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Final Technical Report

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NCSU PULSTAR Reactor Instrumentation Upgrade

University Reactor
Instrumentation Program
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S. J. Bilyj
P. B. Perez

North Carolina State University
Department of Nuclear Engineering
Nuclear Reactor Program
Raleigh, North Carolina 27695-7909

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ABSTRACT

The Nuclear Reactor Program at North Carolina State University initiated an upgrade program at the NCSU PULSTAR Reactor in 1990. Twenty-year-old instrumentation is currently undergoing replacement with solid-state and current technology equipment. The financial assistance from the United States Department of Energy has been the primary source of support. This report provides the status of the first two phases of the upgrade program.

TABLE OF CONTENTS

1.0 INTRODUCTION

The Nuclear Reactor Program (NRP) is administratively a part of the Department of Nuclear Engineering where there is close collaboration between the faculty and the NRP staff. Nuclear Engineering courses and associated laboratories use the PULSTAR Reactor as a teaching tool. Both undergraduate and graduate students engage in a variety of projects involving the PULSTAR Reactor as part of the general requirements to obtain their academic degrees. The published Mission Statement for the NCSU PULSTAR Reactor is as follows:

> *The Nuclear Reactor Program (NRP) was instituted to provide specialized nuclear facilities to the North Carolina academic and industrial communities for the purpose of teaching, research and service. In addition, these nuclear facilities are made available to provide services to the state and federal agencies to support governmental activities.*

The one megawatt PULSTAR Reactor continues to meet its mission of teaching, research and service by having provided over 18,000 megawatt·hours of full power operation since initial criticality in September 1972.

The PULSTAR Reactor has operated quite successfully over the past twenty-years with very little operating time lost to equipment failure. However, the probability of equipment problems increase as the equipment ages. The PULSTAR reactor facility began a multi-phase facility upgrade program in 1990. The facility upgrade program will allow the excellent facility availability and operations which it has provided during its first twenty years to continue. The upgrade program is multi-phased and prioritizes the systems to be upgraded based on importance to safe operation and facility availability. The upgrades will also enhance the facility's role in teaching, research, training, and services.

The equipment purchased with the DOE and NCSU matching funds will greatly increase the PULSTAR Reactor reliability and availability.

2.0 DISCUSSION

When it was learned that grant monies would become available through the DOE for equipment upgrades, the NRP staff met to discuss the various options based on need and safety. The equipment ordered and installed so far was the result of that meeting. The upgrade program provided a new fixed-site radiation monitoring system with an uninterruptible power supply to prevent data loss during a power failure. It also provided a data collection system to continually monitor the status of virtually every system, measuring channel, process controller, and radiation level associated with the PULSTAR reactor facility.

2.1 Radiation Monitoring System

The original fixed-site radiation area monitoring system, while it had served quite well, had required an increasing amount of maintenance. In addition, the instrument read-outs were an analog gauge displaying a logarithmic value on a linear scale. This made it very difficult to accurately read values and introduced a potential for error in reading the variables. The new equipment is solid-state with digital read-outs which are very simple to read even from a distance. Refer to Figure 1 for close-up detail of the recorder and four of the monitoring channels. The new radiation area monitoring system is backed-up by an Uninterruptible Power Supply (UPS) which dramatically reduces the number of alarms associated with power line faults.

Radiation levels within the Reactor Building and in the building ventilation exhaust are monitored in a single equipment rack along with a trending recorder. Figure 2 shows the transition between the original Radiation Monitoring System to the right and the new system during installation. Radiation levels are monitored at the following locations: Control Room, Reactor Pool, West Wall, Primary Demineralizer, Stack Gas, Stack Particulate, Filter GM, Auxiliary GM, and the three liquid effluent tanks. The equipment rack was repositioned to the left and at right angles to the reactor operator as a result of a Human Factors evaluation of the PULSTAR Control Room. This

affords the reactor operator a clear view of the radiation monitoring channels. The new equipment is the original manufacture's recommended replacement for the equipment which was installed in 1971. The new uninterruptible power supply (UPS) for the Radiation Monitoring Rack is located immediately to the right of the Radiation Monitoring Rack. Figure 3 shows the final location of the Radiation Monitoring System with its UPS (white cubical on floor). Data from the Radiation Monitoring Rack is sent to the data acquisition system that is explained in Section 2.2.

