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INSTRUMENTATION OF A SOLAR CROP DRIER

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ABSTRACT

The design of an automatic data acquisition system for the performance analysis of a solar crop drier is discussed. The system is controlled by a single board microcomputer and is portable for in situ data collection. The assembled system has not yet been tested in the field.

INTRODUCTION

The dramatic increase in the cost of petroleum fuels over the past decade has been a spur to the development of low cost, intermediate technology devices which use the sun as an energy source. Most tropical countries receive of the order of 6-8 kilowatt hours per square metre of solar energy on a clear day. One of the most important of such devices is the solar crop drier which can dry fruit, vegetables, grasses, etc. for subsequent human or animal consumption, and seeds for germination. Spoilage, however, remains a major problem in low cost solar driers. A great deal of work remains to be done on the design of these devices with respect to the propagation of spores, the growth of fungi and other factors which affect the material being dried. To this end, a complete determination of the relevant parameters, i.e., insolation and temperature profiles of the solar collectors, together with temperature, airflow and humidity parameters throughout the drying chamber, under working conditions and over an extended period is essential.

The basic solar crop drier design to which we refer the instrumentation described in this paper is shown in Figure 1. The design is due to Dr. O. St. C. Headley of the Department of Chemistry, U.W.I., St. Augustine, and has been in use for several years throughout the Caribbean and elsewhere. It has not, however, to the best of our knowledge, been subjected to the full performance analysis which we propose to carry out. The drier comprises approximately 3 m^2 of flat plate solar air heaters which channel hot air through a drying chamber of about 6 m^3 volume, by natural convection. A small fan may be used to aid circulation, but for maximum versatility in terms of conditions of use, this should be avoided if possible.

The development of large scale integration of electronic circuits has made many complex experimental systems both technically and economically

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accessible at the level of intermediate technology. In particular, the availability of the single board microcomputer and low cost memory has meant that the system we describe, excluding the probes, can be built for less than US$500. The automatic data acquisition system (ADAS) can sample several dozen probes virtually simultaneously and can repeat the sampling at intervals of a few seconds. This performance is well in excess of that required for the present application.

INSTRUMENTATION

The Automatic Data Acquisition System (ADAS)

The ADAS scans the probes or sensors at programmed intervals of time, stores the data in a buffer memory and finally writes the data onto cassette tape when the buffer is full. Battery operation, low power and portability are the main features of the system.

The ADAS comprises the following modules:

(a) Sensor interface
(b) Analog-Digital conversion (ADC)
(c) Single board microcomputer (controller)
(d) Cassette mechanism
(e) Software

(a) Sensor Interface - This module will contain adjustable gain amplifiers for pre-conditioning the signal before presentation to the ADC module. Single or double ended operation (0-10 VDC, -5,0,+ 5 VDC, respectively) and filtering will also be features of this module.

(b) Analog-Digital Conversion - In order to accommodate as many sensors as possible, a sixteen (16) channel multiplexed A/D integrated circuit forms the basis of this module. This chip features programmable switching and can easily accept a Sample and Hold circuit in case of rapidly fluctuating inputs.

A disable input also allows the chip to be placed in a high impedance state thus allowing another sixteen (16) channel A/D circuit to be addressed. This feature therefore allows the controller to select anyone from a bank of twelve (12) A/D converters thus providing a maximum of 192 channels.

(c) Single board Microcomputer (Controller) - This module forms the heart of the system and controls the sequence of events. Based on an INTEL 8085 Central Processing Unit (CPU), the board features a serial port for data transfer to tape, 2k bytes of CMOS RAM with battery backup and provision for 4K bytes of EPROM which will be used to store the controlling software. This software will utilize the features of the on-board system monitor to upload and/or download from larger computers.

The main uses of the controller are as follows:

(i) Select channels in correct sequence and at correct time.
(ii) Store values in memory.
(iii) Dump memory to tape for permanent storage.
(iv) Shut down all power (except to timer) and follow ordered "wake up".

The channel sequence, shut down interval and other variables of the experiment will be programmed into the system via a simple keyboard while basic fault indicators and test points will be field accessible.

(d) Cassette Mechanism - This miniature, low power, digital mechanism consumes less than a watt and will be operated at 2400 bits per second (BPS) or 800 bits per inch (BPI). The 2k bytes of buffer RAM can store approximately ten (10) scans of the 192 channels - i.e. 1922 bytes (2 bytes at the beginning of each record, for identification).

