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Reactors-General

OPERATING PROCEDURE FOR THE BULK SHIELDING REACTOR, FOURTH EDITION

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During the seven-year operation of the Bulk Shielding Reactor (BSR) at the Oak Ridge National Laboratory, the following operating procedure has been developed. This is the fourth revision of the statement of this procedure. It is set forth in this form primarily for the guidance of the reactor operators at the Bulk Shielding Facility (BSF). They should become thoroughly familiar with the information contained herein.

I. Authorized Personnel for Reactor Operation

Appendix A contains the current list of reactor supervisors and operators. This list may be modified as changes in personnel occur. Any new reactor operators will be approved by two of the supervisors. This approval will be noted in writing on Appendix A of the original copy of this procedure.

A reactor supervisor for the BSR has the responsibility for the operation and safety of the Bulk Shielding Reactor. In the event of an emergency connected with the reactor in any way, the reactor supervisor has the responsibility and authority to take the proper remedial action. An emergency is defined as any reactor abnormality which has not been, or cannot be, corrected by the controls on the reactor console.

Routine operations of the reactor will be performed by one of the operators or supervisors listed in Appendix A. In an emergency the operator is empowered to act as a supervisor, if a supervisor is not readily available. All scheduled non-routine operations and operations involving changes of the potential excess reactivity of the reactor will require the presence of a reactor supervisor. Non-routine operations are described in Sections III and IV.

II. Standard Operating Procedure for Reactor Operation

No reactor operations will be carried out under the duress of a time limit.

Startup will be carried out by one of the reactor operators or supervisors. The detailed procedure to be followed is described in Appendix C. An abbreviated check list is written on the reactor console. All items on this list should be checked (at least mentally) during the startup operation. When operation at a steady power level has been achieved, the nominal power level will be announced over the BSF public address (PA) system. The fission chamber monitoring the reactor flux may then be connected with the PA system and the operator may work elsewhere within the Bulk Shielding Facility.

III. Standard Operating Procedure for Reactor Loading

A new loading for the BSR will be undertaken only when a reactor supervisor and an operator are present. However, a single supervisor may re-load a known fuel-element configuration. Chamber tests, Appendix F, will be performed by the supervisor in attendance.

Whenever a new loading is required by an experimental arrangement, the reactor frame (unloaded) will be positioned. Then as fuel elements are added the approach to criticality will be carefully determined by the method of subcritical multiplication. The excess reactivity will be limited to that required by the operating conditions of the experiment and will in any event be less than the maximum authorized.

Whenever experimental apparatus is placed against the reactor (and not permanently attached) in such a manner as to significantly reduce the reactivity, the fuel added to maintain criticality will be unloaded before the reactor is left unattended.

IV. Standard Operating Procedure for Moving Reactor Bridge

The reactor bridge will be moved to a new location only under the direction of one of the reactor supervisors. It may be repositioned in a previously used configuration by a reactor operator. The key to the reactor bridge will be handled in the same manner as the reactor controls key (see Appendix C). The reactor will be partially unloaded whenever it is moved into a new position which changes the reflector adjacent to the reactor or whenever there is the possibility of interaction with experiments being conducted with the Pool Critical Assembly (PCA). Such interaction is normally prevented by permanent mechanical stops.

V. Emergency Operating Procedure

Whenever the operator or another person is in doubt about the safety of further reactor operation he should scram the reactor. Unnecessary scrams are not prohibitively expensive for this reactor so personnel should not hesitate to scram the reactor. Scram buttons are located in the positions listed in Appendix D. A list of typical conditions that might require a scram is given in Appendix E.

Scramming the reactor is the only rapid emergency procedure normally available during reactor operation. During critical experiments, however, the person adding fuel elements to the reactor retains physical control of the element until notified by the supervisor at the console that the element may be released. Thus, until this notification is given at the console, the element may be promptly withdrawn from the reactor as an emergency procedure. Such an action might be dictated by the reactor supervisor on duty during such experiments.

After any scram for emergency reasons, the operator should notify a reactor supervisor and should not operate the reactor again until given a clearance by the supervisor. On a night shift when a reactor operator is in charge of the reactor, he should not start up again unless the cause of the conditions leading to the scram are completely understood. This procedure should be followed for either a personnel or an automatic safety device scram.

APPENDIX A

Reactor Supervisors and Operators

The following persons are designated as reactor supervisors:

K. M. Henry	Phone 5-1544, Oak Ridge
E. B. Johnson	Phone 5-6429, Oak Ridge
J. D. Kington	Phone 5-0975, Oak Ridge
F. C. Maienschein	Phone 5-3805, Oak Ridge

The following persons are designated as reactor operators:

T. A. Love

R. W. Peelle

E. G. Silver

APPENDIX B

Reactor Block Diagrams

Reference to figures below will provide information as to the design philosophy of the control circuits. They will also provide useful information in the case of operating abnormalities.