Figure 1

RADIATION MONITORING RECORDER
AND AREA MONITOR CHANNELS

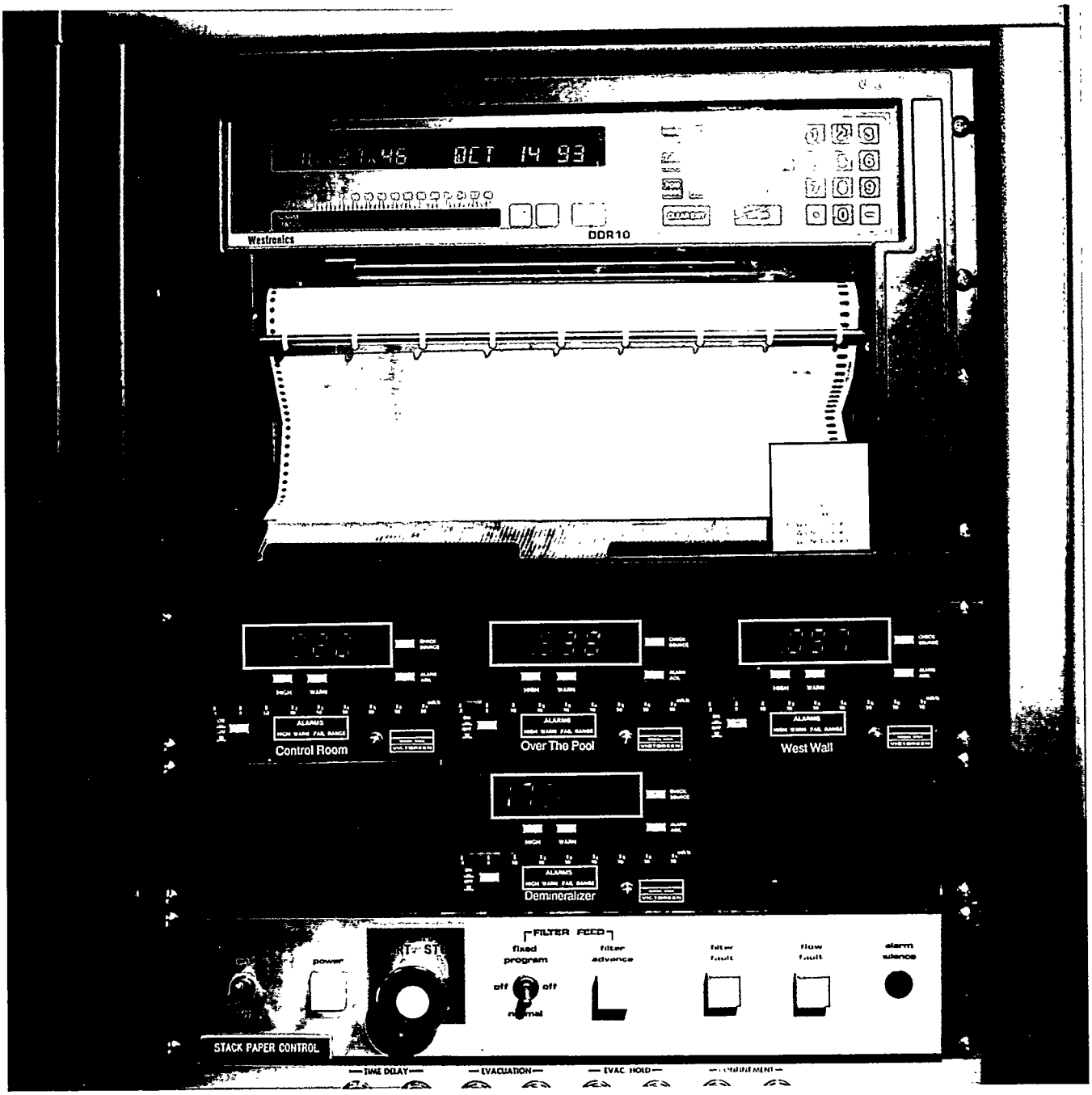


Figure 2

RADIATION MONITORING SYSTEMS

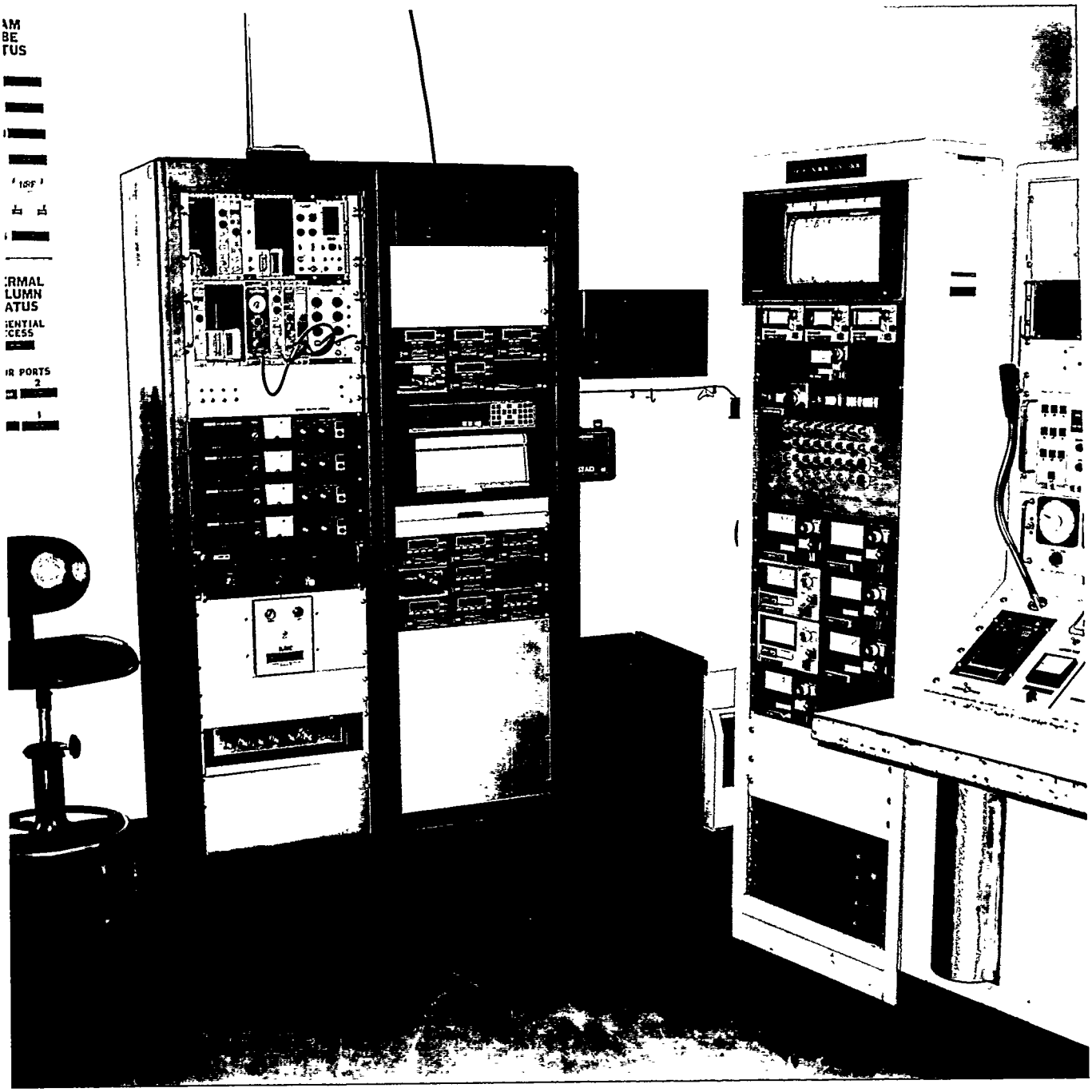
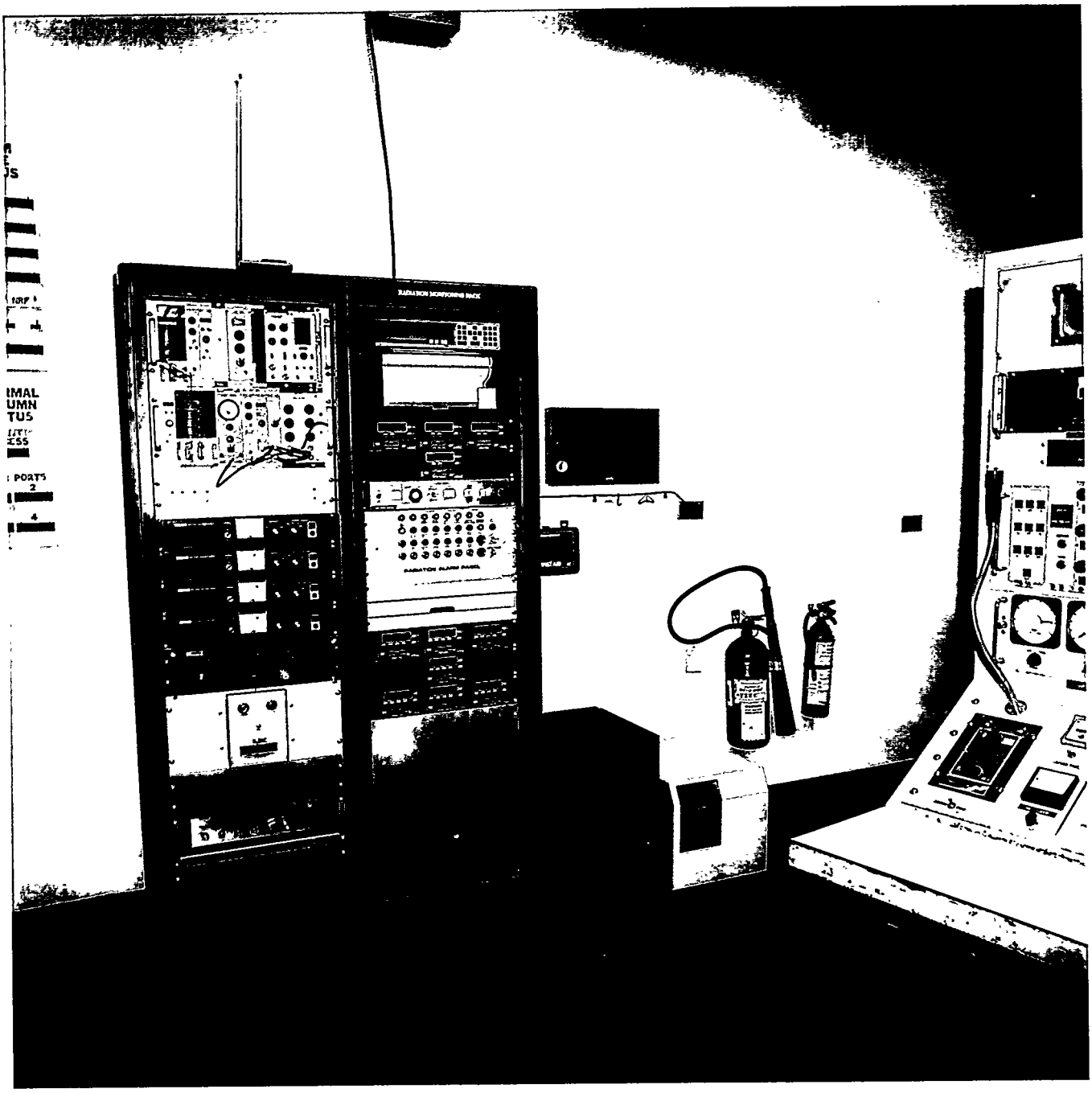


Figure 3

NEW RADIATION MONITORING SYSTEM



2.2 Data Acquisition System

Continuous monitoring of virtually every process variable at the PULSTAR reactor facility gives the opportunity to recognize trends of possible equipment degradation. The early detection of potential equipment failures allows our preventative maintenance program to correct any problems while minimizing repair costs and facility shutdown time. In addition to monitoring trends, access to the various signals is now available for student laboratories and research work. Access to most of these signals was not available until the Data Acquisition System was installed.

