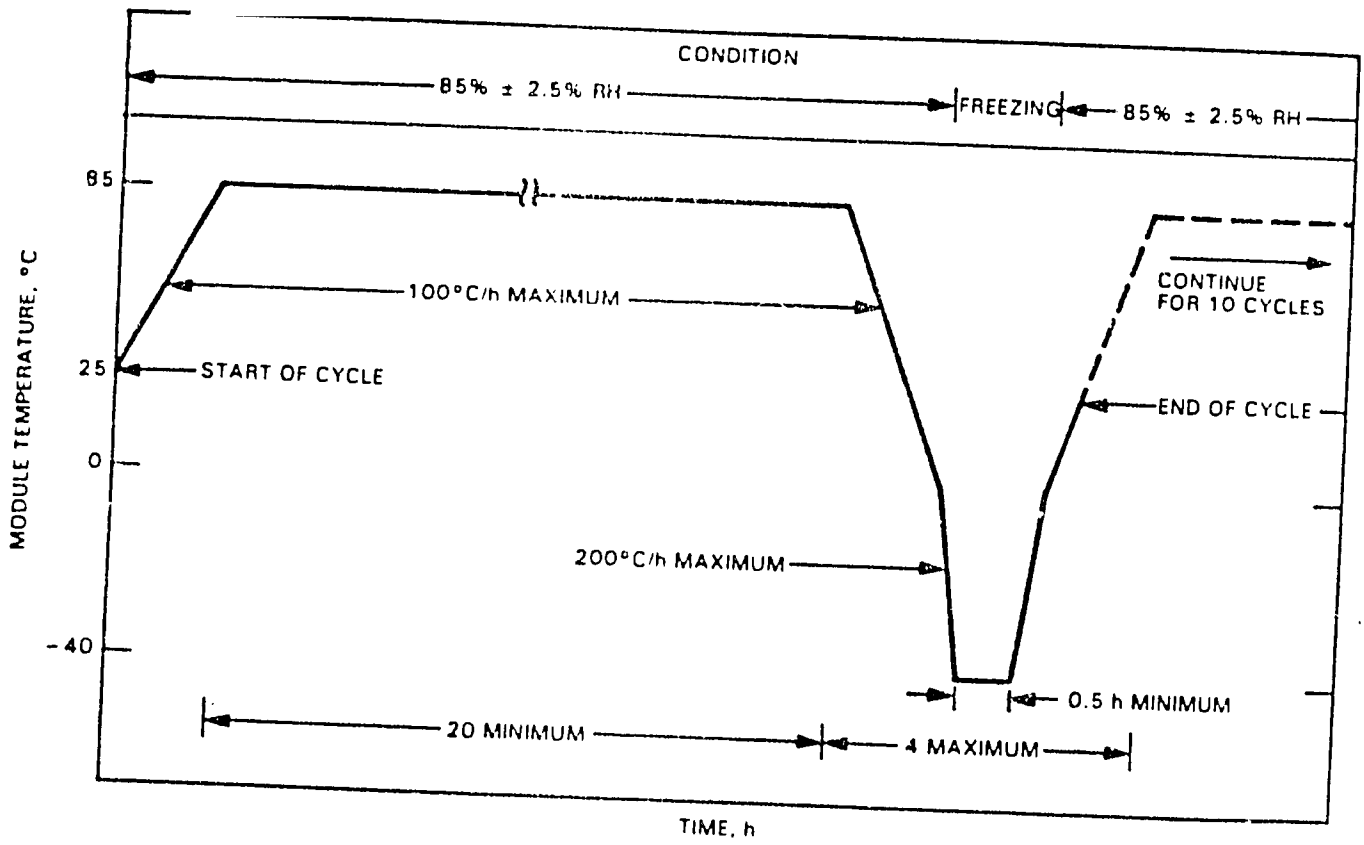

Figure B-2. Temperature-Humidity Regime

I. MECHANICAL LOADING

This test verifies, by simulation, that a wind that produces peak mechanical loading amplitudes of ±2.4 kPa (±50 lb/ft^2) on intermediate-load modules or ±1.7 kPa (±35 lb/ft^2) on panel-type residential modules will not result in mechanical or electrical degradation. The test is performed by applying 10,000 cycles of mechanical load, normal to the module surface. This test is not applicable to shingle-type modules.

J. WIND RESISTANCE

This test verifies, by use of a wind machine providing uplift force, that shingle-type residential modules will withstand an uplift pressure of 1.7 kPa (35 lb/ft^2).