Circuit diagrams of individual blocks, and interconnection diagrams are maintained in the reactor print file, located in the reactor control room.

Figures 1 and 2 are block diagrams for the safety and control circuits excerpted from Fig. 3.

Figures 3 and 4 represent the complete instrument and control systems as block diagrams.

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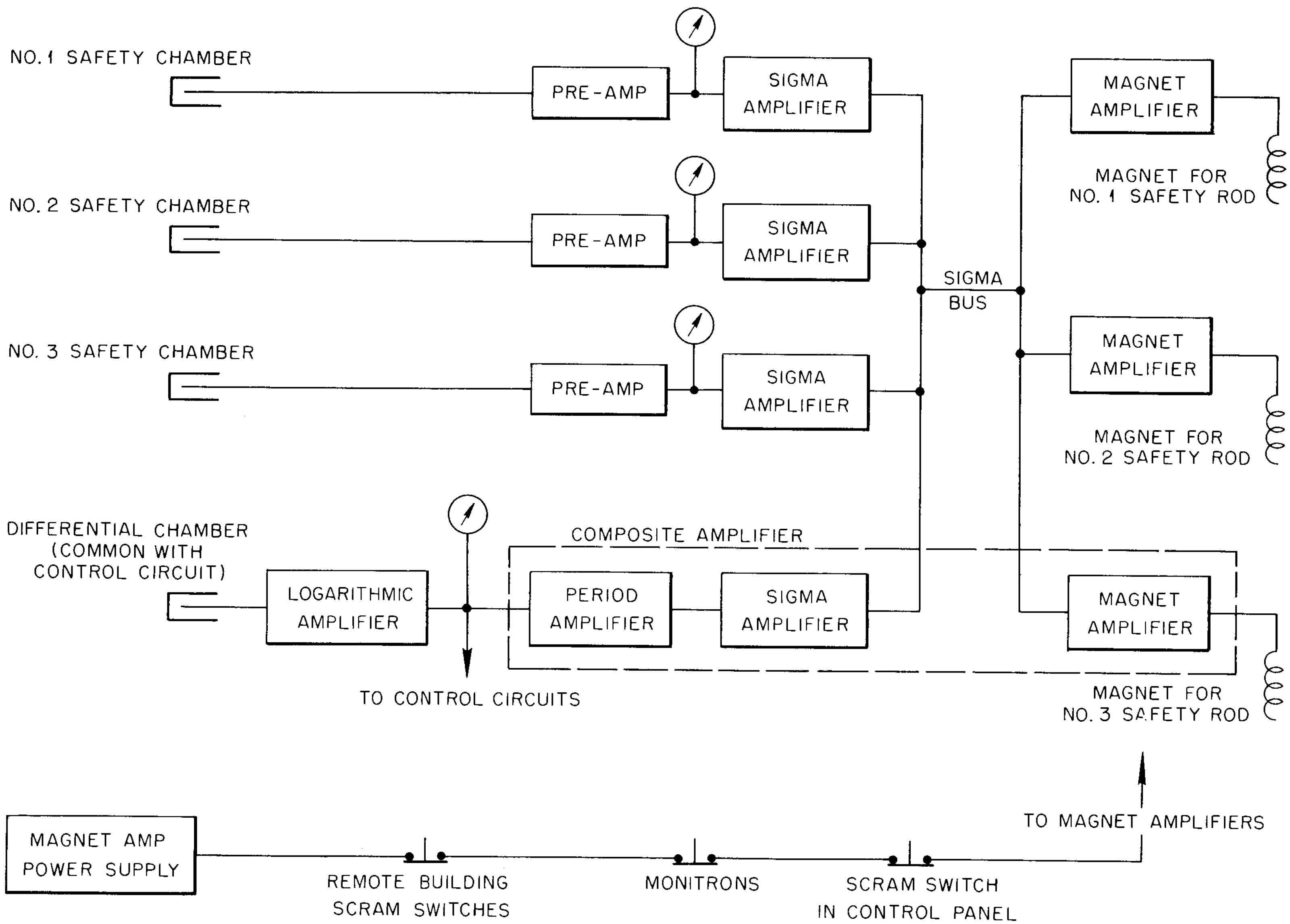

Fig. 1. Block Diagram of Safety Circuits for the Bulk Shielding Reactor.