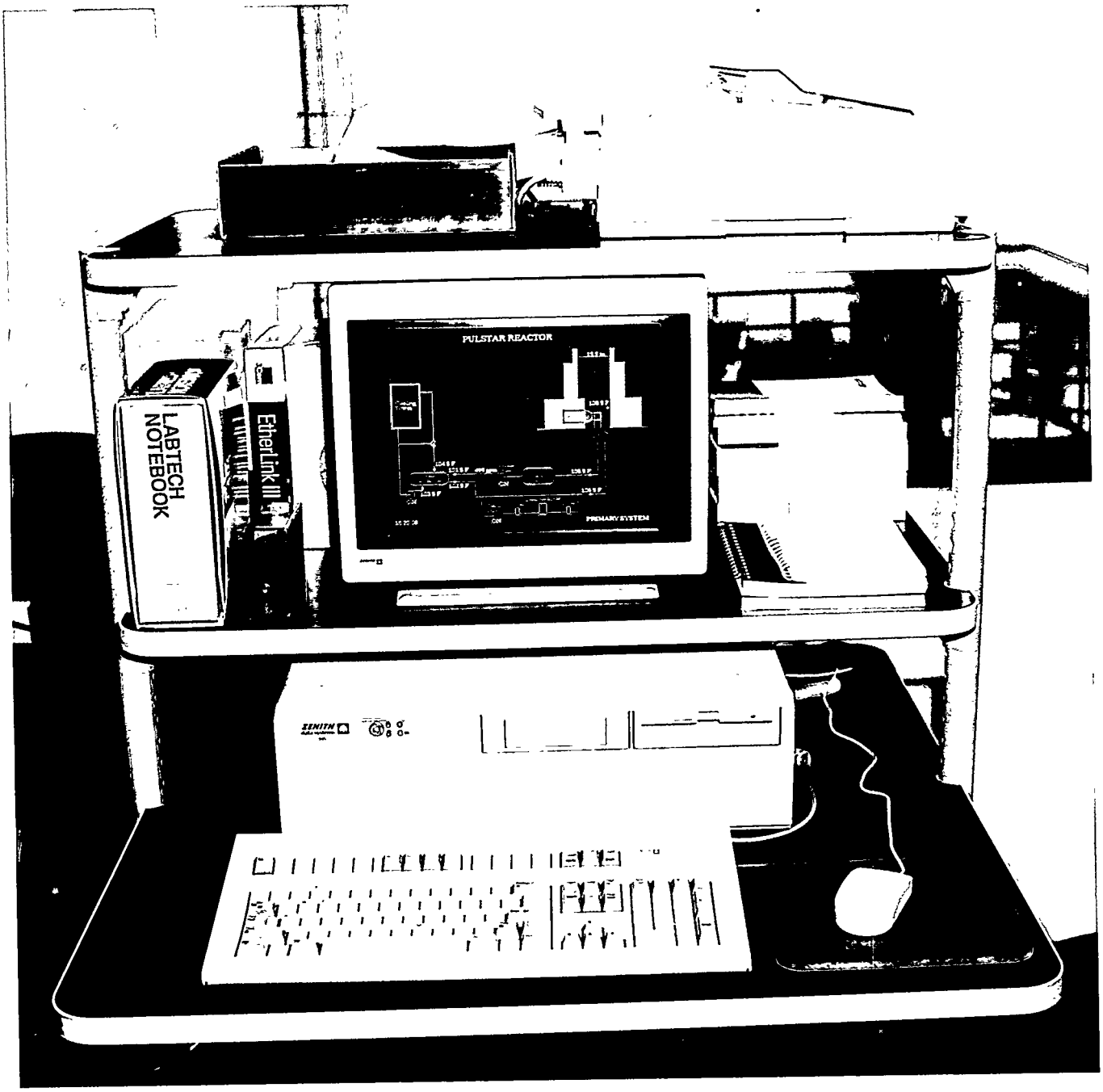
The Data Acquisition System for the PULSTAR Reactor is an IBM compatible 80386DX 33 Mhz computer using a Keithley Metrabyte Series 500 data acquisition system and appropriate analog and digital isolation devices. The data acquisition system is located in the PULSTAR Control Room behind the control console. Figure 4 shows the major components of the system assembled on its work station. The system is available to the NRP staff for reactor engineering projects, and the faculty and students for undergraduate and graduate studies.

The computer along with the data acquisition system produce different viewing screens to display the status of nearly every parameter that is associated with the PULSTAR Reactor. The screens are the Menu, Primary System, Reactor Core, Ventilation System, Digital Inputs, Waste Tank System, and the Area Radiation Monitoring System. The Menu screen shown in Figure 5 lists the different screens available for viewing. One needs to only press the first letter of the screen desired to display that screen. Figure 6 shows the Digital Inputs screen in a table format. This screen displays the status of all of the individual parameters that are monitored. The remaining screens shown in Figures 7, 8 and 9 graphically show each system and its measured parameter with a digital value or a "on/off" status. A permanent record of these values can be produced on the printer. All values shown in the figures were set to arbitrary values and may or may not be indicative of actual values. Also available are

calculated values for processes that are time or reactor power dependent such as xenon concentration in the fuel or the differential temperature across the reactor core.

