UVAR-18, PART I

REVISED SAFETY ANALYSIS REPORT
IN SUPPORT OF
AMENDMENT TO LICENSE R-66
FOR
TWO MEGAWATT OPERATION
UNIVERSITY OF VIRGINIA REACTOR

J. L. MEEM

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With Contributions by:

J.R. Ball
M.G. Bickel
J.A. Dahlheimer
R.D. Derry
J.P. Farrar
T.G. Foster
W.R. Johnson
J.L. Kelly
A.B. Reynolds
J.H. Rust

This report replaces UVAR-8 dated September, 1958 and UVAR-17 dated August 1967. UVAR-18, PART II contains the Technical Specification.

Revision 1 to UVAR-18, PART I combines the contents of the October 1970 version of the SAR and Amendment 1 to the SAR dated March 1971. Additional minor changes are included to make the SAR consistent with Revision 1 to the UVAR Technical Specifications, UVAR-18, PART II.

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III. REACTOR COMPONENTS AND CONTROL

3.1 Reactor Assembly

The reactor assembly is supported by an aluminum framework from a movable bridge which is restrained so the reactor cannot be positioned closer than 4 feet from the pool walls, thus preventing activation of the concrete walls. It is supported with the bottom of the core 4.5 feet above the floor of the pool, thus placing the top of the active section 19.75 feet below the surface (see Fig. III-1). The heat capacity of the pool is sufficient to permit operation at 200 kW with no additional cooling, but for higher power operation, an external heat exchanger system is installed. This system employs a header which fits against the bottom of the core, pulling water downward through the core and out to the external heat exchanger, and preventing the rise of the newly formed N^{16} (n,p) reaction with O^{16} to the pool surface. Details of the coolant system are given later in this report.

The reactor grid plate contains an eight by eight array of holes approximately 2 1/2 inches in diameter for positioning the fuel elements. Small holes are interspaced between the positioning holes to provide cooling flow between elements.

Reflector elements and experiment carrying devices may also be fitted into the positioning holes. Plugs (Fig. III-2) fit into the empty holes of the grid plate so that when ...ced cooling is being used, the cooling water passes downward through the fuel elements rather than through the open holes.

3.2 Fuel Elements

A reactor core with water reflector may contain 16 standard fuel elements as shown in Fig. III-3 and four control rod fuel elements as shown in Fig. III-4. The standard fuel element is approximately 3-inches by 3-inches cross section with an active core length of about 2 feet.

a 4 x 4 array of fuel elements including the four control rods is required. This mass is 2310 grams of U-235. It is with this array that the highest thermal neutron flux and the greatest power density in the core is achieved.

3.4 Reactor Data Table

For ease in reference all pertinent data for the reactor and its operation are tabulated in Table III-1.

3.5 Control Rods and Drives

The reactor has four control rods. Three of these, designated as Shim or Safety Rods, are designed for gross control and safety having a reactivity worth of approximately 3% $\Delta k/k$.

All of the rods are of the bayonet type, fitting into a central gap provided in special control rod fuel elements. A rod may be located in any core position by changing its point of support from the bridge, and locating its fuel element in the desired core position. The absorbing section of the three shim rods is boron-stainless steel clad in aluminum. The stainless steel is alloyed with about 1.5% boron by volume. Each absorbing section is 24-13/16-inches long and has an oval cross section of 2-1/4 x 7/8-inches with semi-circular ends. Four grooves are cut in each side of an absorbing section to increase the surface area.

The shim rods are suspended magnetically from the drive mechanism. The drive is provided by a 115 volt, 60 cycle split phase synchronous motor. The motor, lead screw-drive, and position indicating equipment are contained in a cylindrical tube extending from the top of the core to above the water level where it is supported from the bridge.

TABLE III-1
(Continued)

		Graphite Reflected	Water Reflected
Bottom Reflector			
% Water		39	39
%AL		61	61
Average Thermal Flux at 2 MW Operation $\frac{neut}{cm^2 sec}$		2.2×10^{13}	$.17 \times 10^{13}$
Σ_f, U^{235} cm^{-1}		0.0573	0.0555

Fuel Elements - type: Flat Plate, U-AL Alloy, Clad with Al

		Flat Plate	Curved Plate
Overall Dimensions			
Length	in.	34.38	34.38
Width	in.	2.996	2.996
Depth	in.	3.150	3.150
Standard Element			
Number of Plates		12	18
Width	in.	2.886	-
Thickness (inner plates)	in.	0.050	0.050
(outer plates)	in.	0.050	0.065
Length	in.	24.63	24.63
Cladding Thickness (inner plates)	in.	0.015	0.015
(outer plates)	in.	0.015	0.0225
Fuel Thickness (U-AL Meat)	in.	0.020	0.020
Fuel Width	in.	2.50	2.375
Fuel Length	in.	23.5	23.5
U^{235} vol % in Alloy		3.67	not known
Weight U^{235} per element	gm.	165 $\pm$ 3%	195 $\pm$ 3%
Water space between plates	in.	0.211	0.122
Side Plates - Overall			
Length	in.	28.69	28.69
Width	in.	0.188	0.188
Depth	in.	3.150	3.150