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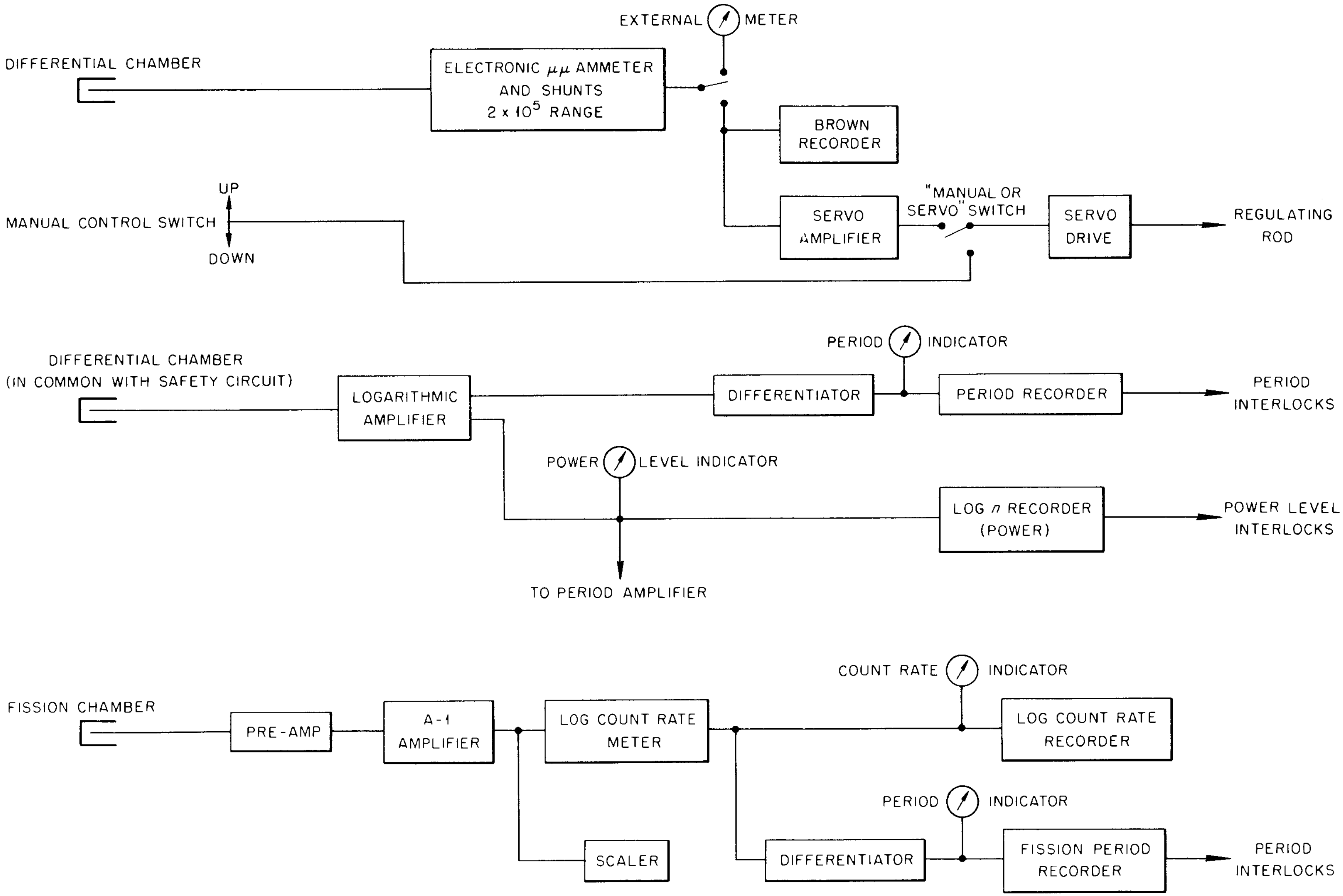

Fig. 2. Block Diagram of Control Circuits for the Bulk Shielding Reactor.