Figure 4

DATA ACQUISITION SYSTEM



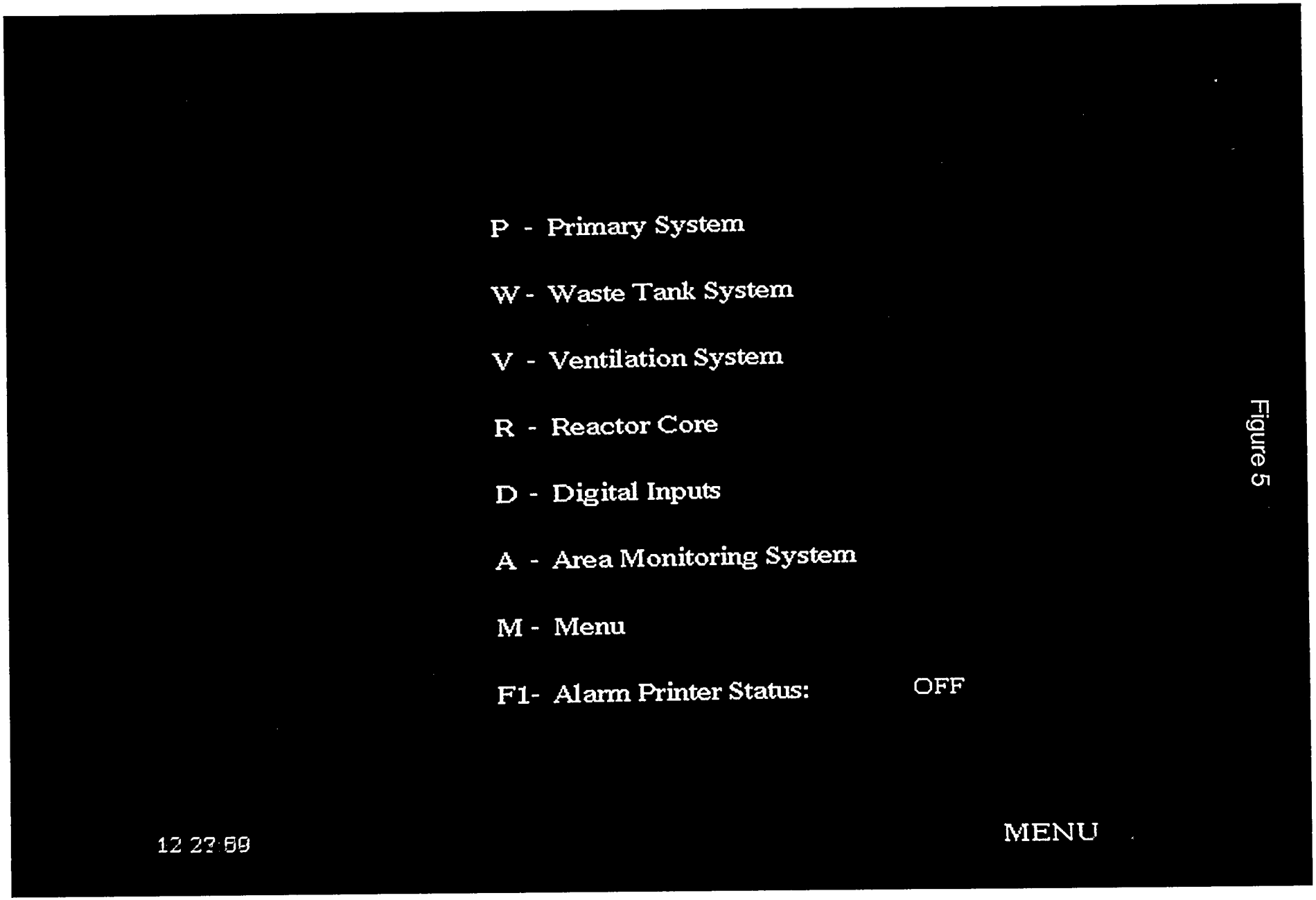

P - Primary System
W - Waste Tank System
V - Ventilation System
R - Reactor Core
D - Digital Inputs
A - Area Monitoring System
M - Menu
F1- Alarm Printer Status: OFF
12 27 59
MENU