K. TWISTED MOUNTING

This test verifies that mounting the module on a twisted mounting surface with planarity deviation of ±20 mm/m (±1/4 in./ft) will not cause module damage.

L. HAIL IMPACT

This test verifies that the module will not be damaged by 10 impacts of simulated hailstones (ice balls) 25.4 mm (1.0 in.) in diameter, travelling at 23.2 m/s (52 mi/h). The impact points are on the surface of the module that is exposed to hail in the intended installation and are the most sensitive points, as determined experimentally.

APPENDIX D

SPECIFICATIONS FOR A FIELD TEST INSTRUMENTATION SYSTEM

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The Renewable Energy Field Test instrumentation system will be used to monitor IPH, PV and wind energy system installations at urban and remote desert locations in Egypt. These energy systems include main power sources (solar collectors, PV arrays and wind turbines) as well as ancillary subsystems depending on specific field test applications. These subsystems include ice-making equipment, desalination systems, a variety of load characteristics ranging from small DC loads to grid-connected applications and back-up power systems (diesel engines and batteries).

The instrumentation system must be a stand-alone system. Failure of the instrumentation system must not affect the performance of the field test system that is being monitored. The instrumentation system must have an on-site data storage system that is non-volatile and capable of easy physical removal and transport to another location for data removal and long-term storage. One form of the non-volatile storage system must be a microchip/ EPROM or CMOSRAM - Type system that can be "milked" on site easily and without danger of a loss of data.

The instrumentation system must be a microcomputer based data logger with programmable input channels and output formats. The user must have control over sampling frequency and output period for each channel. Primary design objectives for the instrumentation system should be reliability, simplicity, small size, low power and the ability to operate in environmental extremes (especially high temperature, sand/dust and tropical/sea coast). The unit must be capable of stand-alone battery operation for a period of at least two months.

The following minimum specifications are required for the instrumentation system. If an exception must be taken to one or more of these requirements, the exception shall be noted and a clear explaination given as to why the

bidder believes that the exception should be acceptable to the purchaser.

Physical Specifications

- Small, stand-alone, self-contained system in an environmental enclosure
- Desired weight: less than 10 pounds
- Desired size: less than 10 inches x 10 inches x 6 inches

System Power Requirements

- Capable of operation using self-contained batteries
- Capability for the use of an external power source to allow continued data collection while changing batteries or the use of a non-battery external power source is desirable.
- Capable of transient protection from spurious electrical charges or lighting.

Environmental Specifications

- Ambient Temperature: -25 deg. C to +50 deg. C
- Relative Humidity: 0 to 90 percent non-condensing
- Impervious to a tropical, oceanside environment with occasional high airborne sand/dust and/or sulphur levels

Analog Inputs

Number of Channels: At least 16 channels with 20 channels desirable

Voltage Measurement Types: Differential or single-ended

Accuracy of Measurements: at least ± 0.5 percent

Range and Resolution: Selectable for any input channel from microvolts to several volts full scale

Sample Rates: At least once per second for each channel

Pulse Inputs

Number of Pulse Counter Channels: at least 4 channels with 6 channels desired

Analog and Digital Control Outputs: a total of three resettable channels each is desired with a range of 0 to ± 5 volts with a 0.5 volt resolution

Output Signal Interface

Memory: Capable of storing at least 3000 data points per day for a period of one month (two months desirable)

Display: A visual display of stored data is required on-site for data verification before data removal

Peripheral Interface: Downloading of data at the site should be by physical removal of the data storage device or simple, reliable data downloading to a non-volatile storage device. Storage data files shall be IBM-PC compatible on floppy disc either directly from the data logger or through a simple, fast, reformatting technique.

Field Test #7 (PV Irrigation and Lighting, preliminary)

Item	Channel Type	Sampling Frequency	Output Interval	Priority Want	Priority Must
Array Power	P	1 sec.	10 min		x
Insolation	A		" "		x
Load Voltage	A		" "		x
Load Current	A		" "		x
Battery Charge Current	A		" "		x
Battery Discharge Current	A		" "		x
Battery Voltage	A		" "		x
Ambient Temp.	A		" "		x
PV ref. cell temp.	A		" "		x
Battery Temp.	A		10 min		x
Water Pump (kilowatts)	A		10 min		x
Water Pumped Production (liters)	A		10 min		x
Suction Head (meters)	A		10 min.		x

13 ("musts") x 6 samples x 24 hours = 1872
Time mark (6 x 24) = 144

Total = 2016 data points per day

13 channels

- 1 pulse
- 12 analog

* To be reviewed and refined following conceptual design