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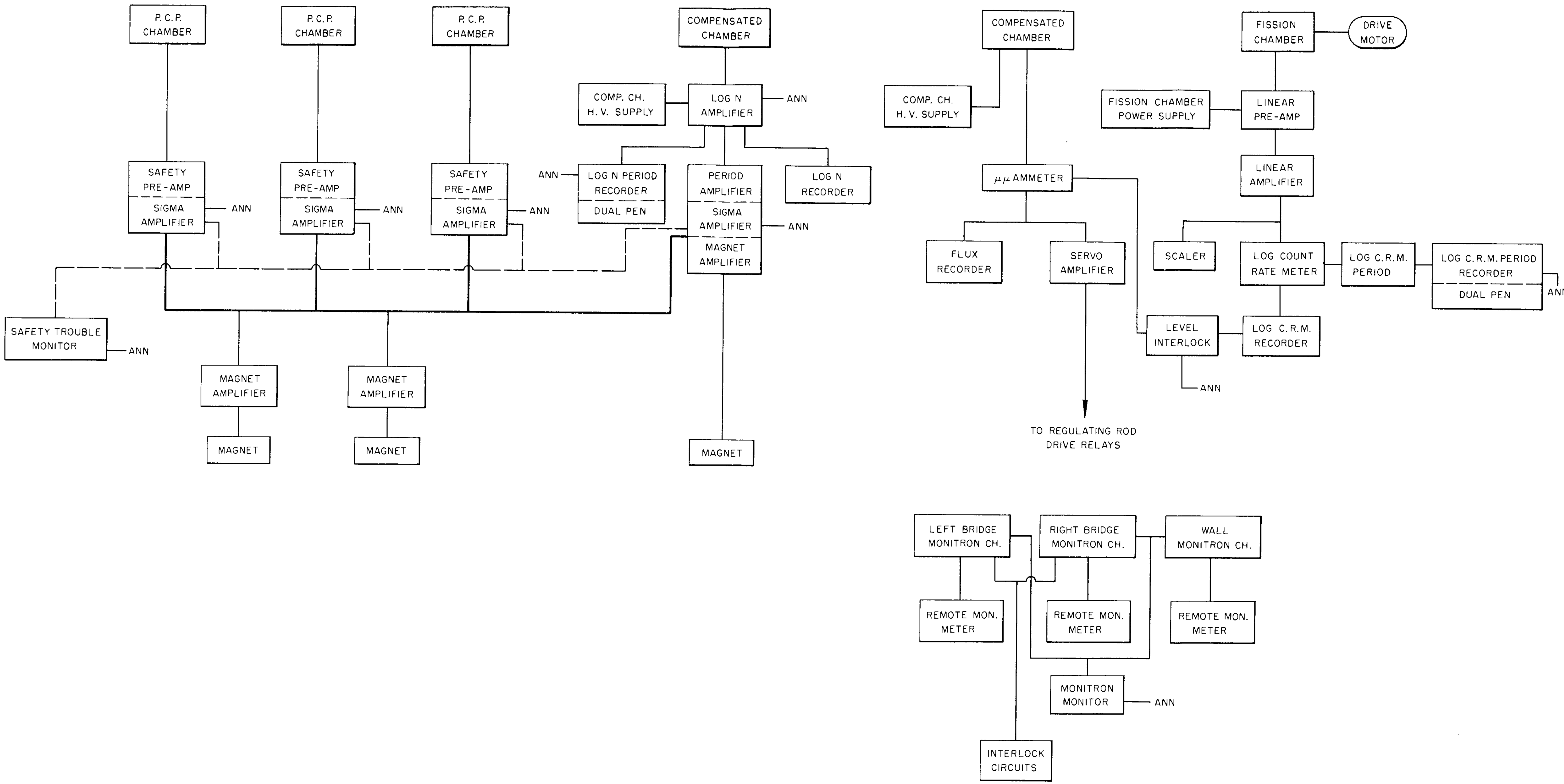

Fig. 3. One-Line Instrument System Diagram for the Bulk Shielding Reactor.

