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GUIDE FOR THE DESIGN OF SAFETY INSTRUMENTATION FOR EXPERIMENTS IN THE LITR AND ORR

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ABSTRACT

This report is to serve as a guide for the design of the safety instrumentation for experiments which are to operate in the LITR and ORR. It is not intended to provide the detailed information that is still needed to complete an acceptable instrumentation scheme. This information may be obtained upon consultation with the ORNL Instrumentation and Controls Division.

II. INTRODUCTION

Before any experiment is allowed in the reactor, it must be established that its containment is sufficient to prevent any damage* to the reactor or harm to building personnel in the event of any conceivable accident. Instrumentation on the experiment acts to maintain parameters within limits such that containment is not put in jeopardy. The instrumentation may act directly on the experiment, such as pumps, heaters, etc.; or it may act to reduce the reactor power. The instrumentation of the first class, since it has little effect, if any, on the reactor and other experiments, is important but will not be considered in this report. The instrumentation of the second class has a much greater effect on the entire reactor facility and is most important to the reactor operators and other experimenters. Uninterrupted reactor operation, for reasons to be given below, is to be maintained if at all possible. Thus, the experiment safety instrumentation must fulfill two basic requirements. First, it must always operate when containment is in jeopardy and second, it must be free of signals which can falsely shut down the reactor.

The safety instrumentation on earlier experiments at the LITR has caused many shutdowns and long delays before reactor start-up. Much of the trouble was due to faulty components and non-standardization of circuits. Non-standardization caused delays in uncovering instrument and system faults.

At the ORR, the xenon problem places a much larger premium on continuous operation. Where, at the LITR and similar reactors, it is generally possible to start the reactor up at any time after a shutdown, shutdowns of more than a few minutes at the ORR will result in downtimes of at least five to six hours. Shutdowns at the ORR necessitate removal of the tank cover and replacement of part of the reactor fuel with elements in which the xenon has decayed. Also, experiments are more apt to give trouble during the reactor start-up following an unscheduled shutdown. Taking all of the factors into consideration, some shutdowns at the ORR might require 10 to 20 hours downtime before the reactor could be started up to full power.

The experience at the LITR has shown the need for good electrical and electronic components and a list of preferred instrument and control components has been prepared by the ORNL Instrumentation and Controls Division. See Section VI for further information.

The design of the experiment safety system has evolved through trial and error so that it is now possible to specify many circuit features which are necessary and others which are undesirable. The method of the tie-in of experiments to the reactor control system has proved to be a very important part of the system. Modular units have been developed which standardize

* Here damage refers to the contamination of the reactor tank and pool water with materials of the experiment as well as the release of reactor fission products.

this area of the system and will facilitate rapid diagnosis of trouble and quick repairs when faults occur. These units are available as stores stock items at ORNL and will eliminate considerable design work in this area on the part of the experimenter.

With above material in mind, the specific aims of the report may now be enumerated.

1. Stress the need for good instrumentation to reduce the number of false reactor shutdowns and at the same time provide reliable safety for the experiment.

2. Stress the need for standardization of instrumentation to insure rapid construction, modifications and maintenance.

3. Describe the various responses of the ORR and LITR to safety signals from the experiments. (Section III).

4. Describe the experiment safety system at the ORR and LITR for transmission of these signals. (Section IV).

5. Describe the manner in which the experiment must provide these signals. (Section V).

6. Inform the experimenter of a preferred instrument and component list. (Section VI).

7. List recommended practices which, if followed, should improve the relationship of the experiment with all personnel associated with reactor building during all phases of its operation. (Section VII).

III. ORR AND LITR RESPONSE FOR EXPERIMENTS

Described herein are the modes by which the experimenter may decrease reactor power or alert the reactor operator of an impending reduction in reactor power.

A. ORR Response

1. Scram

A scram signal will de-energize all shim-rod holding solenoids and all rods will drop under the influence of gravity and water-flow forces. Once the scram relay drops out, the rods begin to move after 0.10 second, and the reactor neutron flux decreases in accordance with Curve A, Figure 1. The gamma flux does not decrease in the same way. Three minutes after shutdown the gamma flux is at least 10% of its value at full power; it is above 5% after 24 minutes. These figures refer only to the gammas from the reactor fuel, and the heating will be increased by gammas from structural materials, other experiments, etc. After the rods are released, the mechanism must be reset to its lower limit, which takes at least five minutes, and the rods must be withdrawn to start the reactor, which takes at least eight minutes. On many occasions the xenon-135 concentration will build up so that after this 13-minute delay it is no longer possible to start the reactor. It will then be necessary to change fuel in order to start.