3.6 Nuclear Instrumentation

3.6.1 General Description

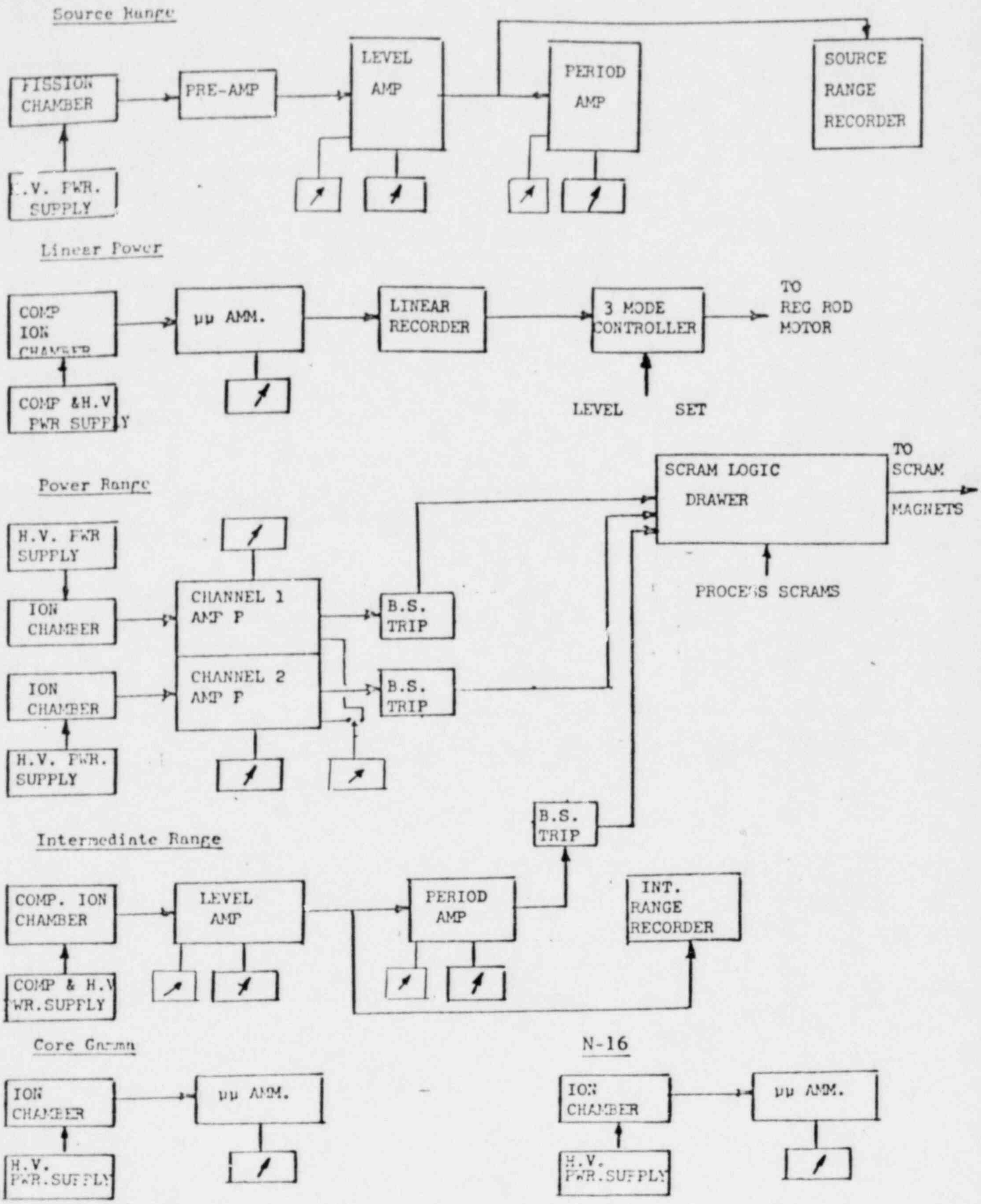
The nuclear instrumentation of the University of Virginia Reactor consists of those components necessary to monitor and display the operating parameters over all ranges of operation from startup to full power, and to automatically terminate operation before any limiting safety system setting is reached. The overall system is shown in Fig. III-10.

The Source Range contains all of the circuitry necessary to monitor reactor power level and period from shutdown through six decades of power level increases. The circuit utilizes a fission chamber as a neutron detecting device. The fission chamber is movable by use of a switch on the console so as to minimize the burnup of U-235 in the chamber while operating at high power levels. Both power level and period measurement are displayed on the reactor console meters and the power level is repeated on a chart. This range of instrumentation prevents rod withdrawal unless minimum source counts are present.

The Intermediate Range receives its input from a compensated ion chamber and provides indication of power level and period over seven decades. Both power level and period measurement are displayed on the reactor console and power level indication is repeated on a chart. This instrument provides protection against a too rapid period by scramming the reactor if the period is less than 3 seconds. The scram is accompanied by an audible alarm.

NUCLEAR INSTRUMENTATION SYSTEM

FIGURE III-10



The Power Range instrumentation contains two completely independent power range channels, each of which indicate reactor power over a range of 0 to 150 percent. Each channel is supplied an input signal from an independent uncompensated ion chamber. The output from these channels are displayed by a single meter through a selector switch on the reactor console. Each of these channels provide independent scram protection from excessive reactor power, set not greater than 150 percent of full power or 15 percent of full power if the reactor is operating without forced cooling.

Indication of reactor power is provided by a linear power instrument over 9 decades of reactor power operations through a range selector switch. This instrument receives its input from a compensated ion chamber and its output is displayed by meter and chart on the reactor console. The linear power channel also serves as the sensing element for the automatic control system which operates the regulating rod to maintain a set power level. The reactor control and safety circuits are shown in block diagram form in Fig. III-10.

In addition to the above instrumentation, the operator has the following indication at his disposal for comparative observation.

An ionization chamber is located on the ground floor in the pump room adjacent to the primary piping to detect gamma radiation from the decay of nitrogen-16. The signal from this detector is displayed on an electrometer at the reactor console.

An ionization chamber is suspended at a fixed position approximately 7.0 feet above the reactor core. The signal from this detector is displayed on a picoammeter on the secondary console and is a measure of core gamma flux. The core gamma monitor is provided for comparative observation of power. It is provided with a floating point alarm normally set at a reading corresponding to 110% full power that sounds on the common alarm panel.

3.6.2 Source Range Circuit

The Source Range Circuit (see Fig. III-11) contains all of the circuitry required to monitor reactor power level and period from shutdown through six decades of power level increase. The circuit will utilize a fission chamber as a neutron detecting device.

A combination high voltage filter and pre-amp, mounted on the bridge above the water line, will provide final high voltage filtering and a three stage pre-amplifier in one module. On entering the drawer, the input signal passes through a pulse amplifier, a discriminator, and a scale of two counter, The discriminator has a fixed discrimination level of 2.2 volts. Actual discrimination can be changed by varying the gain of the pulse amplifier that precedes the discriminator. The scale of two counter divides the input frequency by two so the output is a square wave whose frequency is one-half of the input signal frequency. Log Integrators A and B provide a DC voltage proportional to the log of the input frequency.

Amplifier S is a DC Amplifier whose output provides source range log level indication, level bistable trip logic, input to the source range period section, and remote recorder output.

The period section of the Source Range Drawer consists of a Differentiator Integrator (D-I) which converts the level input from Amplifier S to a signal proportional to the rate of change of reactor power level. Modulator P combines the DC input from the (D-I) with a 10 KC input from the Oscillator module. The resultant, a 10 KC signal proportional in amplitude to the DC input signal, is applied to amplifier B.

Amplifier B is an AC amplifier which amplifies the signal from Modulator P and feeds it to Demodulator P4 where the AC signal is converted back to a DC signal proportional to the exponential rate of change of reactor power. The Demodulator P4 feeds a front panel period meter.

The bistable module installed in the Source Range Drawer is a solid state multivibrator circuit. The output is a logic signal of 0 volts (tripped) if the count rate is less than 2 counts per second, or 10 volts (untripped) if the count rate is greater than 2 counts per second.