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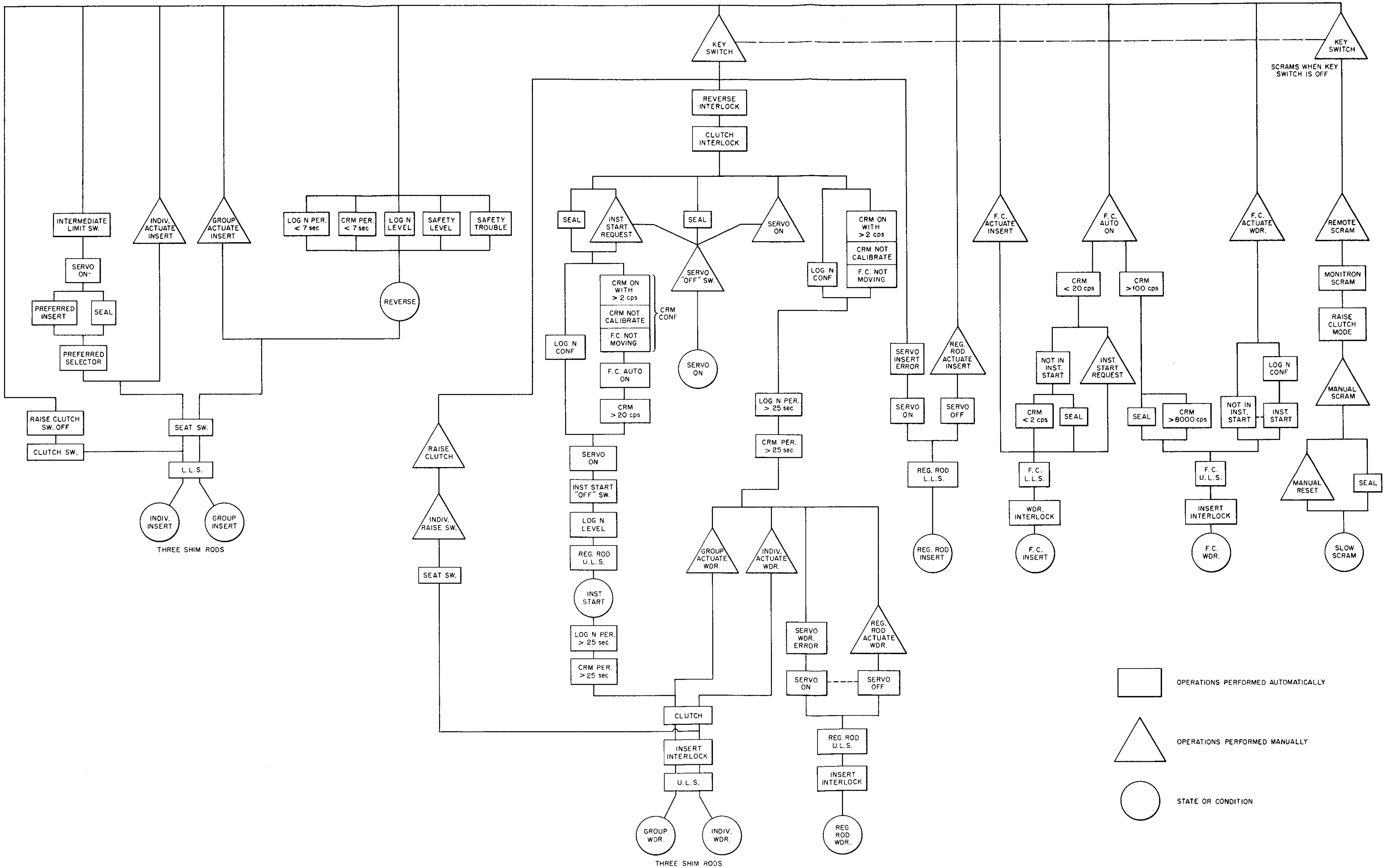

Fig. 4. One-Line Control System Diagram for the Bulk Shielding Reactor.

APPENDIX C

Reactor Operation Check List

To take the reactor critical, the operator should follow the procedure outlined below. If any instrument or circuit is not functioning in accordance with this procedure, the reactor is not to be taken critical.

1. Check gas cylinder gauges to insure an adequate supply of gas. (Cylinders may be changed during a run without reactor shutdown.)
2. Observe gas flow at east side of reactor bridge; it must be $>$ 0.25 cu. ft/hr for all chambers.
3. Calibrate log N meter:

   (a) Turn selector switch from "operate" to "Gnd" position. Log N meter should read 0.0001 (extreme left black mark on meter dial). To change meter pointer position, turn adjustment marked "Gnd set."

   (b) Turn selector switch to "Lo calib." The meter pointer should now be aligned with the "Lo cal" red mark on the left side of the meter face. To correct meter pointer position, turn adjustment marked "calibrate."

   (c) Turn selector switch to "Hi calib." The meter pointer should now be aligned with the "Hi cal" red mark on the right side of the meter face. To correct meter pointer position, turn adjustment control marked "gain."

   (d) If adjustment is needed in any position, the whole procedure (a,b,c) should be repeated until the meter shows correct readings.

(e) Return selector switch to "operate" position.

4. Turn on power switches No. 2 and No. 4 at left rear panel of reactor.

5. Clear the annunciator board by pushing "acknowledge" and "reset" buttons. Trouble indications are as follows:

Annunciator	Circuit
Log N Period	$<$ 7 sec positive period on log N period recorder
Log N Reverse	Log Pile power level greater than servo demand
Count-Rate Period	$<$ 7 sec period on pile count rate period recorder
Safety Level	Have exceeded Simplytrol level on safety trouble monitor
Fast Scram	$<$ 1 sec period in Log N amplifier and safety trouble monitor
Reverse	Log N period, count rate period, log N reverse, level reverse or two abnormal Σ amplifiers
Safety Trouble	Safety trouble monitor indicating an abnormal condition in either a Σ or composite amplifier

Annunciator	Circuit
Monitron High Level	$>$ 8 mr/hr monitron reading
Monitron Out of Service	Monitron in a condition other than operating on high sensitivity*
Shim Request	Instrument operation requires manual withdrawal of a shim rod

The safety trouble monitor responds to signals from the three log N period channels.