2. Setback

A setback is a controlled reduction in reactor power. This is accomplished by driving down, with a motor, the power level demand on the servo system. The decrease is exponential with a period of 20 seconds; the setback is terminated at 500 kw after 74 seconds. Because of gamma heating there is no point in continuing the setback below 500 kw. A complete setback is shown in Curve B, Figure 1. Often, a small decrease in neutron flux will "cure" a high temperature condition. Such setbacks, requiring only a small decrease in reactor power, may be carried out by the servo-controlled rod alone. However, if the setback request continues, the servo-controlled rod will reach the lower end of its travel because of the effect of long-lifetime delayed neutrons. At this time other rods will automatically be inserted as needed to keep the servo-controlled rod in its operating range. As a result the reactor will be subcritical at the end of a long setback, and shim-rod withdrawal will be required at 500 kw to become critical again. The reactor power can, however, be increased again almost immediately, if desired, and if the setback signal has cleared. If the reactor remains below 5 megawatts more than a few minutes, the xenon problem is very similar to the situation after a scram.

3. Reverse

A reverse is an insertion of all shim rods, driven by their drive motors. Although a reverse is not normally provided in the experiment tie-in, it is used to back up setback action as discussed in Section IV below, if for some reason the setback does not take place. This is done immediately if the servo is turned off, and after a short delay if for some other reason the reactor power does not decrease as it should. It is conceivable that a future experiment may need to tie directly into the reverse mode. The reactor power decrease during a reverse is shown in Curve C, Figure 1.

4. Alarm

An alarm signal to the Reactor Control Room will actuate the experimenter's annunciator on the Control Room instrument panel. It should be mentioned at this point that this annunciator is also actuated whenever the experiment is reducing reactor power.

If the experiment is manned, the alarm signal will usually represent either a safety instrument failure, or a particular safety channel approaching the setback or scram level. In the situation where the experiment is not manned, the alarm signal will signify the above, and possibly other troubles which may require the dispatching of a man to investigate the experiment.

B. LITR Response

It is planned to rework the existing reactor control circuits so that the experiment tie-in facilities will be the same in every respect as those in the ORR. The response to a scram signal is very similar to the ORR response shown in Figure 1A. On the LITR, the fast setback decreases the power on a 17-second period and terminates when the power reaches 1% of full power. The slow setback decreases the power on a 90-second period, also to 1% of full power. The fast setback is the only setback available to the experimenter. The power decreases somewhat more slowly than the ORR when a reverse occurs.

IV. ORR AND LITR EXPERIMENT SAFETY SYSTEM

The Safety System to be described here has evolved through several years of experience with reactor experiments at ORNL. Figure 3 shows the details of this System and its relation to the experiment and reactor controls. Terminal blocks on either the north side or south side of the ORR building are available for the tie-in of an experiment into this System. More details concerning these tie-in connections will be given in Section V.

A little study of Figure 3 will show that two action paths are available to produce a reactor scram and two action paths are available to produce a reactor setback. Each device at the experiment which is required to produce a scram or setback must actuate both paths. One path requires that a contact be opened for action (the drop-out path), and the other path requires that a contact be closed for action (make-up path).

The connections to the circuits which actually operate the reactor controls are completed through a device which shall be referred to as an E-panel.

Each experiment must provide its own E-panel. This panel is a stock item and may be purchased out of stores as needed. The unit contains five relays (RE101, 201, 301, 401, 501), 6 monitor lights and a control switch. It is of plug-in construction and may be conveniently inserted into its appropriate spot in a cabinet located in the Reactor Control Room which houses the E-panels for all experiments.

A. Scram Circuits

Relay RE401 is actuated by the drop-out action path mentioned above and RE501 is actuated by the make-up action path. The de-energizing of RE401 and/or the energizing of RE501 will initiate a scram action. Each device (pushbutton, instrument, pressure switch, etc.) which may initiate a scram is equipped with two contacts, for example, U1 and U2. Contact U1 is usually closed, and opens to scram; contact U2 is usually open and closes to scram. The two actions should occur simultaneously. If the device is one half of a two-channel system (see Section V for a definition of a channel and its requirements), and invariably it will be, the other channel simultaneously will operate V1 and V2 in the like manner. The de-energizing of RE401 will open RE401-B which de-energizes R28. The energizing of RE501 will close RE501-B which energizes R28X. R28 and R28X are the reactor slow* scram relays, whose contacts control the shim-rod holding solenoids.

Any loss of the experimenter's power feeding the Safety System will drop out relay RE401, thereby causing a reactor scram. This will be the case even though the experiment does not have any safety switches which operate into the scram circuits.

* Here the word slow distinguishes this type of scram from the one which is initiated by signals from the reactor neutron level and period electronic safety circuits.

B. Setback Circuits

Relay RE201 is actuated by the drop-out action path and RE301 is actuated by the make-up action path. As in the case of the scram, each device which may initiate a setback is equipped with two contacts, for example X1 and X2. Contact X1 is usually closed, and opens to setback; contact X2 is usually open, and closes to setback the reactor. The two actions should occur simultaneously. If the device is one half of a two-channel system (see Section V for a definition of a channel and its requirements), and invariably it will be, the other channel simultaneously will operate Y1 and Y2 in the like manner. The de-energizing of relay RE201 opens contact RE201-B which de-energizes relay R27. A normally closed contact on R27 calls for a reverse, inserting all rods when R27 is dropped out. The reverse is delayed by the slow drop-out of R27, whose movement is damped mechanically. If the setback initiated at the same time through the action of RE301-B on relay R24Y proceeds successfully, the resulting negative period will cause contact RS33 (on the period recorder) to close. This makes up a seal-in circuit on relay R27 through R27-3 before R27 actually drops out thereby inhibiting the reverse.

