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RENEWAL OF INSTRUMENTATIONS FOR EGYPT'S FIRST RESEARCH REACTOR (ETRR-1)

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ABSTRACT

The work reported in this paper presents the tasks completed or currently under completion for the renewal of the Nuclear Instrumentation and Control System, Radiation Protection System and Process Instrumentation System for Egypt's first research reactor (ETRR-1). The mentioned tasks started in 1980. The work reported includes the procurement and installation procedures and gives also a historical background which introduces ETRR-1 and its operating history together with the need for and philosophy behind the renovation of the above mentioned systems which were first put in operation in 1961.

I.1 Historical Background

ETRR-1 is a 2 MW thermal hetrogenous research reactor of the type WWR-C supplied by the Soviet Union. It went critical for the first time in the fall of 1961. The reactor is designed for Neutron Beam Experiments, Isotope Production and Biological Experiments. It has been operating on regular intermitent basis except for shut down periods for major maintenance and repair.

In the early seventies the nuclear power program which was initiated in 1964 was reactivated. It was thought, then, to extend the use of ETRR-1 as an experimental & training facility for the implementation of the national nuclear power program. To meet these new requirements two alternative approaches were considered:-

a) Upgrading ETRR-1 and boosting its rated power to meet the new material/fuel testing, loop experiments, systems performance analysis in order to cope with the national nuclear power program.

b) Construction of a new experimental/prototype reactor facility (in the 20-30 MW range) to meet the requirements of the national nuclear power program keepng ETRR-1 in its existing conditions. Due to the relatively large investments needed for the construction of a new experimental reactor facility it was decided to start with the first alternative to upgrade ETRR-1 and extend its operating lifetime. Before proceeding with the upgrading tasks an inspection was carried out on ETRR-1 internals which revealed the following:-

- Reactor tank and mechanical components (pumps, heat exchangers, control drives-etc) can withstand normal operating schedule for at least 10-15 years.

- Stored fresh fuel in stock is enough to operate the reactor at its rated power level according to current operating schedule for the same period.
- Reactor instrumentation for safety, control and process systems should be renewed in order to support the operation of the reactor for such extended period.

Thus an extensive program was initiated in the late seventies in order to reconstruct and modernise the instrumentation systems of ETRR-1 keeping it at the same design rated power (2 MW.). Building of the new experimental prototype reactor facility has thus been delayed for 10-15 years until enough funds can be allocated for such big task.

I.2 Renewal Philosophy

The need for renewal of the reactor instrumentation systems in the early eighties has a significant importance at that time, because it will probably be exploited during the rest of the reactor life time. Partial renewal of the reactor instrumentation systems was not recommended since the mixing of old and new parts and components could not lead to the needed sufficient and long lasting improvements. The cost of total renewal of the reactor instrumentation systems amounts only to a small fraction of the cost of a new reactor facility. Thus there was a clear economic advantage to renew the existing ETRR-1 instrumentation systems and some other significant parts of it until the new experimental/prototype reactor facility project sees the light.

The need for complete renewal of all ETRR-1 instrumentation systems was based on the following propositions.

1) Aging and obslence of the old systems which was designed in the mid fifties and was operating for more than 20 years. The difficulty in securing the spare parts for the old designed electronic systems made it difficult to operate the reactor without prolonged maintenance periods. This imposed large burden on the reactor operation & maintenance staff.

2) The design of the old system was non modular with insufficient reliability and need for long repair time.

3) Rapid development in the electronic industry made it unfeasible to make partial renewal of the instrumentation systems due to incompatability of the old and new electronic components.

II- RENOVATION OF INSTRUMENTATION OF ETRR-1

This section outlines the approach followed in the renovation process of the three categories of systems, namely

1- Instrumentation and control (I & C) system.
2- Radiation Protection System (RPS).
3- Process Instrumentation System (PIS).

For each category the following items are presented:-

- General Description of the new system with emphasis on new design philosophy.
- Procurement and Installation tasks.
- Renovation effect on improving safety features.

