PN-ABM-706

AGENCY FOR INTERNATIONAL DEVELOPMENT
WASHINGTON, D.C. 20523

DATE: 1/18/89

MEMORANDUM

TO: AID/PPC/CDIE/DI, room 209 SA-18

FROM: AID/SCI, Victoria Ose

SUBJECT: Transmittal of AID/SCI Progress Report(s)

Attached for permanent retention/proper disposition is the following:

AID/SCI Progress Report No. 6.075
PR Dept 88

Attachment

PN-ABM-706
74240

Design and Evaluation of a Low Cost Electronic Water Level Sensor for Irrigation Water Management in Sri Lanka

USAID Project ID No. 6.075

Progress Report

by

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September 1988

Rec'd in SCI: JAN 1 8 1989

2

1.0 Introduction

The research project "Design and Evaluation of a Low Cost Electronic Flow Sensor and Its Application of Microcomputer Aided Irrigation Systems Management in the Dry Zone of Sri Lanka" is a collaborative research project between the Department of Agricultural Engineering, University of Peradeniya (UP), Sri Lanka and the Department of Agricultural Engineering, Virginia Polytechnic and State University (VPI), USA. Work on the project was begun in April 1987. The purpose of this report is to document the accomplishments to September 1988 and to provide a revised schedule of activities.

2.0 Overall Aim and Specific Objectives

The principal goal of this investigation is to design a low cost data acquisition device, evaluate its application to improved irrigation water management, and transfer of this technology to the less developed countries, LDC. Specific objectives of the investigations will be to:

1. Perform a comprehensive review of the available low cost components for the design of water stage sensor.

2. Design and develop a low cost water stage sensor for monitoring of water stage in open channels.

3. Test the device and evaluate its performance and adaptability under LDC conditions.

4. Evaluate an irrigation system incorporating the device to determine its potential application to irrigation system management in Sri Lanka and other LDCs.

5. Train LDC personnel in the development and use of the technology.

3.0 Progress of Work

Many difficulties were encountered which delayed the proposed work plan. Despite these setbacks much has been accomplished by September 1988, and the project is scheduled to finish by the December 1989 completion date.

Phase I The first phase of the project is planned to meet objectives 1, 2, and 5 of the specific objectives of the project. Objective 1 was to review the commercially available low cost components for the system, objective 2 was to design and develop a low cost water stage sensor for monitoring water stage in open channels, and objective 5 was to train LDC personnel in the development and use of the necessary technology. The following tasks were planned for phase I of the project:

TASK	STATUS
1) A comprehensive review of low cost components available for the design of water stage sensor will be undertaken.	*Completed*

The operation of available water level sensing devices and their cost-performance trade-off was studied. The construction cost and feasibility of connecting with a data logger were prime considerations in selecting the devices for testing. It was felt that much lower cost devices could be developed with suitable accuracy. It was decided to carry out further tests with two types of sensors:

1) capacitive level transducer, and
2) float and weight with a variable resistance.

2) Design and develop several low cost alternatives for an electronic water stage sensor and data logger.	*Under Way*

After doing a theoretical analysis of the capacitive type sensor, to allow proper understanding of the device, laboratory experiments were carried out to observe the operation of the device. Fixed capacitances which were equal to values expected in the transducer from calculations based on the dielectric properties of air and water were used to test the prototype design of the electronic circuitry.

Next, capacitor plates were constructed from aluminum pipes. These plates needed to be electrically insulated from water. Paint was tested as the insulating material. Several types of paint were tested for their water resistivity and electrical conductivity properties. These tests are on-going but it appears that a coal tar epoxy is a suitable paint. See the appendix for a photograph of several of the test aluminum pipes with different test paints applied.

A set of aluminum pipes 2 feet in length were prepared for testing. The pipe diameter varied from 2 to 5 inches. A capacitor was formed by placing two pipe sections concentric with water and air as the dielectric medium. See the appendix for a photograph of the detail of the construction of the capacitive transducer.

It was observed that there was a direct relationship between the capacitance and the submerged height of the pipe. It was shown that in theory the time taken by the composite capacitor to charge to a certain threshold voltage was linearly related to the capacitance and hence to the water level. Therefore, the delay time of a voltage pulse applied to the capacitor was a good indicator of the water level. This technique showed the potential for a simple interface to digital circuitry because the transducer converts the change in water level to a change in a pulse length. The device did not incorporate any moving parts which may lead to errors due to mechanical lag and friction.