Figure 5

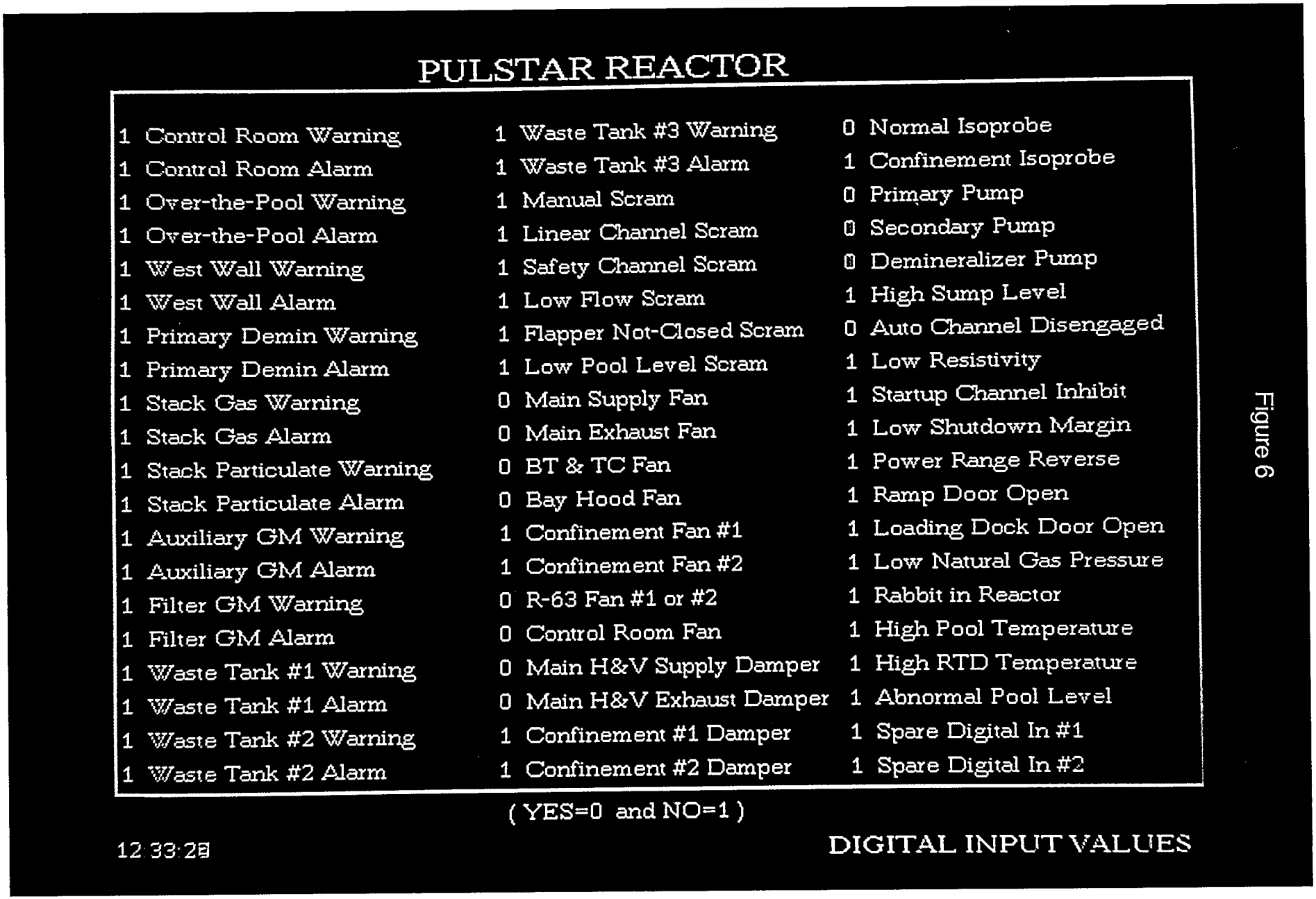

PULSTAR REACTOR
1 Control Room Warning
1 Control Room Alarm
1 Over-the-Pool Warning
1 Over-the-Pool Alarm
1 West Wall Warning
1 West Wall Alarm
1 Primary Demin Warning
1 Primary Demin Alarm
1 Stack Gas Warning
1 Stack Gas Alarm
1 Stack Particulate Warning
1 Stack Particulate Alarm
1 Auxiliary GM Warning
1 Auxiliary GM Alarm
1 Filter GM Warning
1 Filter GM Alarm
1 Waste Tank #1 Warning
1 Waste Tank #1 Alarm
1 Waste Tank #2 Warning
1 Waste Tank #2 Alarm
1 Waste Tank #3 Warning
1 Waste Tank #3 Alarm
1 Manual Scram
1 Linear Channel Scram
1 Safety Channel Scram
1 Low Flow Scram
1 Flapper Not-Closed Scram
1 Low Pool Level Scram
0 Main Supply Fan
0 Main Exhaust Fan
0 BT & TC Fan
0 Bay Hood Fan
1 Confinement Fan #1
1 Confinement Fan #2
0 R-63 Fan #1 or #2
0 Control Room Fan
0 Main H&V Supply Damper
0 Main H&V Exhaust Damper
1 Confinement #1 Damper
1 Confinement #2 Damper
0 Normal Isoprobe
1 Confinement Isoprobe
0 Primary Pump
0 Secondary Pump
0 Demineralizer Pump
1 High Sump Level
0 Auto Channel Disengaged
1 Low Resistivity
1 Startup Channel Inhibit
1 Low Shutdown Margin
1 Power Range Reverse
1 Ramp Door Open
1 Loading Dock Door Open
1 Low Natural Gas Pressure
1 Rabbit in Reactor
1 High Pool Temperature
1 High RTD Temperature
1 Abnormal Pool Level
1 Spare Digital In #1
1 Spare Digital In #2
(YES=0 and NO=1)
12:33:28
DIGITAL INPUT VALUES