II.1 Nuclear Instrumentation and Control (I & C) System

II.1.1 General Description

The new I & C system is composed of the following sub-systems:-

- Safety channels.
- Logarithmic Channels.
- Linear Switchable Channel.

II.1.1.1 Safety Channels

The safety channels consist of three independent channels which monitor the reactor power. These are connected to the emergency circuit through a 2 out of 3 logic. Each safety channel has three (3) ranges (10^{-6} amp., 10^{-5} amp. & 10^{-4} amp) which ensure safe operation of the reactor at different power levels.

Fig. 1. presents a schematic of the safety channels showing its modular electronic components.

The old safety system was composed of only one channel in the start-up range and two chanels in the power range with one common powersupply. There was no buffer amplifiers or recorders on these channels.

II.1.1.2 Logarithmic channels

Three independent channels are used to measure the reactor period during the start-up of the reactor. These are connected to the emergency circuit through 2 out of 3 logic.

Fig. 2 presents a schematic of the logarithmic channels showing its modular electronic components.

In the old system there were no any logarithmic channels instead the doubling time was measured by the operator using a stop watch.

II.1.1.3 Linear Switchable Channel

This channel measures the reactor flux from 10^{-12} amp to 10^{-4} amp. in 16 ranges which allows the precise change in reactor power to the detected. This channel is connected to the automatic rod drive system through a control unit (Motric 96 E) to control the reactor power in the automatic mode of operation.

Fig. 3 presents a schematic of the linear switchable channel showing its modular electronic components. The Motric 96-E is an on/off switch operated from the input signal from the linear amplifier. It connects the voltage of the automatic control rod to the motor drive if the difference between the measured reactor power and the reference value exceeds $\pm$ 1%.

In the old system an amplidyne was used to amplify the difference voltage which operate the motor drive of the automatic control rod. A comparator using d-c supply from a dry cell was used to produce the reference voltage. The resulting transient response was not as good as in the new system.

From the above description of the new I & C system it is clear that it included the following improvements compared to the old system:-

A- Independency: Through the use of independent ionization chamber, power supply and high voltage supply for each channel.

B- Reliability: Through the use of 3 channels for each system with a 2 out of 3 logic unit which enables on line testing.

C- Availability: Through the use of standard modular units and identical components in all units. This enables the operator to interchange the components in the three units without the need of too many spare components. Modular design and identical components made the maintenance a lot easier.

The safety of the reactor is greatly enhanced by introducing the above improvements.

II.1.2 Procurement and Installation

Through a bilateral agreement with KFA Julich, in F.R.G., the design of the new system was jointly developed through 1980. Hartman & Brown company in F.R.G. was selected as the supplier of the new system. Installation was carried out by ETRR-1 operation and control staff with the help of some experts from KFA Julich. Installation was completed in 1984.

II.2 Radiation Protection System (PRS)

II.2.1 General Description

The RPS is designed to cover the monitoring of radiation levels at selected areas in the reactor building. The system is composed of 30 channel gamma radiation assembly, together with an air monitoring and water activity controlling equipment. The distribution of these detectors in the reactor building is shown in Fig. 4. Twenty five channels of the RPS utilize silicium semi conductor detectors covering the different ranges of radiation exposure from 0 to 3×10^4 uSV/h in five steps. The other five channels utilizes Geiger-Muller detectors as gamma indicators for measuring the activity concentration in the sampled air. Each channel has an alarm output with adjustable level. Monitoried radiation levels are continuously compared with alarm set points for each detector channel. As the radiation level approaches the set points, alarm is initiated at the central unit. At the same time alarm signal appears at the detector itself which is equipped with alarm unit. The central unit of the RPS includes a series of electronic channels mounted on 10 racks. These racks contain alarm indicators, linear rate meters of the 30 channels, printer, switches of air monitors ect... Eight of the 30 signals are relayed to the operator in the reactor control room which is located one floor above the location of the central unit.