C. Alarm Circuits

Relay RE101 monitors any alarm condition which is transmitted to the Reactor Control Room. Any device which may initiate a Control Room alarm is equipped with a contact which will operate an annunciator located at the experiment. This annunciator will contain an auxiliary contact on one of its internal relays which will work into the RE101 circuit. This auxiliary contact will open in the event of an alarm condition and de-energize RE101. Contact RE101-B will then open and actuate the experimenter's Control Room annunciator. Those annunciators (at the experiment) which are required to alarm the experimenter's Reactor Control Room annunciator must have their auxiliary contacts wired in series so that any one contact may drop out relay RE101.

D. Feedback of Information to the Experiment

The Safety System is also designed to feed back information to the experiment for the purpose of reassuring the experimenter that a power reduction signal has been received at the Control Room. This is accomplished through the action of the RE401-D and RE501-C contacts in the case of a scram action. If either RE401 and/or RE501 operates, the circuit to the experimenter's scram annunciator is broken and thereby annunciating the fact that the Control Room has received his scram signal. In like manner, RE201-D and/or RE301-C will break the circuit to the experimenter's setback annunciator and inform him that his setback signal has been received by the Control Room. In addition, if the SE1-5 contact is opened, which is the case if the experimenter's E-panel control switch (to be described in detail below) is not in the "normal" position, the circuit to the experimenter's tie-in annunciator is broken. This will produce an annunciation informing the experimenter that his Safety System is not operative.

E. Experiment-to-Reactor Control Panel (E-Panel)

As shown in Figure 3, much of the instrumentation for each experiment operates from its own power source, separate from reactor control power. The interconnection between experiment controls and reactor controls must therefore be associated with two sources of power. The actual interconnecting devices are the five RE relays, located in the E-panel in the Reactor Control Room. The coils of these relays are energized from the experiment power source; their contacts are in reactor control circuits operating on the reactor control power source.

Each E-panel has a control switch which completely isolates the relay coils from the experiment instrumentation and bypasses their contacts in the reactor control circuits, when thrown to the "disconnected" position. This permits working on the experiment equipment without fear of disturbing reactor operation. A "test" position is also provided which permits the experimenter to freely simulate the various scram, setback, and alarm signals without disturbing the reactor system. It is felt that this "test" mode will relieve the experimenter from having to design his own test circuitry and may help standardize check out procedures. It should be noted here that this switch must never be turned to either the "test" or "disconnected" position while the experiment is operating under conditions requiring reactor control for safety. This switch can be locked in the "normal", "test", or "disconnected" position with a key. During the time the experiment is not installed in the high-flux zone, the reactor operator keeps the switch in the "disconnected" position and locked to avoid interference with his operation. When the experiment is inserted into the high flux zone, the switch is locked in the "normal" position and the key retained by the reactor operator to assure continuity of protection.

On Figure 3 can be seen the details of the control switch, SE1. Contacts SE1-1, SE1-3 and SE1-5 through SE1-10 disconnect the E-panel from the experiment by disconnecting all wires fed by the experimenter's power source. Inasmuch as reactor control relays R27 and R28 initiate reactor control action when de-energized, it is necessary to install contacts SE1-2 and SE1-4 to energize these relays when the switch is in the "disconnected" position. In this way, throwing the switch to the "disconnected" position will inhibit all Reactor Control actions initiated by this experiment. In order that reactor and experiment operators be informed of the status of the control switch, and the interconnection in general, the experimenter's annunciator in the Reactor Control Room and an annunciator (the tie-in annunciator) at the experiment will show an abnormal condition when the switch is in the "disconnect" position.

In the "test" position, the loop from the experiment to the E-panel is completed by keeping contacts SE1-1, SE1-3, and SE1-7 through SE1-10 closed. Thus, the feedback of scram and setback signals to the experimenter's annunciators is retained just as though the experiment were tied into the reactor control system. With the switch in the "test" position, all action of relays R27, R24Y, R28, and R28X (and consequently any reactor operation) by the experiment in question is inhibited by keeping contacts SE1-2 and SE1-4 closed and SE1-11 and SE1-12 open.

It should be noted that, with the switch in the "test" position, the experimenter's tie-in annunciator monitoring the position of the switch will indicate that the experiment is not tied in since SE1-5 is open. Also, the annunciator in the Reactor Control Room will indicate an abnormal condition for the experiment since SE1-6 is open, keeping RE101 de-energized.