The Source Range Drawer contains a test module that performs alignment and operational checks of both the level and period sections without the use of additional test equipment.

3.6.3 Intermediate Range Drawer

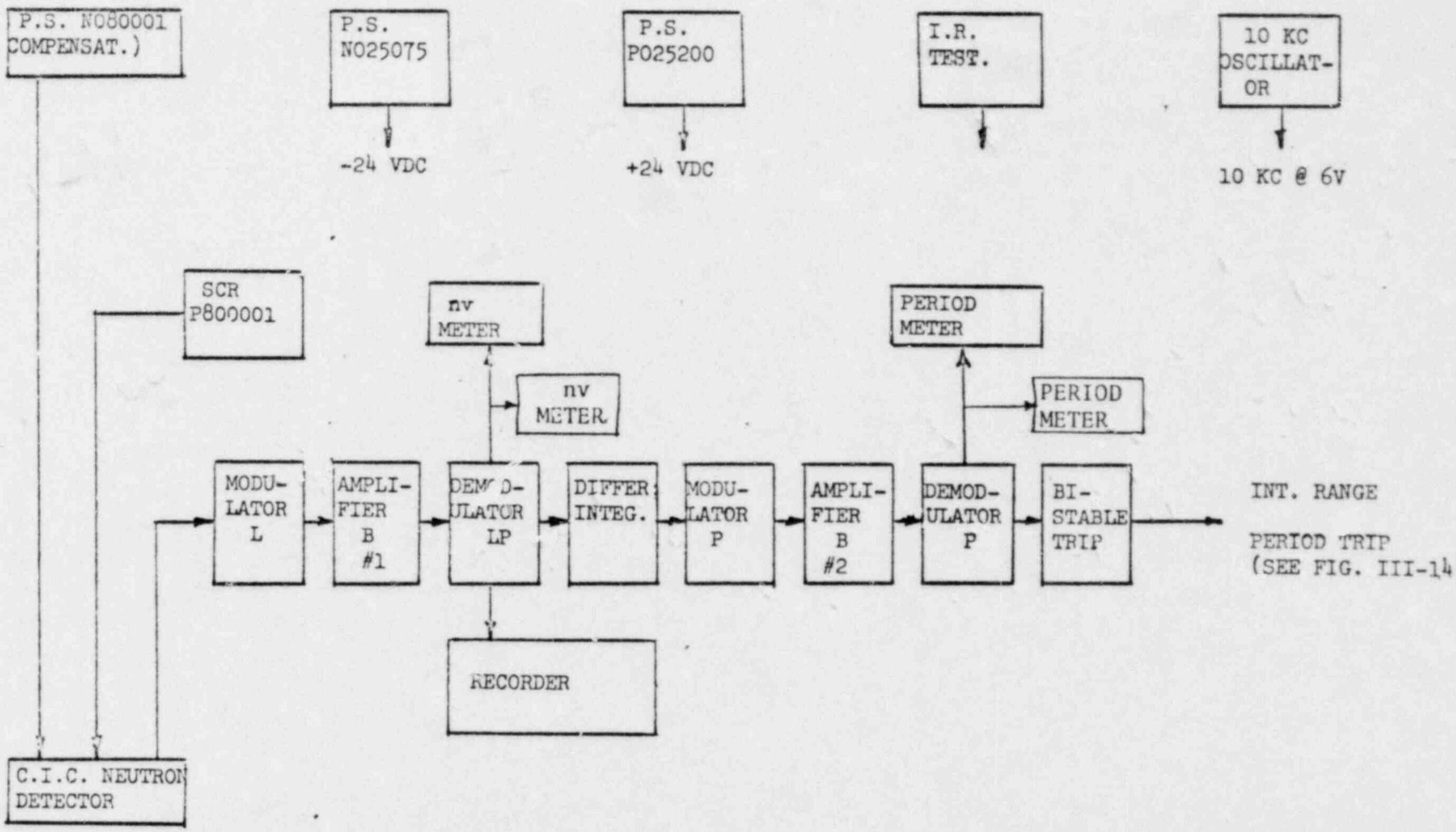
The Intermediate Range circuit (see Fig. III-12) receives its input from a compensated ion chamber and provides log level indication over seven decades, period indication and scram and control logic outputs.

Power supply SCR P800001 provides 200-800 volts DC high voltage to the CIC, with regulation as close as ±0.1%. Power supply N0800001 provides a variable compensating voltage of -10 to -80 volts DC to the CIC.

The DC current proportional to neutron level from the CIC is fed first to Modulator L where it is combined with a 10 KC sine wave. The resultant is a 10 KC signal proportional in amplitude to the Log of the DC input current. The Demodulator, as the name implies, converts the AC output from Amplifier B back to a DC signal which is proportional to the logarithm of reactor flux level. The log level output of the demodulator feeds three devices:

1. Local log level meter,
2. Remote recorder, and
3. Differentiator - Integrator.

FIGURE III-12 INTERMEDIATE RANGE DWR.



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The Differentiator-Integrator accepts an input from the Demodulator and converts it to a signal proportional to the exponential rate of change of the neutron flux. Modulation of this DC period signal takes place in Modualtor LP where the signal is combined with a 10 KC sine wave and the output fed to Amplifier B No. 2 for amplification. Demodulator P receives an amplified AC signal from Amplifier B No. 2 and converts it to a DC signal which is proportional to the exponential rate of change of neutron flux (period). The outputs of the Demodulator P are:

1. A front panel period meter, and
2. A bistable period trip set at no less than 3 seconds.

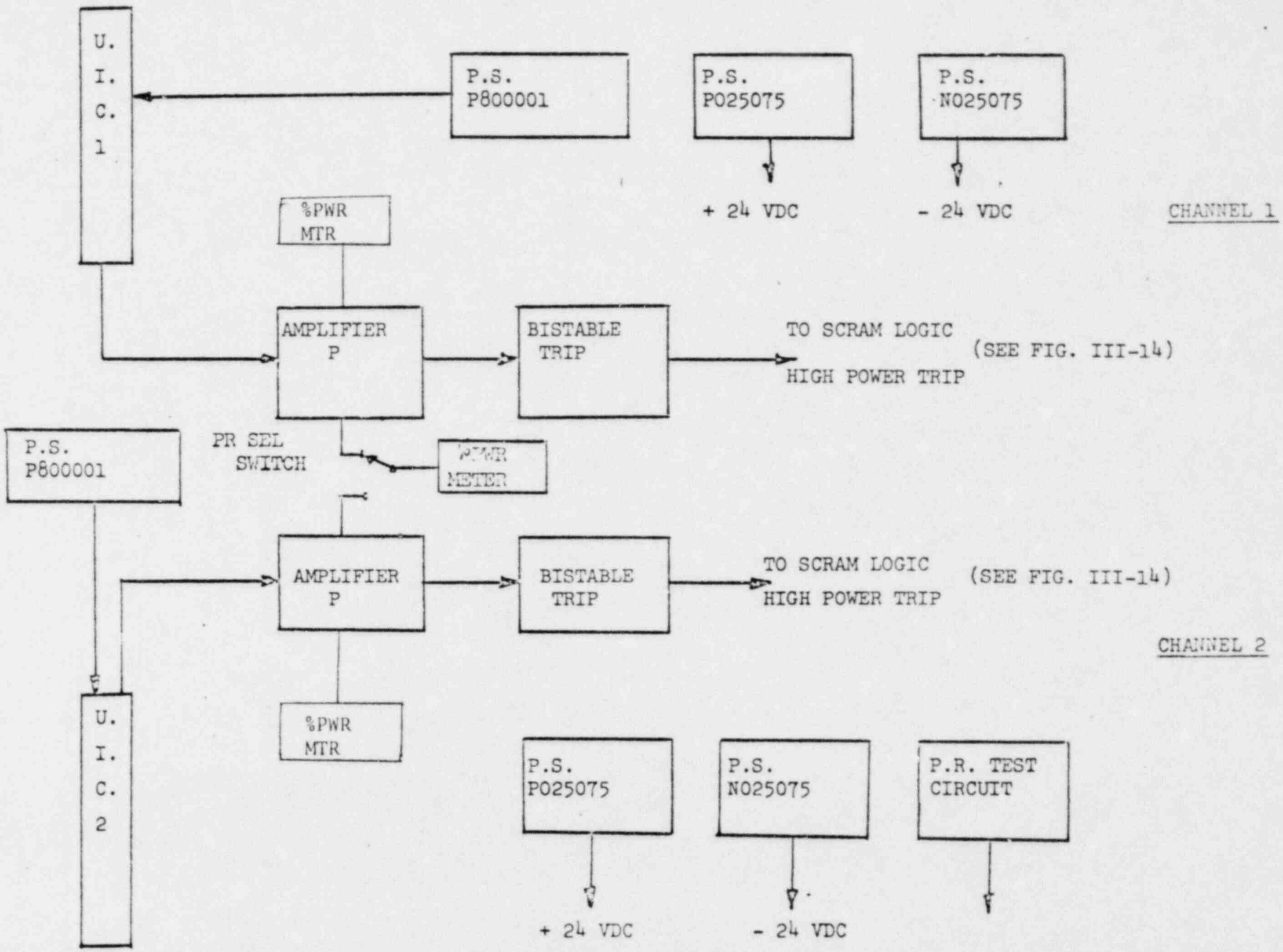
The bistable modules of the intermediate range circuit are identical to those in the source range circuit.

The Intermediate Range drawer contains a test module that performs alignment and operational checks of both the level and period sections without the use of additional test equipment.

3.6.4 Power Range Drawer

The power range drawer (see Fig. III-13) contains two completely independent power range channels which will indicate reactor power over the range of 0 to 150 percent. As can be seen in the appropriate block diagram, each power range channel has its own detector power supply, and its own ±24 volt power supply. The only power supply

FIGURE III-13 POWER RANGE DRAWER



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common to both channels is the 110 volt AC supply to the power range drawer. Upon loss of this supply voltage both level bistables trip off, sending unsafe signals to the scram logic drawer. Each power range channel is supplied an input from an Uncompensated Ionization chamber. Outputs from each channel include a common local power level meter, separate remote power level meter, and a high power bistable trip logic signal.

Power Supply P800001 is a high voltage power supply that supplies 200-800 volts DC to the detector.

The output of the U.I.C. is a DC current proportional to reactor power. This signal is fed to Amplifier P, which is a DC amplifier, where the signal is amplified to a level suitable for use. The outputs of Amplifier P as stated previously are:

1. Local common percent power meter
2. Separate remote power meter
3. High Power Bistable

It should be noted that the amplifier is so designed that a short or open circuit, in any of the outputs, will not cause the other outputs to vary more than a fraction of a percent.

The bistable modules of the power range circuits are identical to those described previously for the Source Range Circuit.

The Power Range Drawer contains a test module that performs alignment and operational checks of each power range channel without the use of additional test equipment.

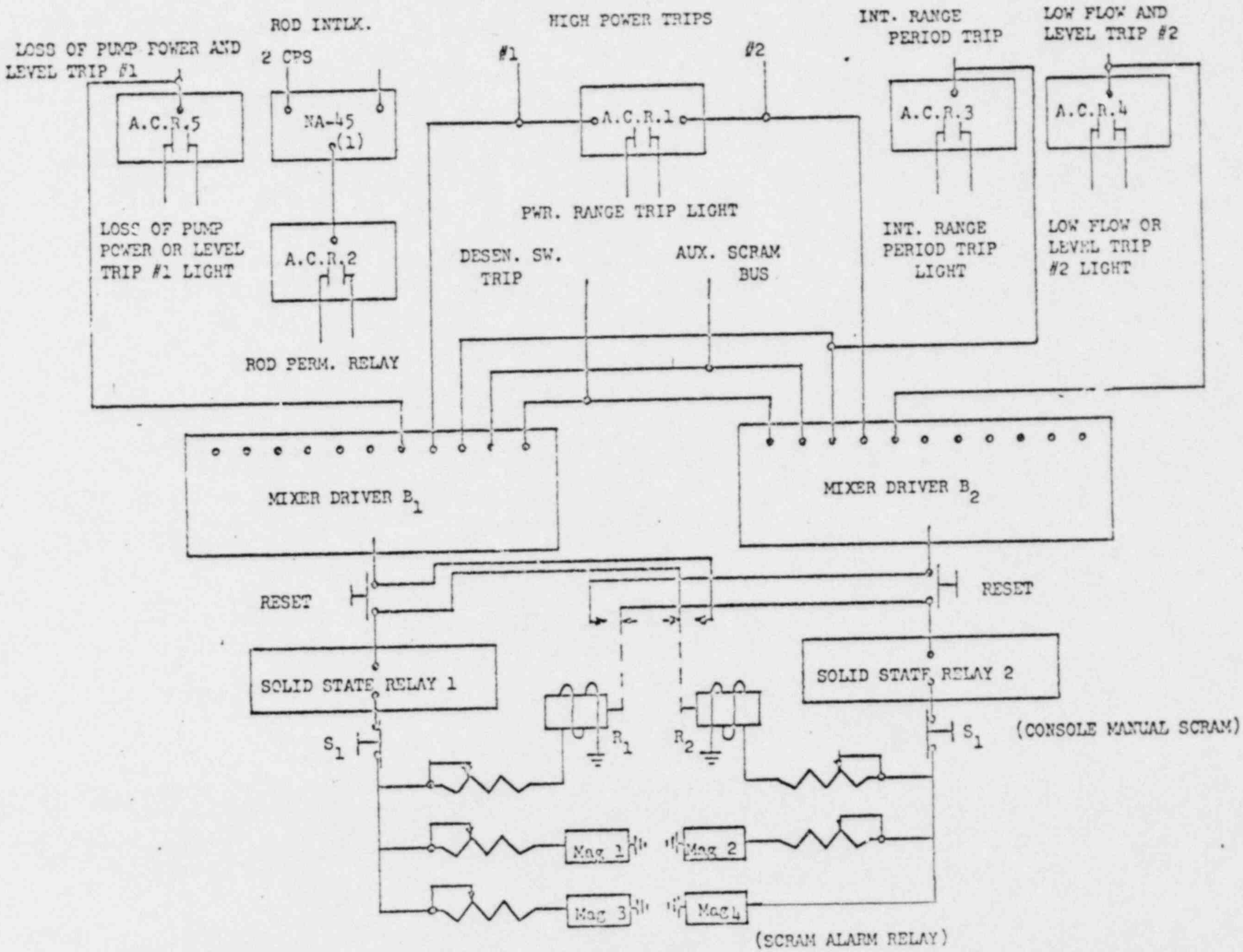
3.6.6 Scram Logic Drawer (See Fig. III-14)