Figure 6

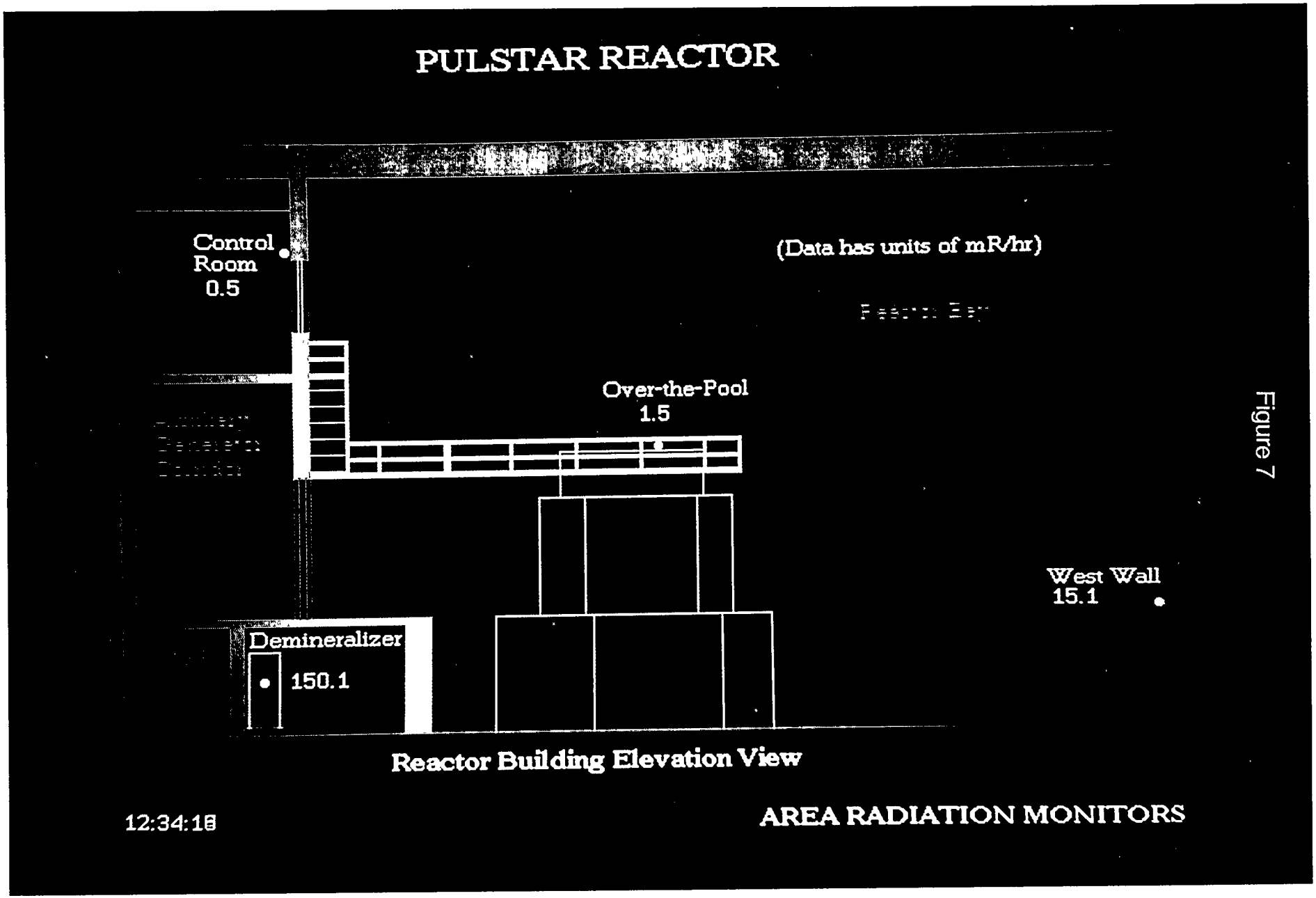

PULSTAR REACTOR
Control Room 0.5
(Data has units of mR/hr)
Over-the-Pool 1.5
West Wall 15.1
Demineralizer
150.1
Reactor Building Elevation View
12:34:18
AREA RADIATION MONITORS