II.2.2 Procurment and Installation

The system was supplied by Hungary through IAEA technical assistance (project No EGY/9/015). Installation was carried out by the operation reactor staff together with the Hungarian experts. First the old system was dismantelled and the wiring completely changed to install the new system which was first operated in 1988. After operation of one year, recalibration and adjustment were under taken in march 1989.

The new system has a lot of advantages over the old system which can be summerized in the following:

- Standardization: the new system contains standard units so it can be replaced by any other similar units.
- Independency: each channel has its own detector, amplifier, rate meter and alarm system.
- Availability: the channel use identical units which enable the change of one unit by another unit from other channels.

The new system has greatly enhanced the radiological safety measure in the reactor building.

II.3. Process Instrumentation System (PIS)

II.3.1 General Description

The PIS consists of 30 channels to measure the process parameters. The sensors in the different locations transfers the parameters to current which is amplified and send a volt signal to 3 centeral units in the control room, where it is displayed and recorded. The parameters measured are:

- Primary coolant circuit: pressure, flow, temp., temp. difference, flow in filter, pump bearing temp.
- Dearator: water level, flow, air flow, outlet temp. depression.
- Secondary coolant circuit pressure, flow, temp., temp. difference..
- Levels: central tank, shield tank, distillate water tank, sprent feal storage, wast storage tanks 1 & 2.
- Air depression: above reactor, under reactor, in spent fuel tank in hot cells, pumproom, before ventilators.
- Thermal power indicator.
- Water conductivity in distillate water tanks.

The 3 central units contain the amplifiers, displayers and alarm signals for each channel as shown in Figures 5,6,7.

II.3.2 Procurement and Installation

The PIS system was supplied from Hungary through IAEA technical assistance (project o. EGY/4/028), in 1989. It is anticipated to be installed by the Hungarian experts and ETRR-1 operation and control staff during the last quarter of 1989.

The new system is a modular system having the same advantages mentioned before for the other two systems namely standardization, availability, reliability and independency.

III- CONCLUSIONS

The tasks undertaken for the renewal of the instrumentation systems of ETRR-1 was cost effective and unique for a developing country. The work highlighted the importance of IAEA technical assistance programs in helping a developing country in the implementation of rehabilitation programs for its nuclear facilities independently from the reactor supplier country.

ETRR-1 was operating since 1961 and the decision to renovate its instrumentation systems was taken in 1980 with Egypt's new open door policy after the 1973 war. The completed work indicated the importance of self dependance in performing the design and implementation of rehabilitation tasks and securing the proper financing channels for these tasks.

The experience gained in performing such an important job justifies the effort and money spent on it.

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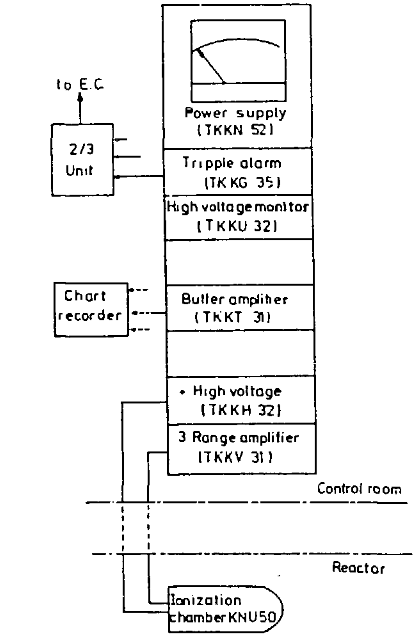