The Scram Logic Drawer contains the logic circuitry necessary to process the scram function inputs and to shutdown the reactor automatically should conditions warrant. The drawer also contains the interlock circuitry to prohibit safety rod withdrawal if certain minimum conditions are not met.

To understand the operation of the Scram Logic circuit, it is only necessary to understand the operation of four basic modules. Negative logic is used throughout the system, in that the normal, safe, input signal is +10 volts and the abnormal, unsafe, signal is 0 volts. All available inputs to these modules may or maynot be used.

1. Transistor Gate NA-45 consists of five separate, four-input, negative logic AND gates, hence the designation NA-45. For each separate AND gate, all four inputs must fall to zero volts to obtain a 0-volt output signal. Any input at +10 volts will hold the output of that gate at +10 volts. The inputs (up to 20) are logic 0 or +10 volt signals and the outputs (up to 5) are also logic 0 or +10 volt signals. As explained later, the rod withdrawal interlock is derived from two logic inputs to NA-45.

FIGURE III-14 SCRAM LOGIC DRAWER



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2. Auxiliary Control Module takes logic inputs in the form of 0 or +10 volt signals and provides a relay output capable of handling 110 vac and 2 amps. The input stage consists of a four input OR gate where all inputs must be at +10 volts to have the relay energized. The relay is de-energized if any input is at zero volts.

3. There are two Mixer Driver B's. A Mixer Driver B is essentially a 28 input OR gate. Any one of the 28 logic inputs falling to 0 volts is sufficient to cause the output to fall to 0 volts. Only when all inputs are at +10 volts is the output at +10 volts. The input is 28 logic signals, while the output is one logic signal.

4. There are two Solid State Relay modules. A Solid State Module takes one logic signal (0 to +10 volts) as its input and provides up to 5 amps DC of output current to the scram magnets if a safe input condition exists. The Solid State Relays are subject to one type of failure that could render the module inoperable as a device for cutting off magnet current. This type of malfunction of the entire module would necessitate the simultaneous failure of two components within the module, in the form of a short circuit in two series silicon controlled rectifiers (SCR). Built-in circuitry within the drawer has been provided that will annunciate a short circuit in one SCR as a warning light. If a short circuit occurs subsequently in the other SCR,

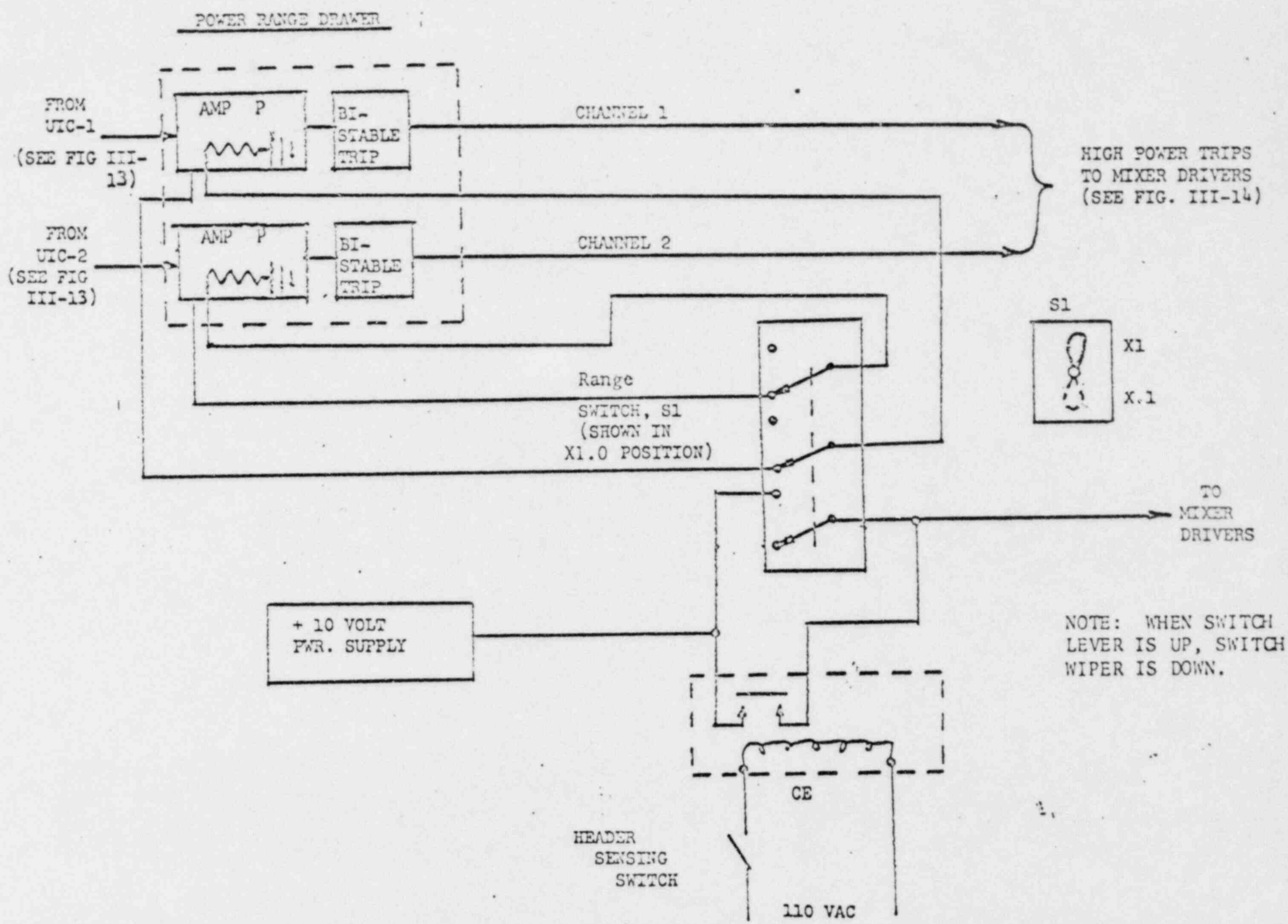
the solid state relay will continue to provide current to the scram magnets even if an unsafe input is aplied. As will be explained in the overall operation of the Scram Drawer, even the existence of the afore-mentioned conditions will not render the entire system inoperable as a parallel network exists which could de-energize at least one safety rod and thereby shut the reactor down.