Several combinations of charging resistors and applied voltages were tried in the experiment. The upper limit of the frequency of the applied signal was critical in getting an accurate reading. It was observed that as the supply frequency was decreased the effect of 60 Hz noise became comparatively high. This effect was found not to be an important problem when the frequency was properly chosen.

A control circuit was designed and constructed to generate the required clock pulses and to measure the time taken for charging. A minimum clock frequency of 10 MHz was necessary to achieve the needed accuracy in time measurements. Further experiments were carried out to perfect the measurement and recording of time. See the appendix for photographs of the experimental circuit used in testing the system.

The previous circuit was improved so that it can activate two capacitive sensors alternatively. This method of having a reference capacitor was developed to eliminate any errors due to changes in dielectric properties of water which is considered to be dependant on factors such as temperature and chemical additives. The modified circuit had the capability of generating sampling pulses also.

A second water level sensing system was also developed. It incorporated a variable resistance connected to a buoyancy type water level sensor. The output was digitized using the same technique of capacitive charging, but in this case the resistance varied proportionally to the water level and the capacitance remained constant.

3) Train LDC participants in the design aspects of the electronic technology. — *Completed* *See Phase II*

Mr. Mahinda Alahakoon (Electrical and Electronics Engineer) was recruited as an Assistant Lecturer in the Department of Agricultural Engineering, UP. He was sent to VPI in October 1987. He has now completed 87% of the course work required for the MS degree at VPI. He is currently enrolled in the remainder of the required course work and should finish it by the end of December 1988. See the appendix for a specific list of his course work. Mr. Alahakoon has carried out much of the equipment design and development under the direction of and with the assistance of Dr. Byler and Dr. Mostaghimi.

4) Preliminary selection of a location and study of irrigation management of an the irrigation scheme in Sri Lanka will be made. — *Under Way*

Dr. Goonasekera has made arrangements with the International Irrigation Management Institute, IIMI, to conduct our work at one of their research sites. IIMI has three years of data for the site and will cooperate by sharing that data with us. Dr. Mostaghimi is planning to visit the site in October, 1988 to finalize the site selection.

5) Conduct a field investigation at the selected location to assess the current performance of the irrigation system and provide feedback information for the design of the device. — *Planned for October 1988*

Dr. Mostaghimi will assist in the planning and management of this investigation during his visit to Sri Lanka in October. It is assumed that the three years of data which the IIMI has will be invaluable in this task.

Phase II The activities of the second phase concentrate on objectives 3 and 5. During this phase testing of the devices was planned to be carried out at VPI and the training of LDC personnel was to continue. The following tasks are to be accomplished during the second phase:

1) Evaluate the devices in the U.S. for suitability for applications in irrigation management and hydrology. — *Completed*

The microprocessor based logger units have been redesigned and modified. Several of the logger units have been under continuous field test and the testing period has now passed 4000 logger days. The results of these tests have been quite favorable. Minor errors in the software have been detected and corrected. Several improvements have been made to the hardware. New boards are currently under design, based on the field testing. These boards incorporate all of the design improvements and result in a smaller board. Several of the loggers have failed during field use due to a detail of the power supply. The required repair is fairly simple but a change in power supply design will eliminate this problem. See the appendix for photographs of a typical circuit board and box used in the field tests of this prototype device.

The capacitive stage sensing devices were used in a field test with favorable results. The system clock was set at 500 kHz so that CMOS digital devices could be used. The required level of accuracy was preserved by changing the resistor and capacitor values appropriately. Several full size units have been constructed. A special test stand for field testing the full size units has been designed and is under construction.

2) Develop the microcomputer compatible data output. — *Under Way*

Work on this portion of the data collection system was begun for the field testing of the logger units. Several errors were detected and corrected. Software for the data transfer to personal computers is being tested.

3) Select the two most promising devices for field installation in Sri Lanka. — *Completed*

A system based on the capacitive transducer and another based on a float and weight connected to a variable resistor have been chosen for further testing in Sri Lanka. These two measurement systems will be compared to a commercial system.

4) Continue training the Sri Lankan personnel in the necessary technology. — *Under Way*

Mr. Alahakoon is continuing to make progress on the completion of his course work and is involved in the design and development of the electronic transduction system.