If the interconnection (between experiment and E-panel) is disturbed without the control switch having been actuated, the circuits are arranged so that it is very unlikely that protection will be lost without warning. Severing the interconnecting cable will initiate an alarm, a reverse, and scram. Grounding all wires will do likewise. Connecting all wires to the "hot" side of the line will initiate a setback and scram. While there are 3-wire faults which will inhibit one type of correction without warning, it is extremely unlikely that enough of these will occur accidentally and simultaneously to endanger the experiment.

Another feature is incorporated into the E-panel which permits the checking of the operation of the individual action paths for both setback and scram circuits. The red light (L1) which is operated by RE401-C will turn on if RE401 is de-energized due to a scram signal. The red light (L2) operated by RE501-D will turn on if RE501 is energized by a scram signal. The operation of the light circuitry under description here may be somewhat clearer if it is understood that these lights are neon lights with a 47K resistor built in the base. This resistor is not shown in Figure 3. In a similar fashion, RE201-C will turn on its red light (L3) when a setback signal de-energizes RE201, and RE301-D will turn on its red light (L4) when the setback signal de-energizes relay RE301.

The alarm circuitry is monitored by an amber light (L5) which is turned on whenever RE101 is de-energized. The operation here may not be obvious. The contacts which operate RE101 will short out the amber light when the contacts are all closed. When any one contact is opened, the amber light is connected across the experiment power bus through a 47K resistor.

Lines for a sound powered phone system will be available to all areas of the building for communication to the cabinet containing these E-panels in the Reactor Control Room. These are not shown in Figure 3. This sound powered phone system may be employed by the experimenter to aid him in checking his safety circuits through his E-panel.

V. ORR AND LITR EXPERIMENT SAFETY SYSTEM REQUIREMENTS

The Safety System described in the previous section has been designed especially for use by experimenters to protect the integrity of their equipment through reactor control. This section attempts to describe the requirements which must be fulfilled by the experiment if the high degree of reliability of the System is not to be degraded.

It is deceiving to build an elaborate safeguard system which can act only on a signal from a single thermocouple. The first requirement which must be met by the experiment is that at least two independent sensing elements (each with make-up and drop-out switches) will be provided for each parameter requiring the reduction of reactor power through the Safety System. Each sensing element, with its associated switches, will herein be referred to as a channel.

The two channels are to be independent in the sense that no single failure can disable them both. It is conceded that it is possible that any one channel may fail, sometime in a manner that may become evident, sometime in a manner that is not. However, it is maintained that the possibility of both channels failing is relatively remote, particularly if the best of instruments and components are used in each channel. The position is then taken that a self-checking or trouble monitoring scheme is not required on either channel.[2]

A. General Requirements

1. At least two channels will be provided for each parameter which requires the reduction of reactor power through the Safety System.* This does not necessarily imply that one must install two thermocouples and two recorders (which provide the necessary switches); perhaps a flowmeter or a high-pressure contact may be used as a second channel for a temperature signal.

2. The Safety System will not be used to alleviate abnormal conditions in the experiment until all other available means (i.e. turning off of heaters, opening of valves on coolant lines) have been exhausted.

3. The experiment will have a manual control of reactor power (either scram or setback, not both) equal to the fastest mode of reactor shutdown that is possible with his safety circuits.

* In extremely rare cases, one sensing element may be used, at the experimenter's option, to operate the setback circuits of the Safety System.[3] Here it must be clearly a case of protection of experimental data rather than the integrity of containment, and that no other control available to the experimenter can provide the same protection. See item two under General Requirements.

4. Automatic retraction of the experiment, when feasible, will be used to relieve abnormal conditions in lieu of reducing reactor power through the Safety System.

B. Specific Requirements of Each Channel

1. The speed of response of each channel, and this usually will be dictated by the response time of the sensor and process, will be compatible with the response expected of the reactor.

2. The switch contacts which actuate the Safety System will not be employed to operate any other control function associated with the experiment. (The relay mentioned in item three below will be the only exception).

3. The switch contacts which actuate the Safety System will operate both the make-up and drop-out circuits of the System. In extreme cases, where the channel cannot provide separate switches for this, a relay may be used which is actuated from the single contact in the safety device. (Refer to A-Box in this section for further details.) However, it is preferred that the safety device contain the necessary contacts and thereby eliminate the relay, which detracts from the reliability of the system.

4. The switch contacts which actuate the Safety System will not be designed to "seal in". Rather, they will remain in the abnormal state only so long as the trouble is present.

5. All adjustments for scram, setback and alarm levels will be enclosed within the case of the instrument. Pressure switches or similar devices must be enclosed in cabinets or mounted behind the instrument panels well out of the way of any operation associated with the panel.

6. No blocks or by-pass switches for such purposes as reactor startup, special meter reading, adjustment of setpoints, etc., will be permitted to inhibit the action of scram or setback switches.

7. All instruments requiring external power which are used to operate safety switches will contain a power monitoring system which will operate a relay contact if power is removed from the instrument. This contact will first operate the experimenter's local annunciator. Then, the auxiliary contact on this annunciator will provide the alarm signal for the Safety System.