Fig(1) Safety channel(modules in bracket from H&B company

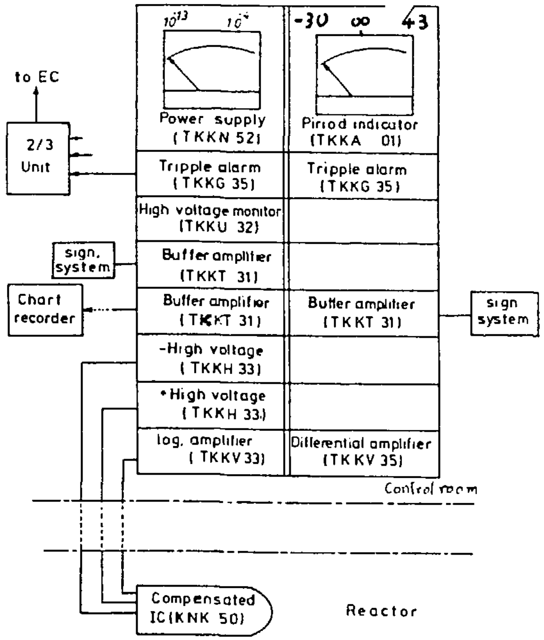
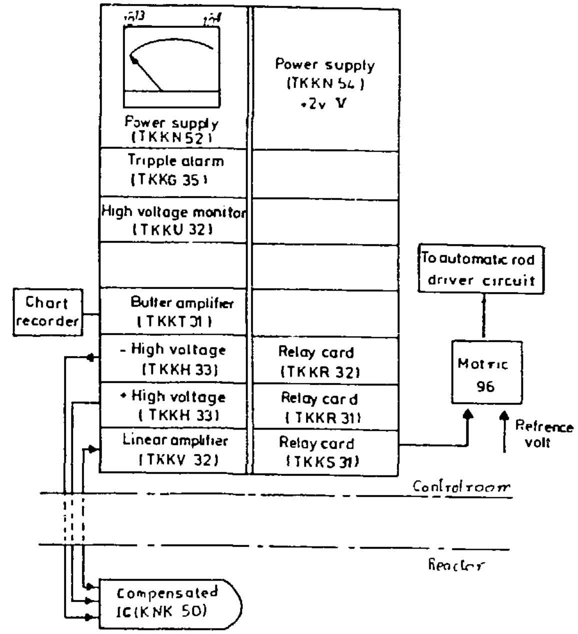


Fig (2) Log. d.c. channel (modules in bracket from H&B company)



Fig(3) Multirange d.c. channel (modules in bracket from H&B company)