Phase III The activities of the third phase will concentrate on objectives 4 and 5. During this phase the systems are to be tested in the field in Sri Lanka and used in an irrigation scheme as part of the

irrigation system control. Training of the Sri Lankan personnel will continue. The following tasks are to be completed during the third phase.

1) Assess the field installation requirements of the device and construct suitable structures.	*Begun*

We have gotten pertinent information from Sri Lanka and are incorporating it with other design factors of the system. Work is ongoing on the more detailed design necessary for the installation of the devices and the stage measurement testing. Dr. Mostaghimi will assist with this during his visit to Sri Lanka in October.

2) Train field personnel in Sri Lanka on the use of the device for data collection.	*Planned for early 1989*
3) Evaluate the device under tropical field conditions.	*Planned for mid 1989*
4) Data collection using the device.	*Planned for early and mid 1989*
5) Use the data in water management.	*Planned for mid 1989*
6) Develop personal computer based software to facilitate decision making regarding water control and allocation.	*Planned for early and mid 1989*
7) System analysis to improve system performance.	*Planned for mid 1989*

4.0 Revised Work Schedule

The preceding section, broken down by Phase and Targets, includes the current work schedule. It has been necessary to revise the schedule from the previous report. Problems were encountered in ordering some of the necessary equipment, primarily the standard devices. After they were ordered, the manufacturer could not deliver promptly. These delays necessitated the delay of the installation of the devices in the field in Sri Lanka. The standard data loggers have been received at VPI and have been tested.

Communication between the UP and VPI continues to be a problem. Letters are a slow but reliable method of communication. We have tried several approaches with Telex, with limited success. Communication from the UP to VPI is good but from VPI to the UP is not reliable by Telex. It has been difficult to purchase equipment in the US with money in the budget for the UP but it now appears that this problem has been solved, after a considerable period of time. Despite these problems much progress has been made on the project and the engineering aspects of the new device look quite promising. We currently anticipate that the project will be complete by December 31, 1989 as planned.

Appendix

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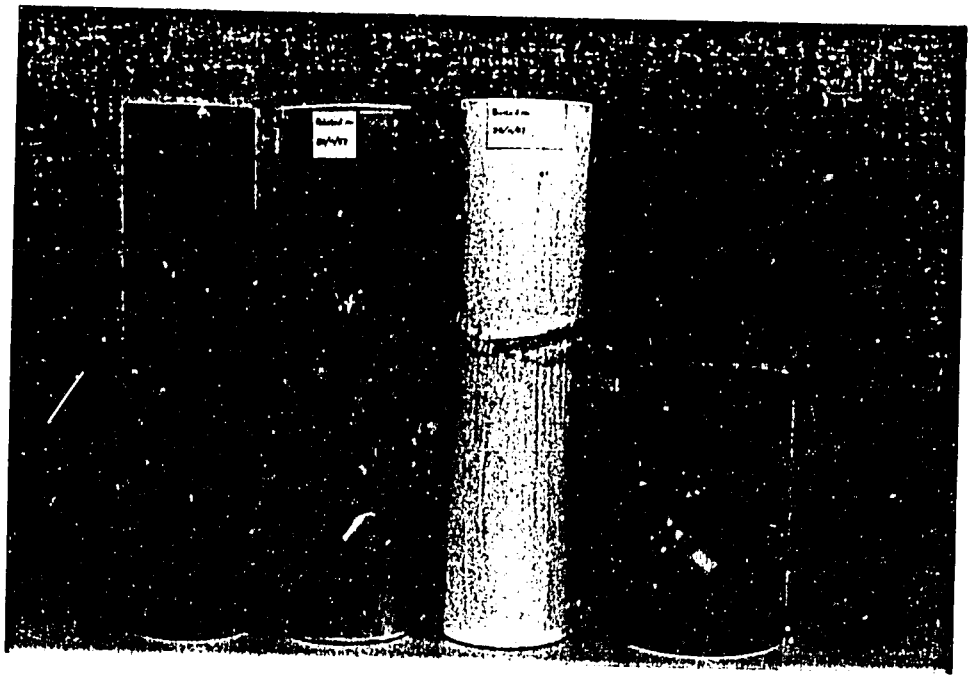
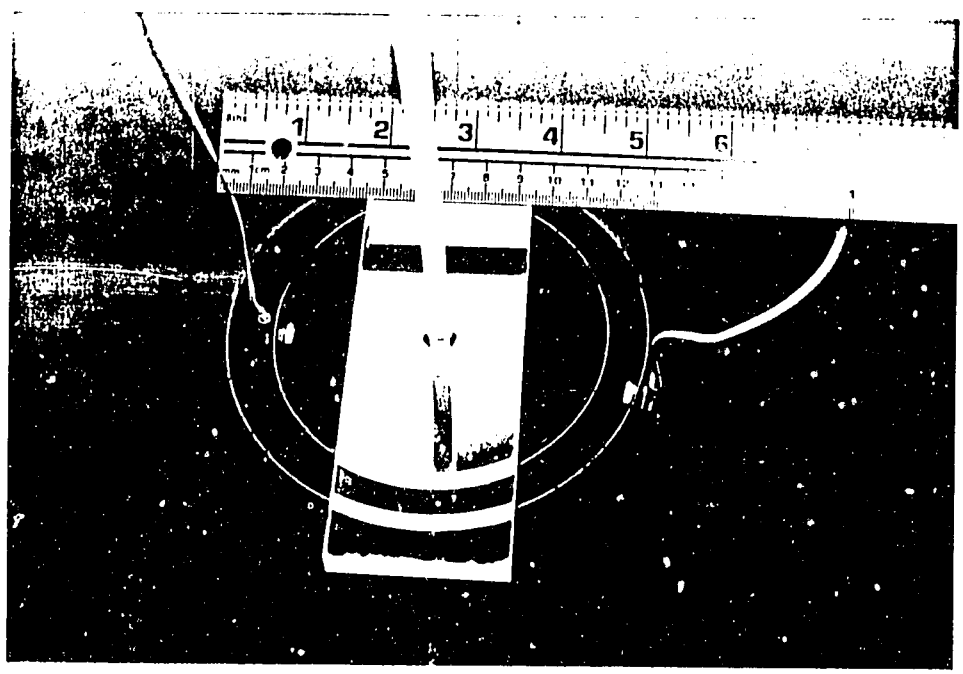