8. All temperature instruments which are used to operate safety switches will contain thermocouple burnout protection. It is preferred that this burnout drive the instrument in a direction opposite to that which would call for a reduction in reactor power. (This will be so whether the experiment is manned or not.) If there is not already a safety switch operating in this direction, an additional switch will be required. This switch should be connected in series with the power monitoring switch on the instrument.

9. Controllers should not be used to operate safety switches. Special concessions will be made in certain cases. Where a controller is used to operate a safety switch, the burnout protection will drive the controller in a direction which takes the experiment to a safe state of operation.

10. Each safety channel which can cause a reduction in reactor power must provide a forewarning alarm signal for the Safety System. If the safety device does not have enough contacts for this, another instrument indicating the same variable may be employed.

11. The need for both setback and scram on a safety channel will vary from one experiment to another. Where the variable being monitored is under the direct influence of reactor neutrons and its response time is slow, a setback prior to a scram may prevent some scrams.[2]

C. Annunciator Requirements

Annunciators will be needed at the experiment for several purposes which play a very important role in the safety of the experiment and reactor. Because of this, it is necessary that close control be maintained on the type of annunciator used in the experiment. The unit which is to be used at the LITR and ORR is shown in Figure 2, which gives the sequence of operation and the circuit. Each annunciator has an auxiliary contact on one of its internal relays which permits the re-transmitting of a trouble signal to the alarm circuit of the Safety System if so desired.

The annunciators are employed to monitor the following items:

1. Minor process troubles.

2. Process troubles immediately leading to a demand for reactor power reduction.

3. Instrument trouble (power failure).

4. Information fed-back from the experimenter's E-panel.

   a. Tie-in connection

   b. Actuation of setback relays in E-Panel

   c. Actuation of scram relays in E-Panel.

Items 2, 3, 4 (b) and 4 (c) are re-transmitted to the alarm circuits of the Safety System. The tie-in information, 4 (a), is not re-transmitted since first, it would be redundant and secondly, it would prevent any testing of the alarm circuit unless the E-panel control switch were in the "normal" position.

D. Interconnection Requirements

The importance of the connection of the experiment safety contacts to the Safety System cannot be over-emphasized. Standardization of the tie-in connections for all experiments is stressed to minimize errors in connection, and to facilitate the trouble shooting of the experiment for safety circuit faults.

Associated with each experiment there will be two junction boxes (E-Box and S-Box) which will serve as terminal points for the various wires in the Safety System. A third and fourth box may be used in special cases to be discussed below.

1. E-Box

The Safety System for all experiments is terminated in the ORR building in two large junction boxes which will be referred to as E-Boxes. One is located on the north side of the building, and one on the south side of the building. At the LITR, E-Boxes will be located throughout the building at convenient locations. Each E-Box at the ORR has the capacity to handle 15 individual experiments. The cables which connect these E-Boxes to the E-panel are already installed. The experimenter must install similar cable from this E-Box to an S-Box at his experiment. Five-conductor cable is being set up as a stores stock item for this purpose. This cable must be pulled in conduit with no cables other than similar safety cables for other experiments.

2. S-Box

The S-Box will terminate the cables from the above described E-Box at the experiment instrument panel. This box and its terminal blocks are also set up as a stores stock item. This box can be mounted on the back of one of the instrument panels or on a wall near the instrument panel. The wall mounting will require a conduit run over to the instrument panel.

The S-Box has been designed to accommodate a standard set of connections for all experiment switches that initiate an alarm or a reduction in reactor power. Terminals are also provided for the interconnecting cable to the E-Box. The layout and wiring are shown in Figure 4. It should be emphasized that <u>all</u>

setback and scram switches should be brought to the S-Box for interconnection. It is extremely important to avoid making a "daisy-chain" of these switches through several instruments.

The box will accommodate nine usually open and nine usually closed scram switches, and nine usually open and nine usually closed setback switches. Usually open switches close to initiate a scram or setback and usually closed switches open to initiate a scram or setback.

If an experiment requires more than nine scram circuits or more than nine setback circuits, additional S-Boxes will be required.

The box contains five rows of terminal strips, ten terminals per row. It can be supplied completely wired so that the experimenter need only connect the power-reduction switches to designated terminals in this box to assemble the tie-in to the reactor controls. Installation of the 10-conductor cable to the E-Box then completes the tie-in to the Control Room.

All experiment switches which close to initiate a scram are connected to terminal strip 2 (11 through 20); switches which open to initiate a scram are connected to terminal strip 3 (21 through 30); however, jumpers must be removed from the terminals on strip 3 as switches are connected. All experiment switches which close to initiate a setback are connected to terminal strip 4 (31 through 40). Switches which open to initiate a setback are connected to terminal strip 5 (41 through 50); however, jumpers must be removed from the terminals on strip 5 as switches are connected.

The first terminal strip (1 through 10) is reserved for the ten-conductor cable from the Reactor Control Room; however, it will be necessary for the experimenter to connect the 110 VAC experiment power HOT wire to point 1 and the neutral lead to point 10, to connect point 6 to the annunciator cabinet and point 9 to the local annunciator monitoring the reactor tie-in. The local annunciator monitoring the feed-back of scram signals to the experiment is connected to point 7. The local annunciator monitoring the feed-back of setback signals is connected to point 8.