6. Insert key (furnished only to approved personnel) in lock and turn on power.

7. Check to see that the positive voltages of the ionization chamber power supplies are within the operating range and that magnet supplies indicate current flow.

8. Turn on instrument recorders.

9. Calibrate fission-chamber log count rate meter: Turn switch to "calibrate" position and manipulate "adj. 60 cps." control until recorder indicates 60 counts/sec. Return calibrate switch to "use" position.

10. (a) Make sure fission chamber is in the "0" withdrawn position and recorder is indicating at least 2 cps. (If counting rate is less than 20 cps, instrument start cannot be accomplished; 2 cps is the minimum for manual start.)

    (b) Visually check the neutron source location.

    (c) Note A-1 PHS setting.

    (d) Withdraw fission chamber to upper limit and determine the PHS at which the noise is counted.

*Note: When monitron is on "low sensitivity," access to pool must be restricted by barriers.

(e) Record this value in log book.

(f) Return the PHS to the previous setting. Electronic repairs must be made if this setting accepts noise counts. Insert the chamber to the lower limit.

11. Test scram circuits:

(a) Push scram reset push button.

(b) Check each sigma amplifier independently by raising the safety rods about 1 in. and inserting a small probe into the hole marked "scram" on the sigma amplifiers. The clutch pilot light should operate and the magnet drive insert to make up the clutch circuit.

(c) Turn Log N switch to "gnd."

(d) Raise each rod about 1 in. Push scram test button on Log N amplifier; period composite amplifier should initiate a scram.

(e) <u>Return selector switch to "operate" position</u>.

(f) Raise rods about 1 in. again and operate red scram button on console; all rods should drop. Push scram reset push button.

12. Set demand helipot on servo amplifier for desired scale reading on the demand meter.

13. Set servo microammeter to most sensitive range.

14. Clear annunciator board. The board must either be clear or the exact cause of any abnormality known.

15. Take reactor critical in the following manner:

Announce over the public address system that the reactor is being taken critical.

(a) Manual Operation:

Check critical experiment data in reactor log book for particular loading in use to determine previous safety rod positions. Then cautiously pull safety rods to the predetermined position, watching fission chamber recorder reading for any indication of criticality. Pull regulating rod until fission chamber count rate indicates a slowly increasing level. When the ionization chambers are positioned for 1-megawatt operation, the fission chamber will provide the best sub-critical and low-power flux level indication. Above 0.1 watt, the period meter, the log N recorder, and the recorder on the microammeter should indicate a power increase. The period should be determined from the response of all responding instruments, not from just the period meter. A 20-sec period interlock on the period recorders will prevent further rod withdrawal if activated. If it is necessary to withdraw the fission chamber before the response of the other instruments is trustworthy, no control rod withdrawal should be attempted until both the fission rate and period recorders stablize. Adjust the microammeter range to achieve the desired power level. After the pre-assigned power level is reached put reactor on "servo." Complete positioning the shim safety rods as dictated by the experiment. Adjust fission chamber count rate to about 1 register per second and connect to PA system. Announce the reactor power.

(b) Instrument startup (requires an indication of ~20 cps from the fission count rate meter).

Turn fission chamber actuator to automatic. Set the servo demand power selector. Press instrument start "on" button. When the regulating rod reachs its upper limit, the shim-safety rods will withdraw until a reactor period of ~40 sec. is maintained. Instrument start will remain activated until either the fission chamber is withdrawn or until end of start is reached. Do not re-activate instrument start if the fission chamber automatically withdraws.*

Confidence is required in either the log N or the fission chamber output before the instrument start mode is converted to instrument start. The instrument start mode remains activated until the reactor has reached the preset demand power.

Adjust fission chamber count rate to about one register per second and connect to PA system. Announce the reactor power.

16. Write on Brown charts the date, time, experiment number, run number, and scale factor.

*The reactor power will continue to increase until confidence is established in the log N channel and instrument start will continue.

17. Record data specified in reactor log.

18. Fill out reactor log sheets at hourly intervals. (See specimen, p. 19.)

19. Change of Power.

In general, manual control of the reactor power produces less awkward level changes. Announce over the building PA system (if being used) that the reactor is being taken "off PA." Push servo "off" button, turn fission-chamber automatic positioner to "off."

(a) Increased power.

Set servo power demand controls to the new required power. Withdraw regulating rod to put the reactor on an acceptable period. When the desired reactor power level is reached, push servo "on" button. Use the fission chamber manual withdraw button to position the fission chamber to give an acceptable count rate so that the reactor may be put "on" the building PA system after a power level announcement.

(b) Decreased Reactor Power.