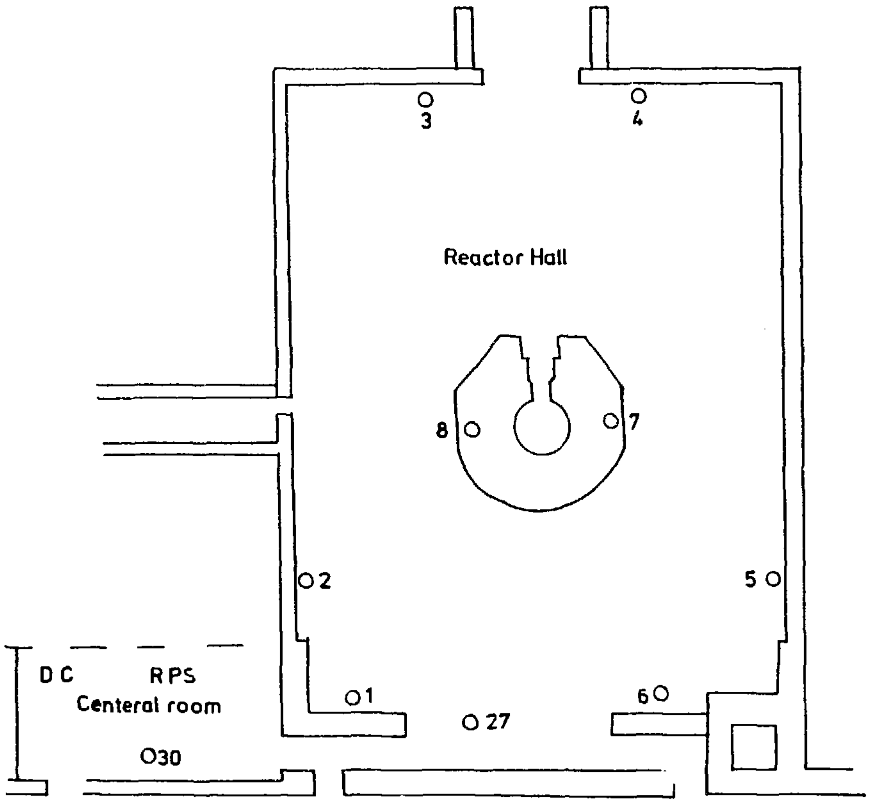
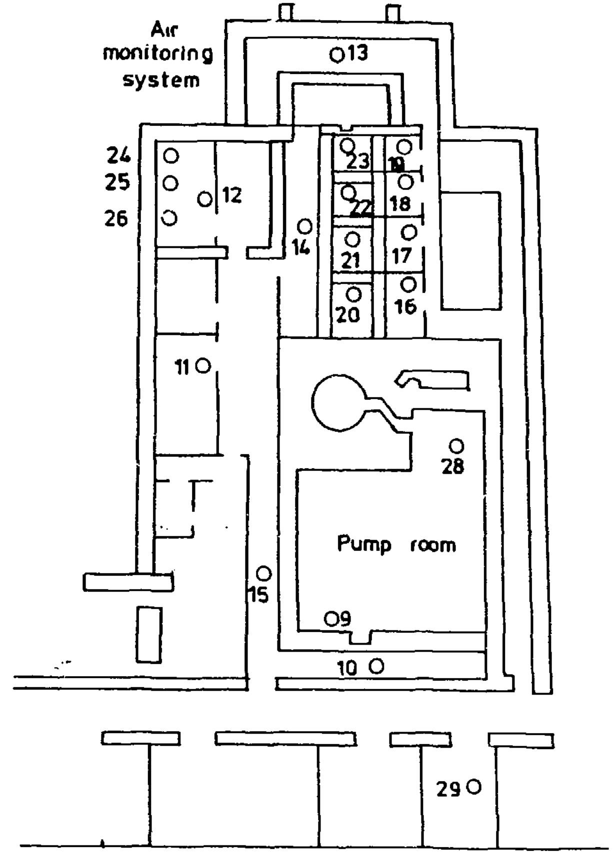