An example of a typical scram and setback tie-in is also shown in Figure 4. The make-up switch in an instrument for the purpose of initiating a setback is connected to points 31 and 32. The drop-out switch in the instrument which is to initiate a setback is connected to points 41 and 42 after removing the jumper. The drop-out switch for the purpose of initiating a scram is connected to points 21 and 22 after removing the jumper. The make-up switch in the same instrument which is to initiate a scram connects to points 11 and 12.

If more than one S-Box is required, the interconnections must be made as follows: Connect points 1 through 5 in the first S-Box to points 1 through 5 respectively in the second S-Box. Remove the SCRAM DROPOUT wire from point 30 in the first S-Box and remove HOT wire from point 21 in the second S-Box. Connect point 30 in the first S-Box to point 21 in the second S-Box. Remove SETBACK DROPOUT wire from point 50 in the first S-Box and HOT wire from point 41 in the second S-Box. Connect point 50 in the first S-Box to point 41 in the second S-Box. Any number of boxes may be connected together by following the same procedure.

3. Auxiliary E-Box

There are special situations where several individual experiments all related to one project are operated in the same laboratory or general area. In this case it has been permitted that each S-Box output (cables going to the E-Box) be terminated in an auxiliary E-Box near the experiments. Then, one or two conduits are run to the main E-Boxes mentioned above. This not only simplifies the conduiting to the E-Box, but also permits any experiment to be temporarily removed from that area without requiring the removal of long conduits and cables that go to the E-Box. A standard design is being offered for this auxiliary E-Box which will be used in all cases where it is requested by the experimenter.

4. A-Box

The A-Box has been designed to provide a standard array of relays for the purpose of providing extra contacts for devices which operate into the Safety System. The layout and wiring of the A-Box is shown in Figure 5. It contains six relays and six 6-point terminal strips. The standard wiring connects the coil and the two normally open contacts to the six terminals. If a normally closed contact is desired, a wire is moved on the relay.

VI. PREFERRED INSTRUMENT AND COMPONENTS LIST FOR EXPERIMENTS

A list of preferred instruments and control components has been prepared by the ORNL Instrument Department. This list is not incorporated as part of this report since it will be revised, as required, to take into account additional instrumentation which may be found to meet ORNL requirements, to keep abreast of new instrumentation, and to cover new areas whose inclusion is deemed necessary for better reactor operation. Each time the list is revised, it will bear a revision number and date. The user should make sure that he is in possession of the latest version. Information and copies of the list may be obtained from the ORNL Instrument Department, Building 3500.

The experimenter should make every effort to utilize the instruments and components on the preferred list because :(a) their reliability has been proven to the satisfaction of the ORNL Instrument Department; (b) maintenance personnel at ORNL are familiar with these devices and can provide better and faster servicing; and (c) spare parts, or complete spare instruments, are generally available at ORNL.

VII. GENERAL PRACTICES AND PROCEDURES FOR EXPERIMENTS

The material presented in this section is of extreme importance and covers all phases of the experiment - from its construction and installation, through its operational period to its termination. Adherence to the practices and procedures given here can mean the difference between a successful experiment and one which is not.

A. Construction Practices

Construction drawings should be available for all instrument work. These drawings should include wiring diagrams showing the physical wiring of panels and interconnection cables. The wiring and device coding should be as per ORNL CF Report 58-12-141.[4]

Construction drawings should also specify either Special (clean) electrical power or Normal (dirty) power. The Special power system is a 120/2 ?V. single phase bus which is distributed about the ORR. The Normal power system is a 120/208V. three phase bus which is distributed about the ORR.

It is recommended that the Special power be reserved for all critical instrumentation, such as high-gain pulse equipment, regulated power supplies, etc., where noise-free line voltages are required. Outlets for this Special power when used should be clearly and permanently labeled. This special power system has a limited capacity and will in general not be used by most experiments.

The Normal power is recommended for use on the bulk of the instrumentation used in experiments such as safety circuits, annunciator, control circuits, heater power, etc.

A 480 volt, three phase emergency power system with a 100 ampere capacity is available at the south side of the ORR for experimental use. This system is normally fed by the building 480 V., three phase, Normal power bus. It is automatically transferred to a diesel-driven emergency generator upon loss of this Normal power.

It is recommended that all safety instruments be wired directly into the power bus. The method of wiring should be such that the power leads for a particular instrument may be removed without de-energizing other instruments on the same bus. Twist-lock connectors are recommended as an alternate method, although not nearly as desirable.

It is recommended that one circuit breaker be employed for all safety instrumentation. No other instrumentation should be powered through this breaker.

It is recommended that utility outlets be made available at the rear of all instrument cabinets. These outlets will be powered from the Normal system and will be of the three-prong type.