Insert the control rods until the desired rate of decrease of power is achieved. Decrease servo demand in a manner such that the servo recorder always remains on scale (the servo back-up will cause a reactor reverse if the power indication on the log N exceeds that of the servo demand by a factor that varies between 2 and 20). When the power becomes less than the new demand, manually withdraw the regulating rod from its lower limit position, then turn servo "on." This action is necessary since with the servo "on" and the regulating rod in the lower limit a shim safety rod is automatically inserted. The adjustment of the position of the fission chamber will create positive periods in that channel. Extreme care must be exercised if a period reverse is to be avoided. The method that offers the least frustration is to temporarily disable the period recorder (turn off recorder power switch). Insert the fission chamber while observing the period on the log N amplifier. Then reactivate the period recorder.

20. Shutdown.

Announce the shutdown over the PA system. Turn off fission rate register. Insert all control rods to lower limits. Turn log N amplifier to "gnd" position. Insert fission chamber. Turn log count rate meter to "calibrate." Turn off Brown recorders. Write on charts all information listed in item 16. Turn reactor power "off." Lock handle and remove key. Turn off power switches No. 2 and 4 in the rear of the reactor console. Complete hourly operating sheet and operating log book. Sign the log book to indicate who shut the reactor down.

X-972 (Rev. 10-58)

BULK SHIELDING FACILITY

REACTOR DATA

Exp. No.____ Run No. _____

Description ______________

____

Reactor Position _________

Reactor Loading _________

Fission Chamber Location (Grid Plate) _________

Shim-Safety Rod No. 1 _________

Shim-Safety Rod No. 2 _________

Shim-Safety Rod No. 3 _________

Σ_1 ______ M_1 ________

Σ_2 ______ M_2 ________

Σ_3 ______ M_3 ________

Date _____ Page No. ______

Log Book No. ____ Page ______

Operator ______________

Reactor On _____________

Period Going Up __________

Reactor Full Power ________

Time	Power	Log N Power	$\mu\mu$ Ammeter (Servo)		Monitron			Reg. Rod	Pool Temp.	Fission Chamber	
			Brown Reading	Factor	1	2	3			Position	Counts

Fig. 5.

APPENDIX D

Location of Scram Buttons

Class A Scram

On the reactor console (the only red button).

Class B Scram (This will affect BSR-I and PCA)

Room 100, pool room, 4 large red buttons on columns adjacent to the 4 pool corners. (see Fig. 5)

Room 102, laboratory room, 1 red button in black box.

Room 103, laboratory room, 1 red button in black box.

Room 201, upstairs at north stairway, 1 red button in black box.

Room 202, upstairs north laboratory, 1 red button in black box.

Room 203, upstairs at south stairway, 1 red button in black box.

Bldg. 3080, machine shop, 1 red button in black box.

All operators should locate and memorize the positions of all of these scram buttons.

A Class A scram removes the A-C regulated power from the BSR shim-safety rod magnet power supplies. A Class A scram is initiated by the reactor operator and the A-C power circuit reactivated by pushing the scram reset button on the console.

A Class B scram removes the A-C regulated power from the shim-safety rod magnet power supplies of both the BSR-I and the PCA. Power may be restored to each system individually by pushing the scram reset button after a careful check to determine the reason this system was actuated.

The buttons that produce a Class B scram should be tested on the first work day of each month.