The Scram Logic Drawer, as a safety system, can be divided into two sections. Namely, a scram logic process section and an actuation section. The process section takes logic signals from the various bistables, power supplies, and relays; processes these signals with respect to preconditions and emits output signals that exercise either scram control or rod interlock control. The modules included in this section are the NA-45 gate circuits and the Auxiliary Control Relays. The actuation section, consisting of the Mixer-Drivers and the Solid State Relays, take only safe or unsafe logic inputs, and, depending on the nature of the inputs, control current to the safety rod scram magnets.

The rod withdrawal interlock is derived from two logic inputs to NA-45 (1). A +10 volt signal is emitted from the source range level bistable if the source count rate exceeds 2 counts per second. A second +10 volt signal comes from the intermediate range recorder via a +10 volt power supply and micro-switch, if the indicated flux exceeds $2x10^3$ nv. These two signals is fed to one gate of NA-45 (1). If this input is at +10 volts the appropriate output is at +10 volts. This 10 volt signal is fed to Auxiliary Control Relay 2 which energizes its output relay permitting safety rod withdrawal. If both inputs to NA-45 (1) drop to zero (<2 cps), the NA-45 (1) output drops to zero. This zero volt input signal to Auxiliary Control Relay 2 will cause the output relay to de-energize, preventing the withdrawal of either safety rod.

The reactor can be operated at two megawatts with forced convection cooling or at 200 kilowatts with natural convection cooling. The High Power Trips are initiated from the power range drawer (see Fig. III-13) and provide overpower protection in both the natural convection cooling mode and the forced convection cooling mode of operation as shown in Fig. III-15. A range switch is used to determine the scram point for each mode. In the natural convection mode (see Fig. III-15), the flow header is down and header position relay CE is de-energized. A safe +10 volt logic signal is passed through the range switch only if the switch is in the X.1 position. Under this condition, the power range channels are sensitive over a range of 0-15% of rated power for an amplifier output of 0-150% of normal range, i.e., 100% of output from amplifier corresponds to 10% of rated reactor power. If the reactor power level reaches 15% of rated power, the power range channel will indicate a power level of 150% and will send an unsafe (0 volt) signal to the mixer drivers scramming the reactor. When the reactor is operating in the forced convection mode, the flow header is in the UP position. Therefore, relay CE is energized, which allows the range switch to be placed in the X1 position without losing the 10 volt, safe, signal. In the X1 position, the range

FIGURE III-15 HIGH POWER TRIP



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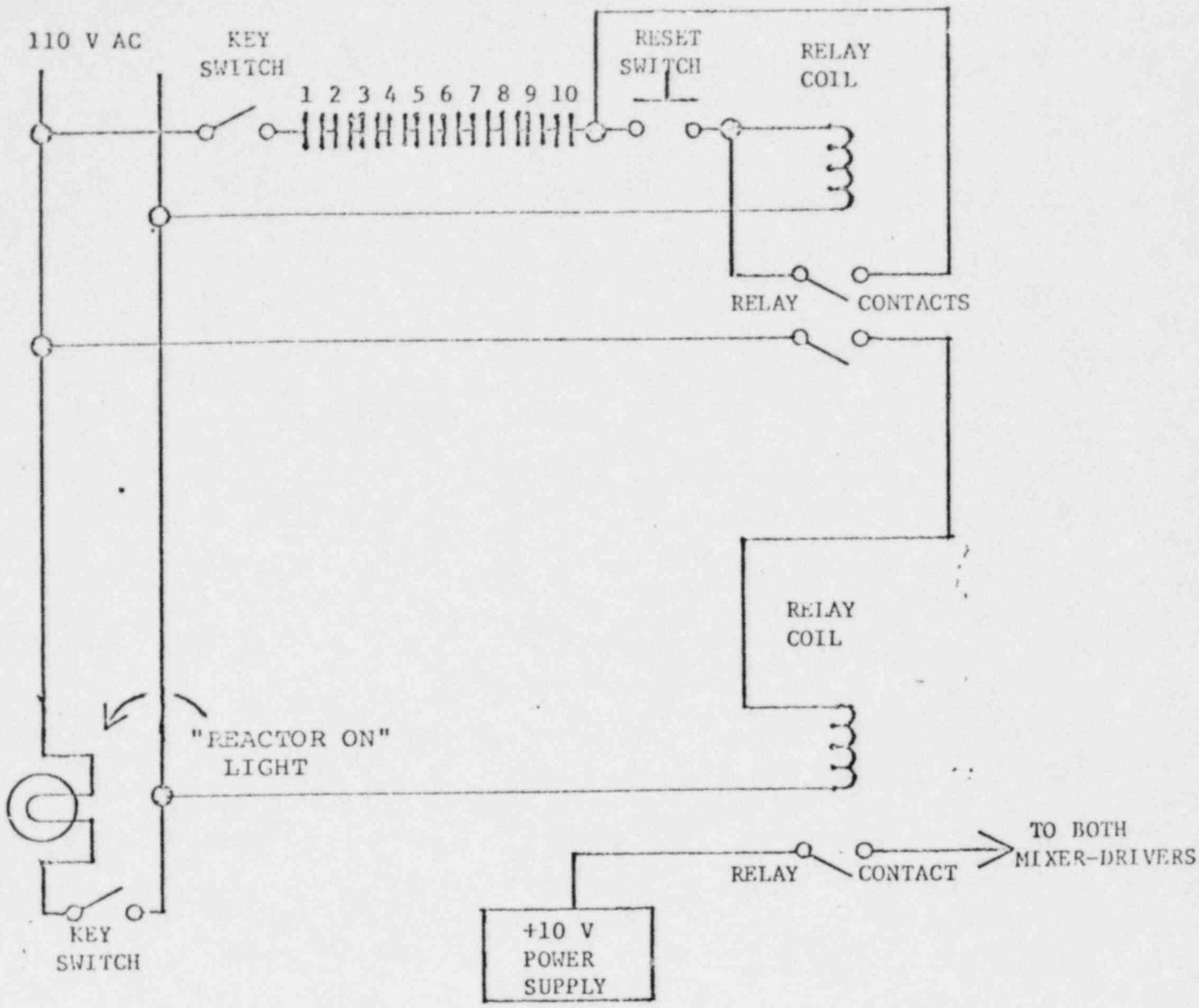
switch also reduces the output sensitivity of the two power range amplifiers by a factor of ten. Each channel now indicates over a range of 0-150%, which now corresponds to a reactor power of 0-150% of rated. The scram trip point is also increased by a factor of ten by placing the desensitize switch in the X1 position and will scram the reactor when reactor power reaches 150% of rated. When operating in the natural convection mode, any attempt to change the position of the desensitize switch to the X1 position will immediately initiate the scram, through loss of the 10 volt signal through the switch.