B. Maintenance Drawings

It is recommended that maintenance drawings be available for trouble shooting and modification purposes. Two different types are generally needed. An elementary drawing and a maintenance elementary are both very useful. The elementary is devoid of tie-point information and detailed wire coding and is convenient to use to learn the operation of system and thereby permit the localizing of faults. Once this has been determined, the maintenance elementary will be more useful in finding the faulty contact or component in the system. ORNL Report CF-58-12-141 describes the standards that should beemployed in the coding of wiring and devices for these two drawings. An ORNL electrical symbols list should also be used in making these drawings.

It is also imperative that the maintenance elementary and elementary drawings be kept up to date and on file at the experiment.

C. Operation of the Experiment

The instrumentation of the experiment should be so designed that the minimum use of reactor operating personnel is required. This particularly applies to the interval of time following unscheduled shutdowns of the reactor.

The experiment control instrumentation is also to be so designed that the reactor start-up can proceed smoothly, and with no delays other than those imposed by reactor control instruments. Normally, the reactor will be taken from the shutdown state (about 1% of full power) to full power in 90 seconds.

The experiment must in no way impair or delay the operation of other experiments in the building. All last minute preparation should be eliminated because this means that regularly scheduled work is disrupted and will invariably result in the delay of reactor start-up. Just as important, it may result in a hastily checked out experiment that could lead to a serious accident.

D. Use of Mercury

The hazard of mercury amalgamation and resulting damage to the aluminum system of the LITR and ORR makes it essential to forbid general use of mercury in or around these reactors. This includes all devices such as mercury switches, thermometers, etc. However, there are certain applications where mercury has essential qualities which are not obtainable in any non-mercury substitute device. Therefore, exception is made in the case of specific items listed in the Preferred Instruments and Components list. These units are given approval on the basis of several years experience with wide usage at ORNL. They have proven to have good reliability, and due to their construction, to constitute practically no danger of leakage of mercury due to failure of mishandling. These units must not be used in any location where spillage of mercury into or onto any of the reactor aluminum system could occur as a result of any failure or breakage of the device.

Any use of mercury other than as prescribed above must have the approval of the ORNL Operations Division.