Figure 7

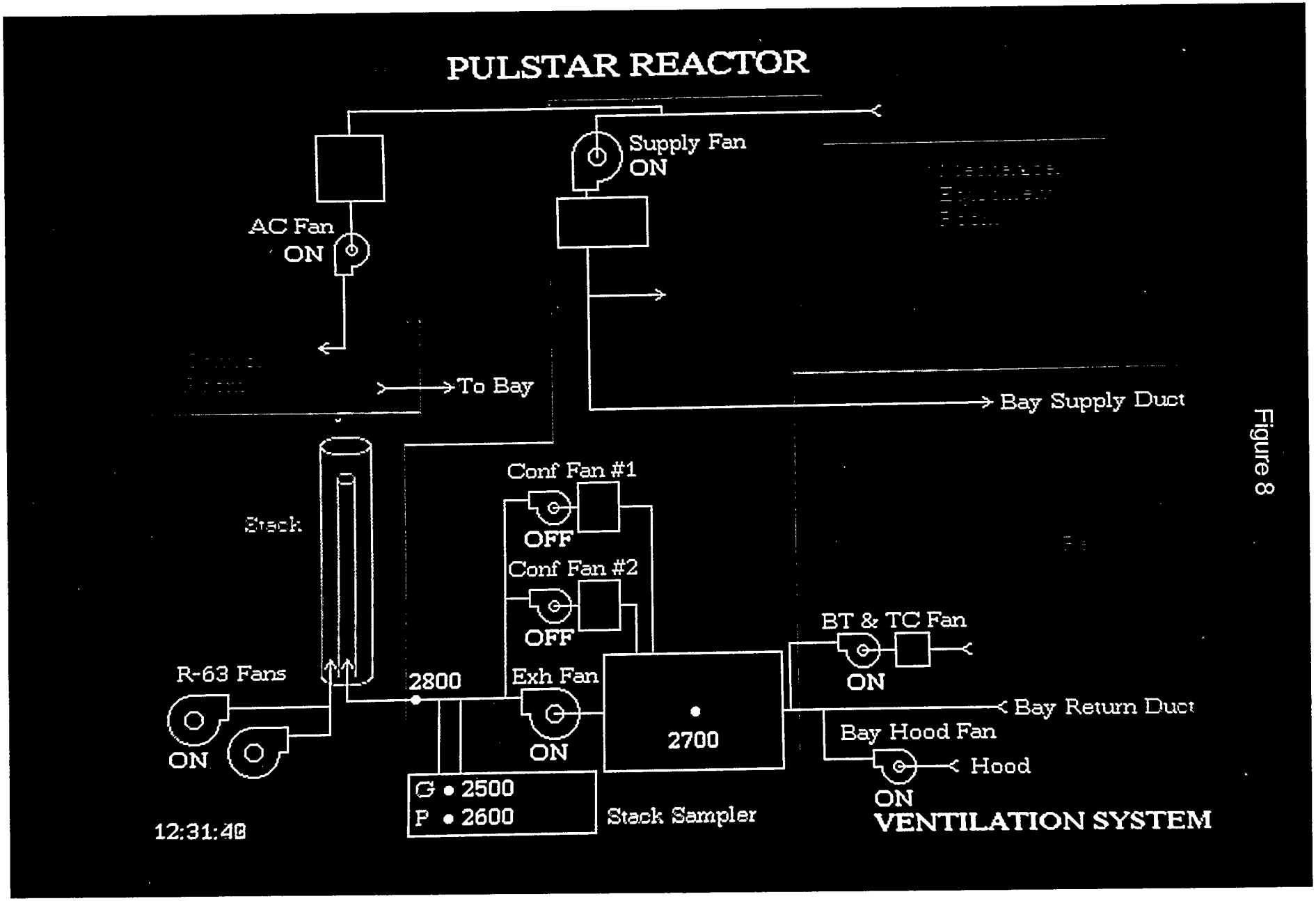

PULSTAR REACTOR
Supply Fan
ON
AC Fan
ON
To Bay
Bay Supply Duct
Stack
Conf Fan #1
OFF
Conf Fan #2
OFF
BT & TC Fan
ON
R-63 Fans
ON
2800
Exh Fan
ON
2700
Bay Return Duct
Bay Hood Fan
Hood
ON
G • 2500
P • 2600
Stack Sampler
12:31:40
VENTILATION SYSTEM

Figure 8

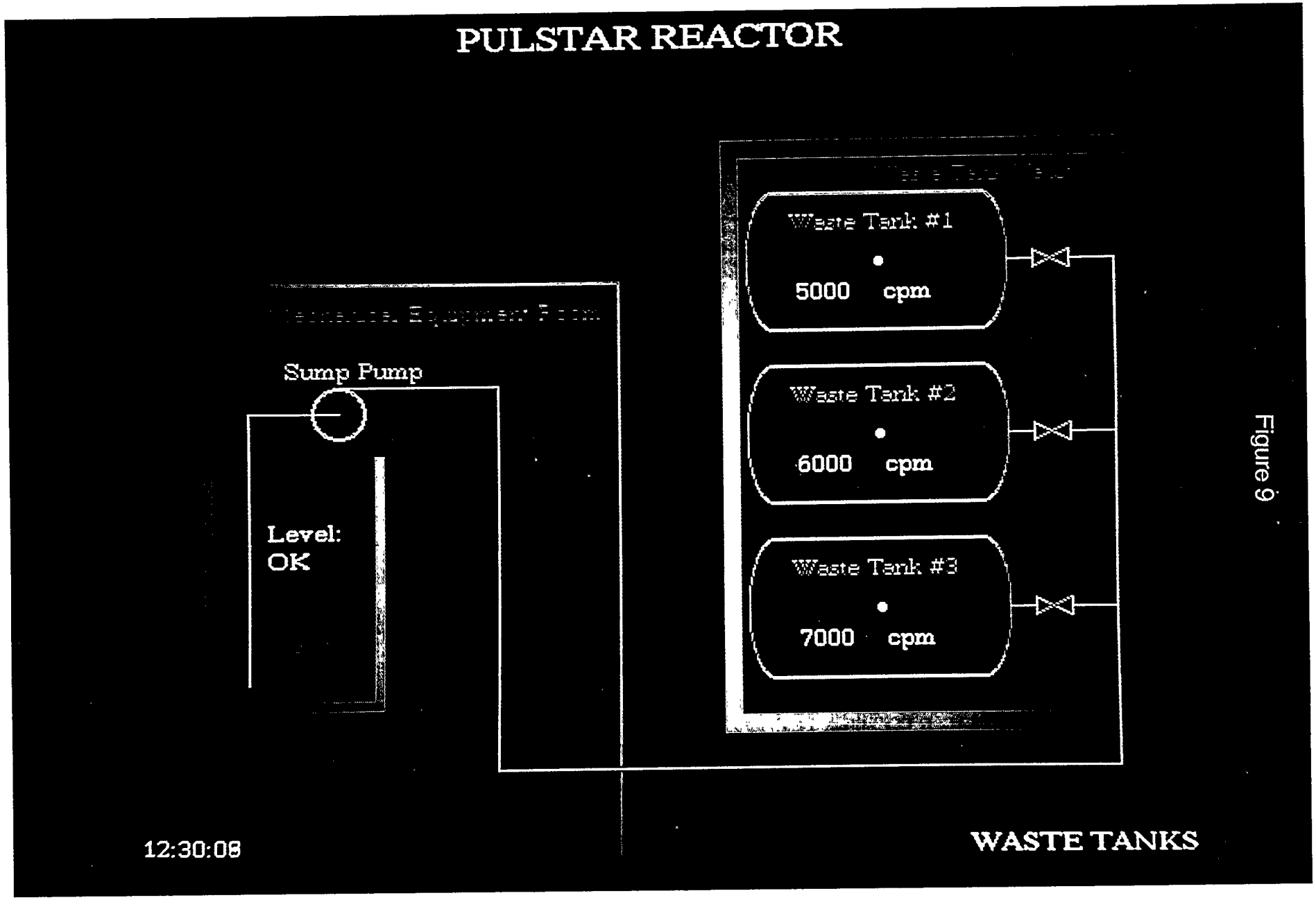

PULSTAR REACTOR
Sump Pump
Level:
OK
Waste Tank #1
5000 cpm
Waste Tank #2
6000 cpm
Waste Tank #3
7000 cpm
12:30:08
WASTE TANKS

Figure 9

3.0 CONCLUSION

The first two phases of the PULSTAR Instrumentation Upgrade Program are now complete. The equipment upgrades described in this report are independently functional and are available to provide data for reactor operations as well as Nuclear Engineering laboratories. Undergraduate, graduate, and researchers now have a valuable asset with which they can explore other disciplines associated with Nuclear Engineering and reactor operations.