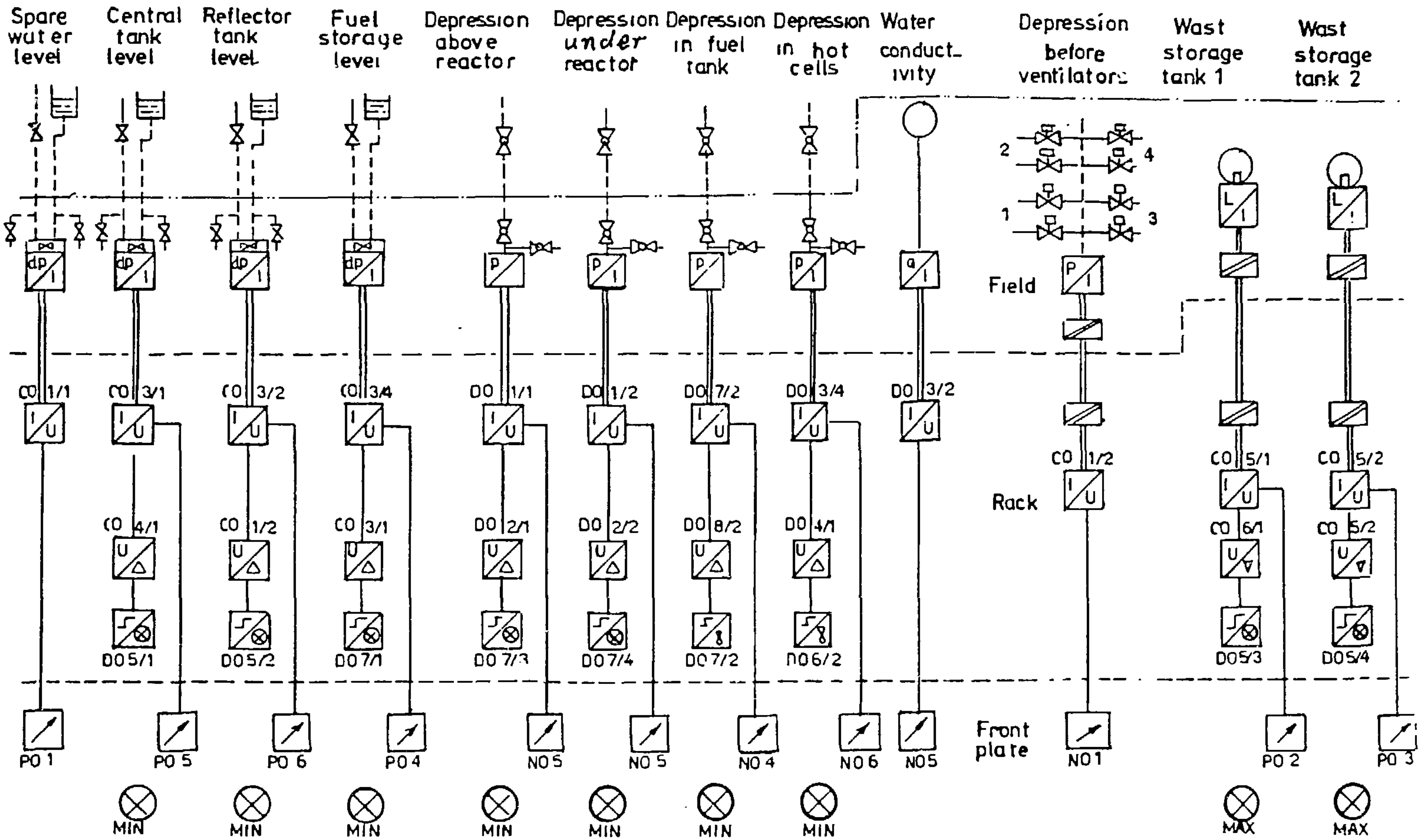