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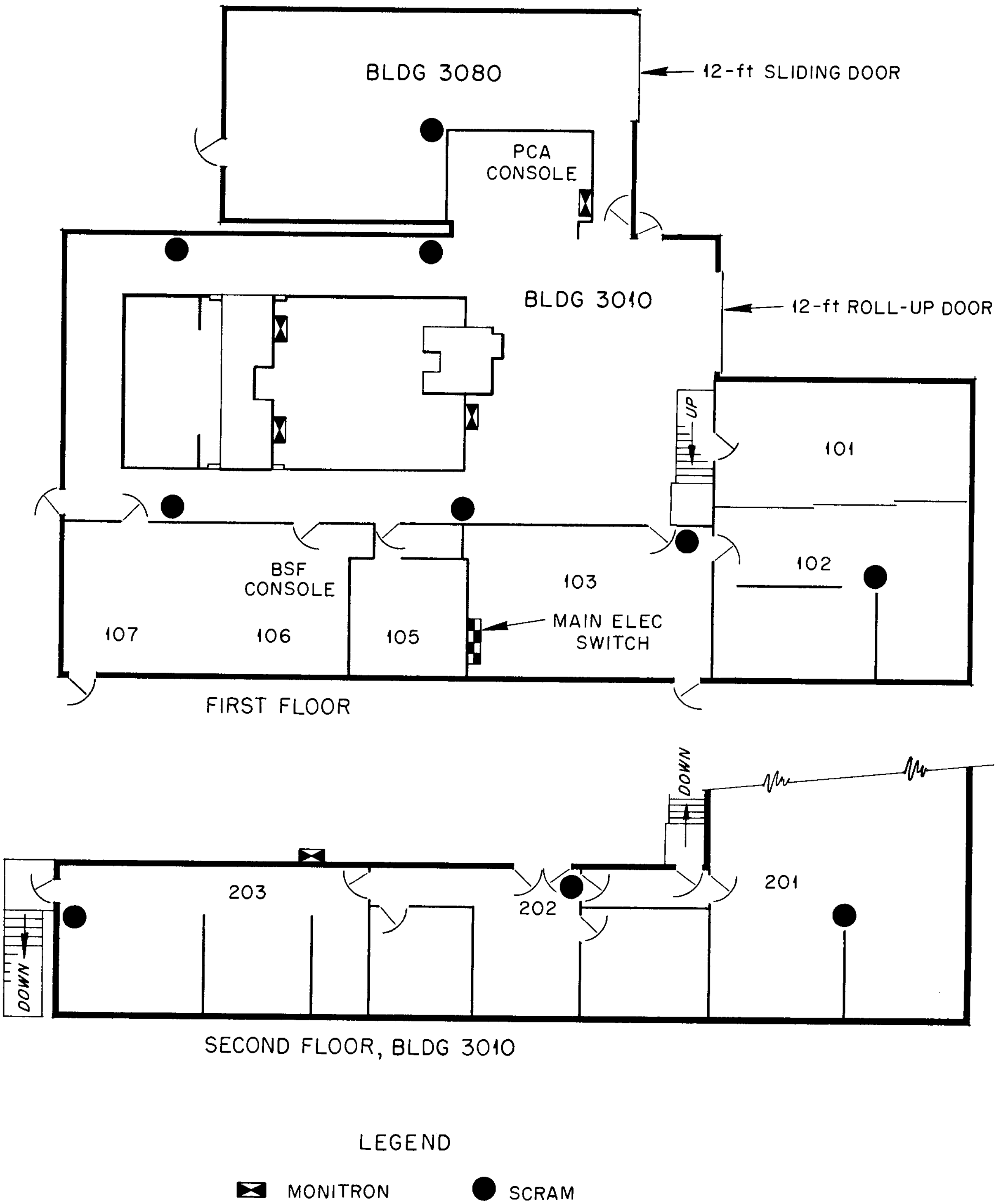

Fig. 6. BSR Scram Locations.

APPENDIX E

List of Conditions that Might Require an Operator Scram

The most probable conditions calling for a reactor scram lead to an automatic instrument scram. However, the following are examples of situations that might lead to an operator scram.

Class A

Erratic readings of magnet amplifier current.

Oscillations of increasing magnitude showing on servo recorder.

Class B

Persons falling in pool.

Building evacuation for any reason.

Variations in the count rate of the monitor attached to the PA system.

APPENDIX F

Control and Safety Chamber Tests

The reactor chambers are normally located at one of three distances from the core. The three positions are:

1. Fully Inserted. This position is used when the reactor is to be operated at a fraction of a watt power level or when critical tests are being executed.

2. 100-kw Position. This location of the chambers, used for power levels from a fraction of a watt up to 100 kw, provides a direct reading of the power level for loading 33. It provides relative readings for other loadings.

3. 1-Mw Position. This location, used for power levels from 100 kw to 1-Mw, also provides direct readings for loading 33 and relative readings for other loadings.

Control Chambers

The control chambers must be checked for compensation after each change of either fuel or chamber position. The linearity of response should be checked by comparison with the response of the reactor fission chamber. The compensation should be adjusted (by variation of the negative voltage of the chamber power supply) to give a parallel slope for the response of the two chambers. The period response is then checked by scramming the reactor with a 3-sec period when this can be achieved.

Safety Chambers

The safety chambers, when located in either the fully inserted for 100-kw position, scram the reactor on test power (level) excursions.

When the BSR has "hot" fuel in the core, a test excursion will be produced by increasing the reactor power on a long period. The chamber outputs, as noted on the sigma amplifiers, and the safety trouble monitor should be plotted against the excursion power level, as shown on the servo power level Brown. A curve of this type indicates the power at which the chambers will give a 150% power level (the scram level). The chambers are checked independently only if there is a large difference of sigma amplifier voltage readings. When "cold" fuel is in the core, a test excursion cannot be produced without exceeding the maximum operating power level of the cold fuel.

When the chambers are in the 1-Mw position, the sigma amplifier readings are to be compared to the power level as before. However, unlike the test in the previous paragraph, the reactor cannot be scrammed by an excursion without exceeding the approved maximum power of 1 Mw. Extrapolation of the power vs chamber output readings will indicate the approximate scram level.

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