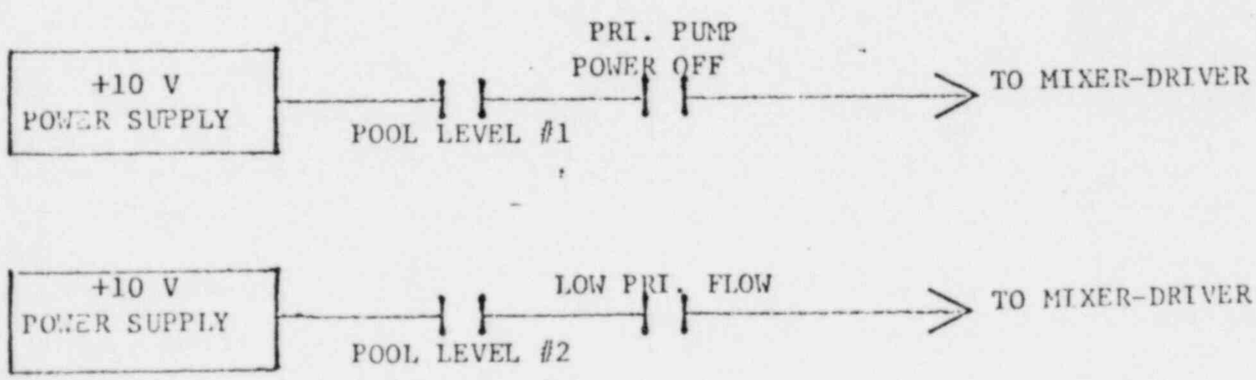
Referring again to Fig. III-14, the intermediate range period trip function originates at the period trip bistable, (see Fig. III-12). This logic signal is sent directly to the Mixer Drivers. A parallel signal is also fed to Auxiliary Control Relay 3 which actuates a relay to annunciate the trip on the intermediate range drawer.

The auxilliary scram system (see Fig. III-16) provides mechanisms for supplying safe or unsafe logic signals to the logic drawer from the non-nuclear parameters associated with reactor operations. Those parameters on which safety system settings are based have two independent means of detection i.e., 2 pool level indicators and low flow in addition to loss of pump power. These are paired and provide go, no-go signals directly to the mixer drivers via two + 10 volt power supplies. Should either of these supplies fail, an unsafe signal is sent to the mixer drivers, scraming the reactor. Should any one device fail, i.e., pool level number one micro switch, only that one device is lost to the safety system. The actuating devices are separated in space as much as 40 or 50 feet so that a complete

FIGURE III-16 AUXILIARY SCRAM SYSTEM



DUAL PRIMARY SCRAMS



short across all four devices if highly remote. The remainder of the processed scrams are connected in a series string and incorporated into one logic signal to the mixer drivers via relays CR and CP. Any one processed scram function will cause an unsafe logic signal to be sent to the mixer driver.

The scram actuating portion of the Scram Logic Drawer consists of two independnent channels cross connected in such a way as to afford maximum scram protection against component malfunction. The two Mixer Drivers receive identical logic inputs in parallel. If one of these inputs is an unsafe signal (0 volt), the output of both MD's will be at zero volts. The input to each Solid State Relay going to zero causes the outputs to stop conducting, cutting off current flow to the scram magnets. To nullify the effects of a complete failure of one MD, the two scram channels are cross connected through relays R1 and R2. If a failure occurred in one of the MD's, say MDB1, which would prevent it from tripping off when an unsafe input signal is received, MDB2 would be tripped off by the same unsafe input signal, SSR2 would stop conducting, dropping magnets 3 and 4 and de-energizing relay R2. The contacts on R2 which feed an input to SSR1 would be opened, causing SSR1 to also stop conducting and dropping magnets 1 and 2. Magnet 4 is the scram alarm relay.

Only the simultaneous failure of both MD's in the safe mode or a failure of four diodes in two separate modules, the SSR's, could result in the scram logic system being rendered as "can't scram."

3.7 Scrams, Interlocks, and Alarms

Scrams

1. * Safety Channel 1 >150% power or 15% power
2. * Safety Channel 2 >150% power or 15% power
3. Period Amplifier <3 seconds
4. Push button on console
5. High radiation level on bridge (a) $\geq$ 30 mR/HR
6. Primary cooland pump turned on or off (b)
7. Low reactor coolant flow (c) <800 gpm
8. Push button at reactor room personnel door
9. Push button on ground floor
10. Reactor room truck door open
11. Emergency escape hatch open
12. Air pressure to primary header 2 psi
13. High reactor inlet water temperature >108^{o}F
14. Low pool level (2) 19 ft. 2 in.
15. High radiation at reactor face $\geq$ 2 mR/HR
16. Key switch on console
17. Range switch in 2 MW with header down
18. Evaluation alarm

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* Scram setpoint for Safety Channel 1 & 2 depends on position of range switch.