Paint Test Specimens



Detail of Capacitive Transducer

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8

Full Sized Capacitor Transducer

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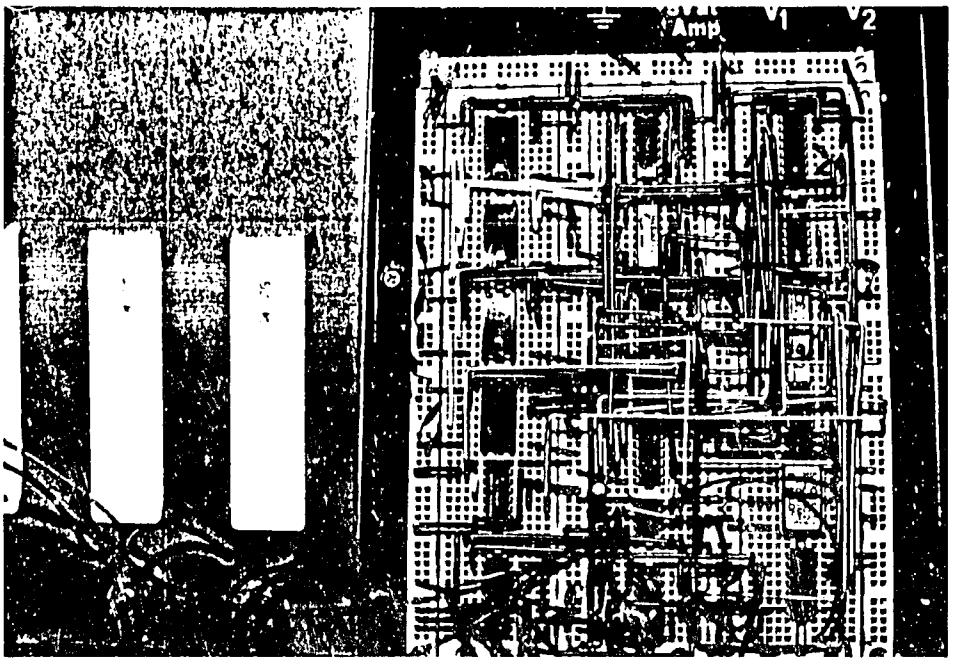
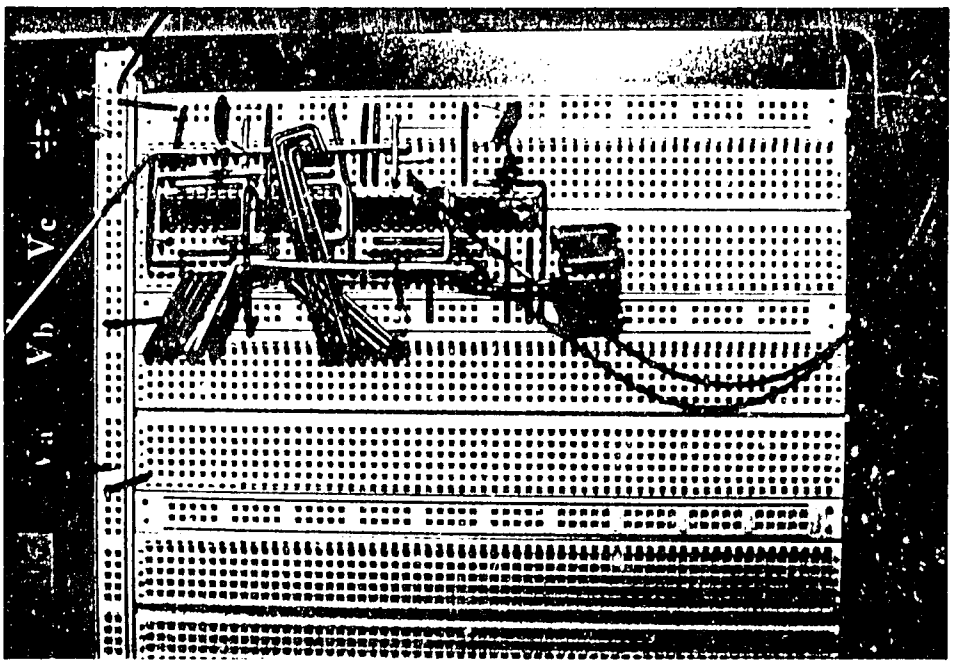