At 3 ips, one record will thus require 19.22 inches plus 1 inch for start/stop take-up, making a total of 20.22 ins per record (IPR). Tapes of 80 feet in length can therefore store approximately 47 records. In the time domain, each record will take approximately 6.75 seconds thus, for a 20 minute off interval, a single tape will last about 15 hours.

(e) Software - The controlling software will be stored in EPROM and control the processes already described. The retrieval and analysis of data from the tape will be handled by a larger in-house computer thus duration of system operation will depend on power supply used.

Sensors and Probes

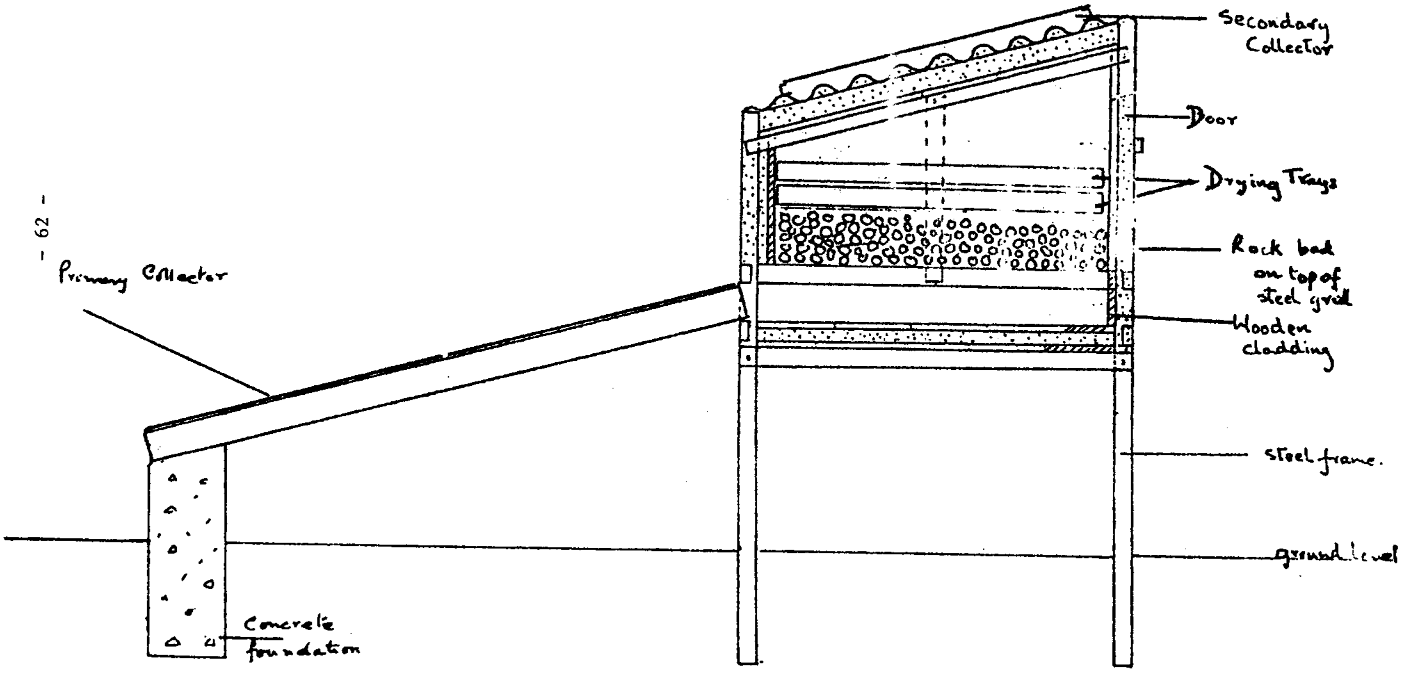
Solar radiation is sensed by some form of thermoelectric device - e.g. Kipp and Zonen type of solarimeter producing small voltage signals proportional to the insolation received.

The temperature (possibly wind speed) in and around various sites of the chamber is sensed through thermocouples or some form of resistance thermometer.

Humidity is to be monitored through a capacitive dewpoint transducer - here the temperature and dew sensors could be accommodated on single silicon chips.

Optimally, in selecting the sensors, it would be necessary to bear in mind properties like sensitivity, low power requirements, good response time and fast natural warm-up. To ensure that these properties are maintained, great care and attention should be paid to the associated electronic circuitry.

Figure 1


Primary Collector
Secondary Collector
Door
Drying Trays
Rock bed on top of steel grid
Wooden cladding
steel frame.
ground level
Concrete foundation