Fig.(4 _ a) Location of RPS detectors in 1st Floor



Fig(4 _ b) Location of R PS detectors on ground floor



Fig(5) Rack1 of PIS

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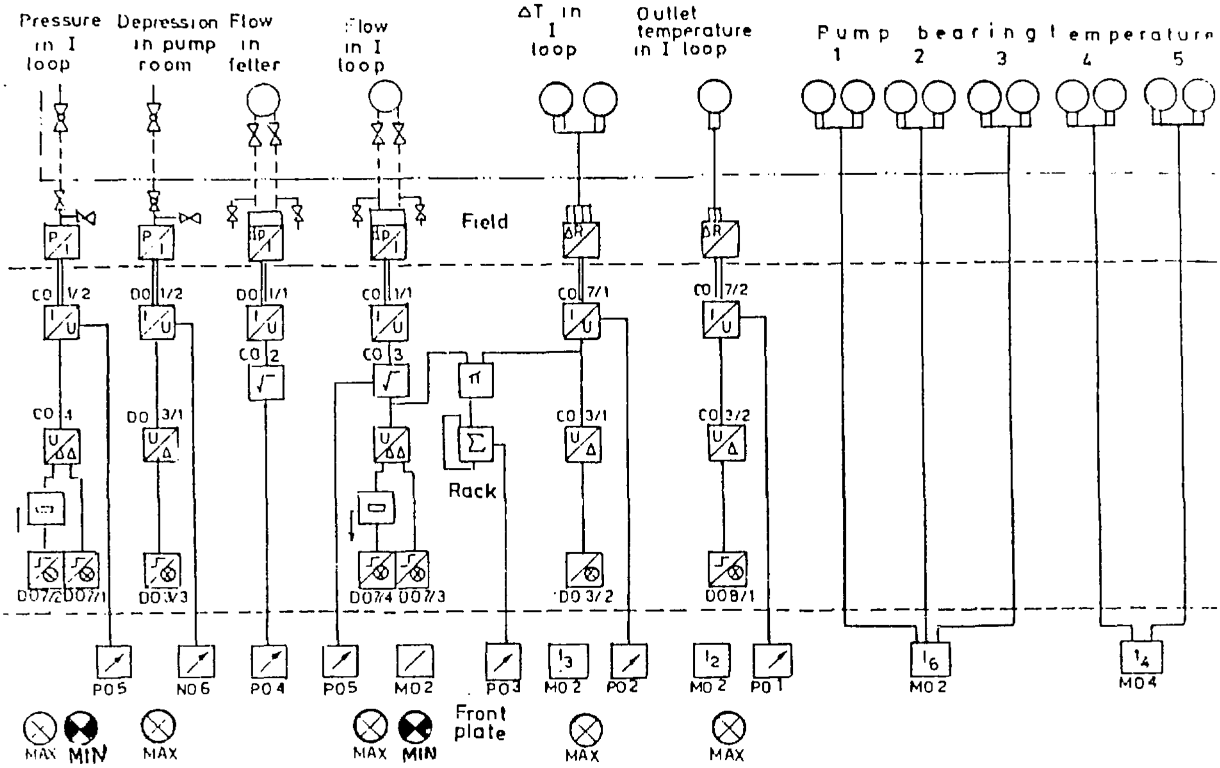
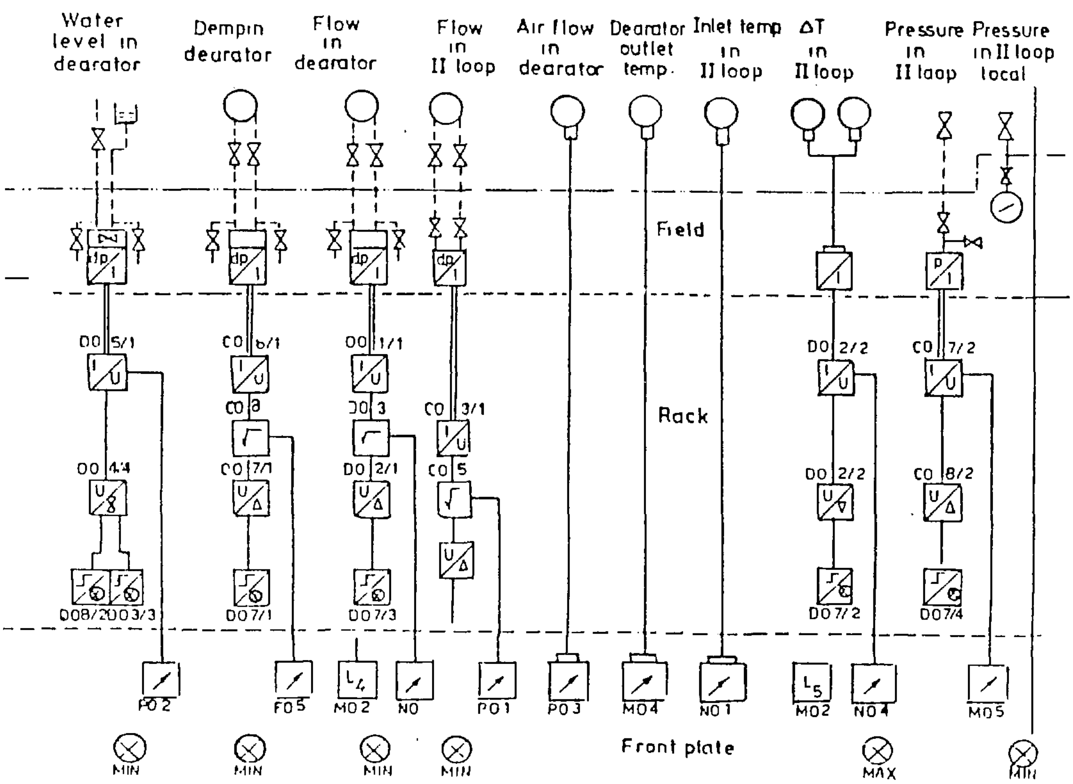


Fig(6)Rack 2 of PIS



Fig(7) Rack 3 of PIS