Experimental Circuit Used to Determine Accuracy of Capacitive Transducer



Experimental Circuit Used to Interface With a Microprocessor

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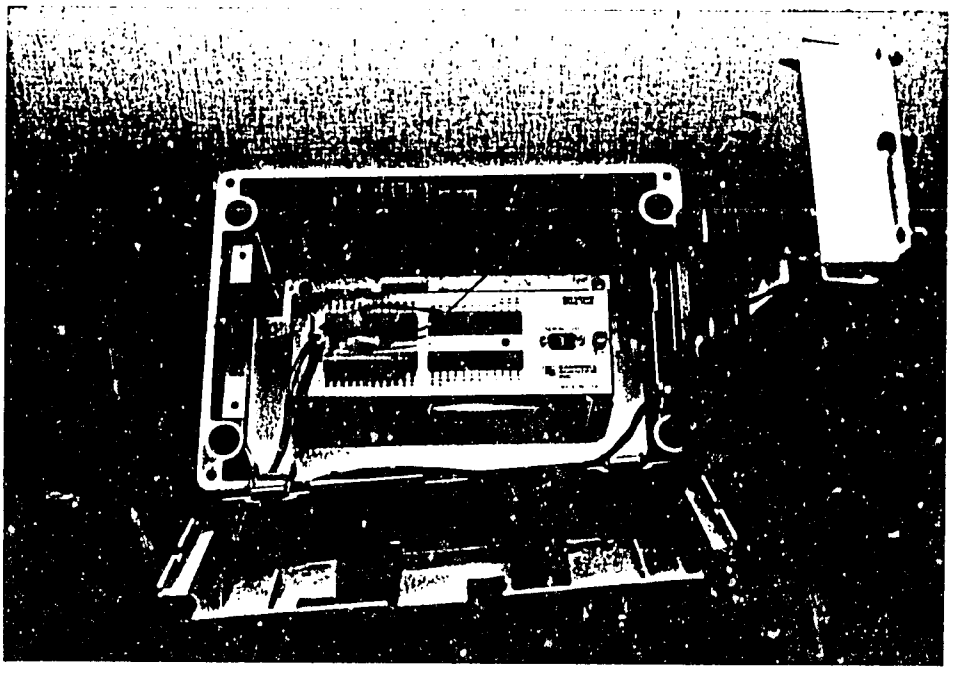
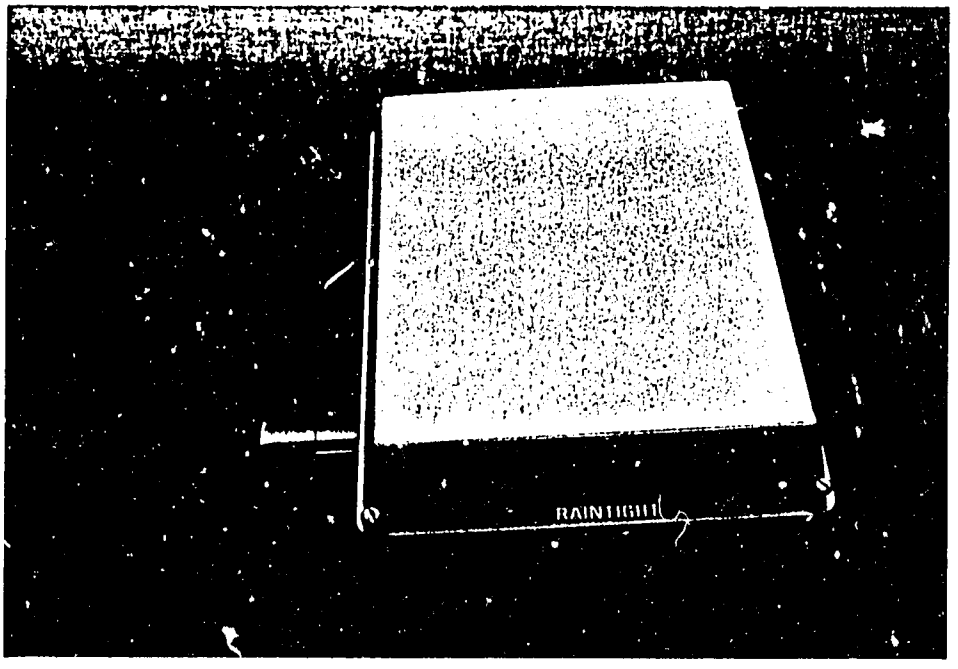