(a) High radiation level at this point also automatically closes the ventilation door, and closes the reactor room personnel door.

(b) Action of turning the pump on will cuase scram, and loss of electrical power to pump will cuase scram. The reactor may be operated while the pump is running if the header is up.

(c) A reading of less than 800 gpm on the flowmeter will cause scram. The reactor may be operated with no flow indicated by the flowmeter providing the header is down.

Interlocks

1. Source range must be indicating at least 2 cps and nuclear instrumentation must be out of test mode to withdraw a safety rod.

Audible Alarms

All audible alarms are processed by the common alarm panel on the primary console. Each audible alarm is accompanyed by a red light indicating the alarming condition and an amber light that locks in, to indicate a previously alarming condition.

1. A continuous tone is sounded whenever the reactor scrams. This alarm may be silenced by either reseting the scram logic drawer or pressing the "silence" button on the common alarm panel.

2. An intermittent tone sounds under any of the following conditions

   a) Regulating rod control shifting from automatic to manual.

   b) High radiation on any area monitor or on either argon monitor.

   c) High radiation on core gamma monitor.

   d) High radiationon criticality monitor.

   e) High radiation on constant air monitor.

   f) Entry into the demineralizer room.

   g) Entry into the heat exchanger room.

   h) High ΔT across reactor core.

   i) High demineralizer conductivity.

   j) Secondary pump de-energized.

   k) Primary pump on with the header down.

   The audible alarm will automatically reset after about two minutes or may be reset manually by pressing the "silence" button.

3. Local alarm bells are supplied at the heat exchanger room and demineralizer room when the key switch is on to warn a person that he is entering a possible high radiation area.

3.8 Automatic Control is Provided via the Regulating Rod to Aid in Maintaining a Constant Power

A Voltage signal proportional to reactor power is developed by a slide wire potentiometer in the linear power recorder. This signal is compared to the voltage developed by the "Power Set" potentiometer on the control console. Any difference in these signals is displayed on a deviation meter and supplied to the controller as an error signal. The controller converts this small error signal into 60 cycle power either in phase or 180^{o} out of phase with line voltage. This power supplied to the servo motor for the regulating rod will drive the rod in if the linear signal is higher than the power set voltage or out if the linear signal is below the power set voltage.

Several conditions will automatically cause control to shift to the manual mode and sound an alram to alert the operation that power is no longer being controlled automatically. These are:

1) Any attempt to move the regulating rod with the normal control switch; this insures that manual control is always instantly available to the operator.

2) The regulating rod either at its top limit or bottom limit; this insures that regulating rod has free movement to control reactor power.

3) The error signal, as displayed on the deviation meter, exceed 7.5% (arbitrary units); this insures control is shifted if the regulating rod is unable to control power for any reason, such as the reg rod being stuck.

4) A switch is provided that allows the operator to select either the manual or automatic mode of operation.

4.2 Filling and Draining the Pool

A flow diagram of the water system is shown in Fig. IV-1. City water enters the building into a catch tank through a hand valve and a float valve. All the water entering the pool or primary cooling system is drawn from this tank and the float valve precludes the possibility of any backflow of radioactive water into the city system. The pool is filled by a 40 gallon per minute pump through a mixed bed demineralizer. With the pool gate in place either side may be filled independently.

Draining of the pool may be done on either side of the pool gate when it is in place. The pool is drained through two manually operated valves located in a sump pit in the heat exchanger room. These valves are normally locked shut. The discharge from the drainage system empties into the waste pond described in Section 4.8.

4.3 Primary Cooling System

With the reactor in position at the south end of the pool, an air operated header may be raised into place. This header is actuated by the emission of compressed air at about 50 psi into a header skirt which floats the header up to the reactor grid plate. Once positioned the header is held in place by a differential pressure of 0.26 psi created by the downward flow of 900 gallons per minute through the reactor to the primary piping system. After the pump has started and sufficient flow is established to hold the header in place, the air pressure which lifted it is vented to atmosphere so as

Water temperature and pressure are measured on the inlet and outlet sides of the heat exchanger. The temperatures are displayed on the secondary console in the reactor room. A separate continuous monitor is located above the core which will initiate a scram if the pool water temperature exceeds 108^{o}F.

4.4 Measurement of Temperature Differential

A system ahs been installed to continuously monitor the temperature differential across the reactor core when it is operated with forced convection cooling. The ΔT value, measured directly by this system, can be related to the reactor thermal power level. Separate coolant inlet and outlet temperatures are read periodically and subtracted manually to obtain this information in addition to the constant monitor.

The sensing elements used in the system are platinum resistance bulbs. One is located in the reactor pool, about three feet above and to the side of the top of the core, to indicate core inlet temperature. Core outlet temperature is sensed in the primary coolant line, just upstream of the primary coolant pump. The sensing elements are placed in a resistance bridge network where the differential temperature values are measured, then amplified and displayed on a digital meter. An alarm with an adjustable setpoint is provided to give alarm signals for ΔT values in excess of preset levels. The range of the instrument is 0-20^{o}F, while the normal ΔT across the reactor is at two megawatt is about 15^{o}F.

5.4.2 Isotope Release

The amount of radioisotope released from a fueled experiment and becoming airborne is assumed to be that specified by TID-14844: 100% Noble Gas; 50% Halogen; 1% Solid Fission Products. These values provide a very conservative upper limit for fission product release from a fueled experiment over a broad spectrum of accidental conditions (e.g., fission plate clad failure).

Isotopes initially released to the reactor building in general (other than to the reactor room), are assumed to be released subsequently to the atmosphere at a uniform rate, over a 2-hour period. This assumption maximizes the inhalation dose (or isotope concentration) for a 2-hour exposure time, by making the entire isotopic inventory available for inhalation. For material released to the reactor room, which is automatically closed upon receipt of a high radiation level signal, the isotopes are assumed to be released at a uniform rate over a period of 20-hours.* The retention properties of the reactor room, a windowless structure designed to provide confinement, will be measured, and the 100%-in-20 hours exfiltration value verified prior to operation of a fueled experiment utilizing the 20-hour release period (2-hours will be assumed until proven otherwise).

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*A gamma-ray sensitive chamber at the top of the reactor pool provides automatic closure of the reactor room (and reactor trip) for radiation levels above the set point, normally 30 mr/hr. In addition there are 2 independent air monitoring instruments in the reactor room which would sensea fission product release, and alarm. The operator would have ample time to close the reactor room to prevent an excessive amount of exfiltration by the building exhaust system--normal rate ~11% per minute. Note that forced exfiltration by the building exhaust would give an elevated, puff-type release, resulting in lower site boundary doses.