Commercial Logger - Open



Commercial Logger - Closed

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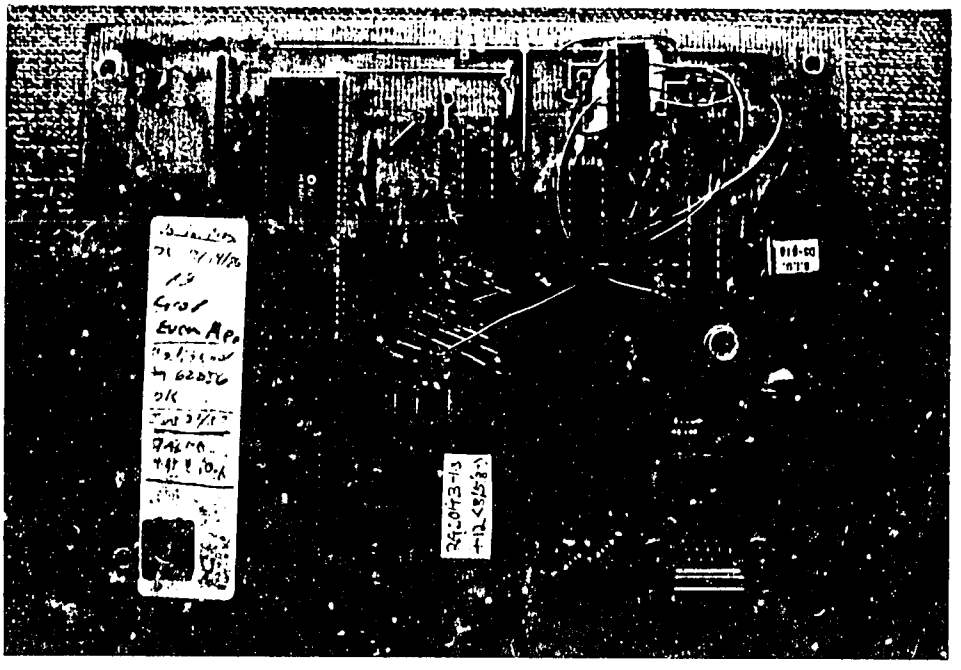
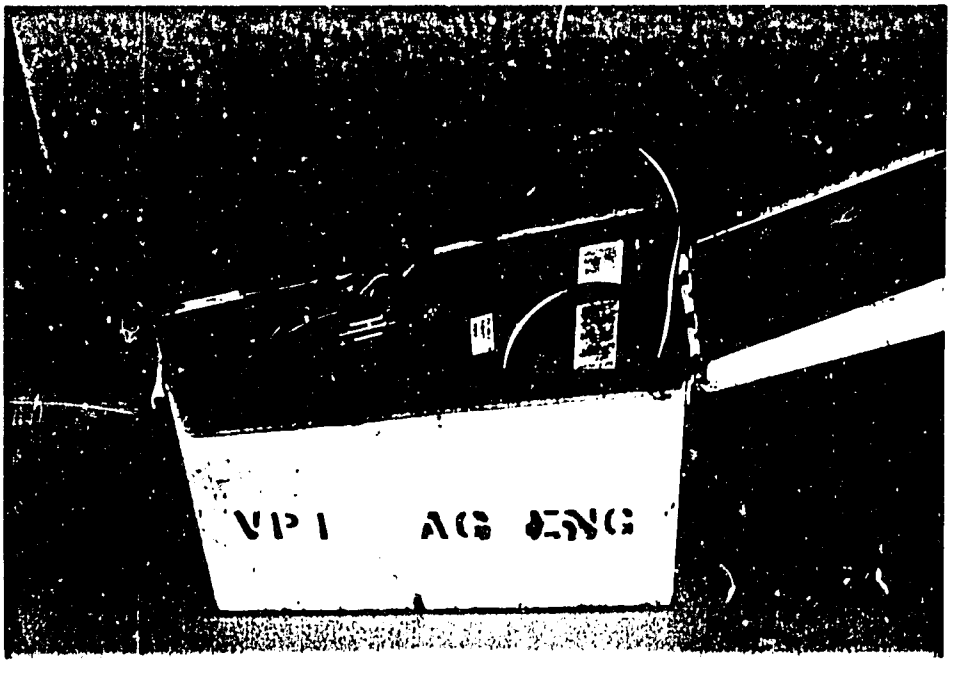
11



Logger Under Development - Showing Retrofits.



Logger Under Development With Case

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12

GRADUATE PROGRAM OF

PULATHISI M. K. ALAHAKOON

LEADING TO THE DEGREE OF
MASTER OF SCIENCE
IN
AGRICULTURAL ENGINEERING

DEPT. AND COURSE NO.	COURSE TITLE	YEAR PLANNED	TOTAL CREDITS
AGE 5990	RESEARCH AND THESIS		15.0
5000 AND HIGHER LEVEL COURSES			
AGE 5984	EXPERT SYSTEMS	88-89	4.5 *
AGE 5114	PHYSICAL PROPERTIES OF AGRI. PRODUCTS	88-89	4.5 *
AGE 5974	INDEPENDENT STUDY	88-89	1.5 *
STAT 5051	STATISTICS IN RESEARCH	87-88	3.0
STAT 5052	STATISTICS IN RESEARCH	87-88	3.0
STAT 5053	STATISTICS IN RESEARCH	87-88	3.0
4000 LEVEL COURSES			
AGE 4150	HYDRAULIC SYSTEMS AND CONTROLS	87-88	3.0
EE 4501	DIGITAL SYSTEM DESIGN	87-88	4.0
EE 4502	DIGITAL SYSTEM DESIGN	87-88	4.0
EE 4503	DIGITAL SYSTEM DESIGN	87-88	3.0
MATH 4531	APP. MATHEMATICS FOR ENGINEERS	87-88	3.0
SUPPORTING COURSES			
AGE 4160	WATER RESOURCES ENGINEERING	87-88	3.0

SUMMARY

(a)	5990 and/or 7990	15.0
(b)	Courses 5000 or higher	19.5
(c)	Courses 4000 or higher	17.0
(d)	Courses not approved for graduate credit	3.0
(e)	Total credits for degree requirements	36.5
(f)	Total credits for supporting courses	3.0

* Currently registered.

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