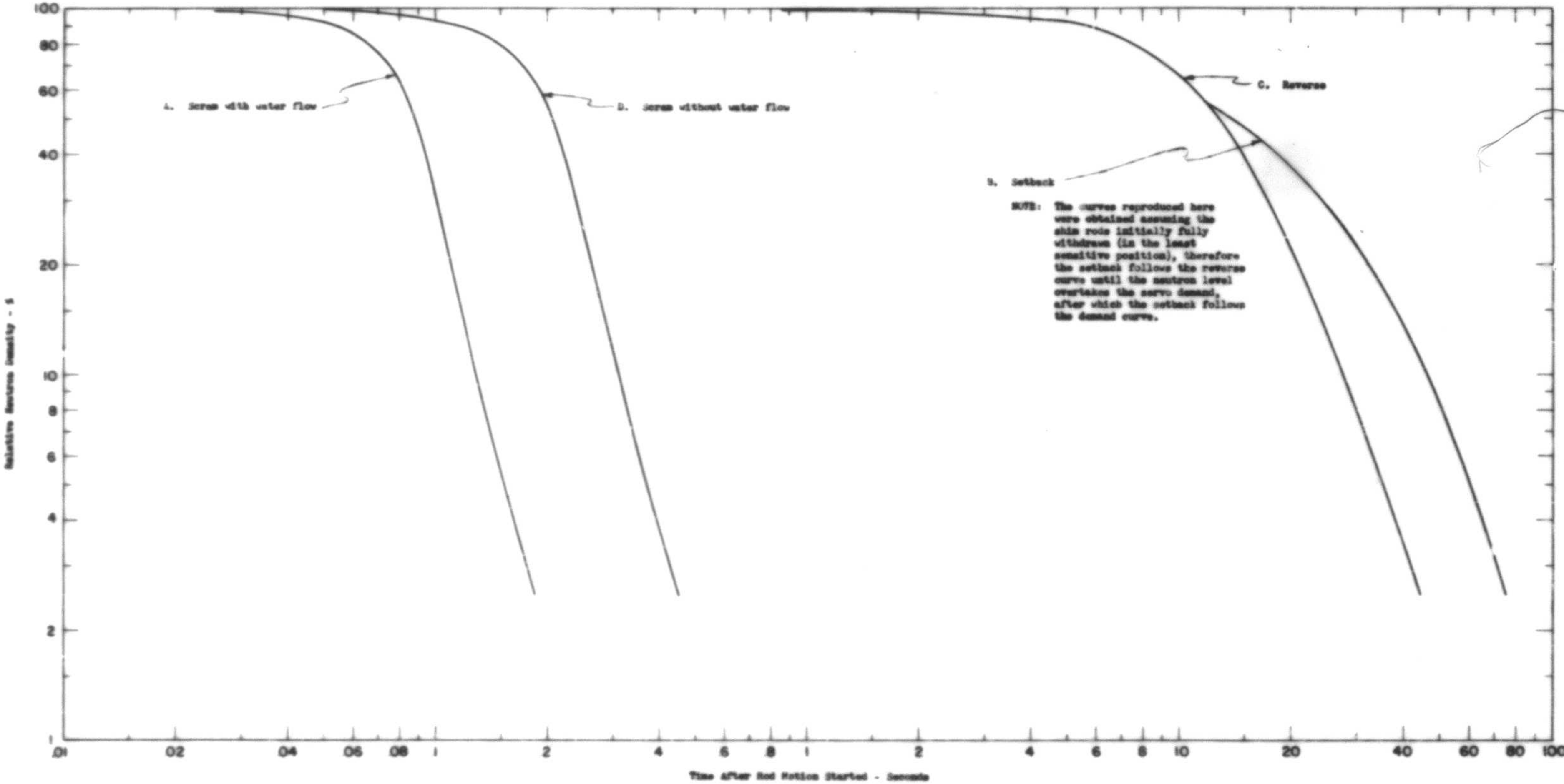
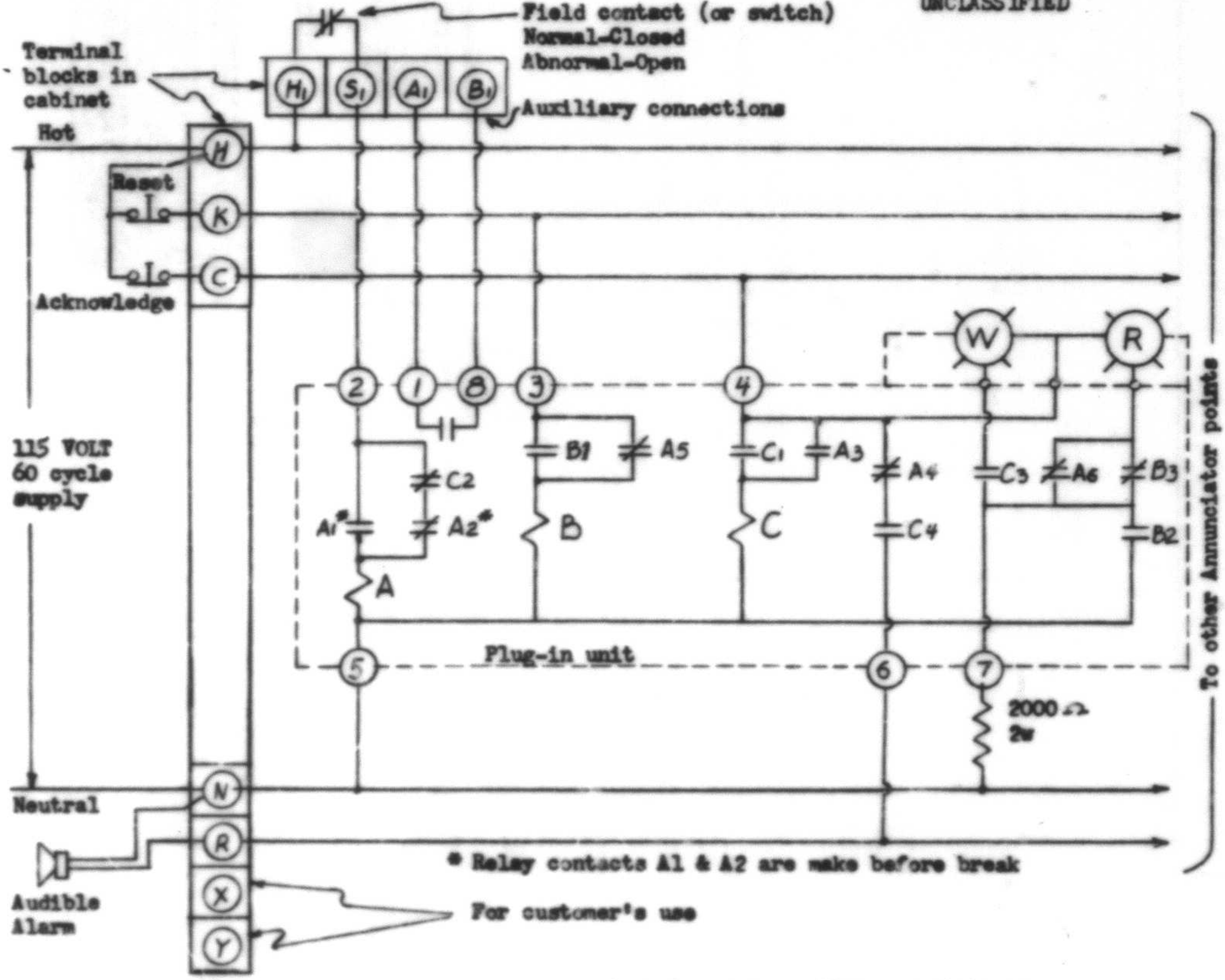


FIGURE 1. ORR NEUTRON BEHAVIOR DURING SHUTDOWN

ORNL-LR-Dwg.-26227
UNCLASSIFIED



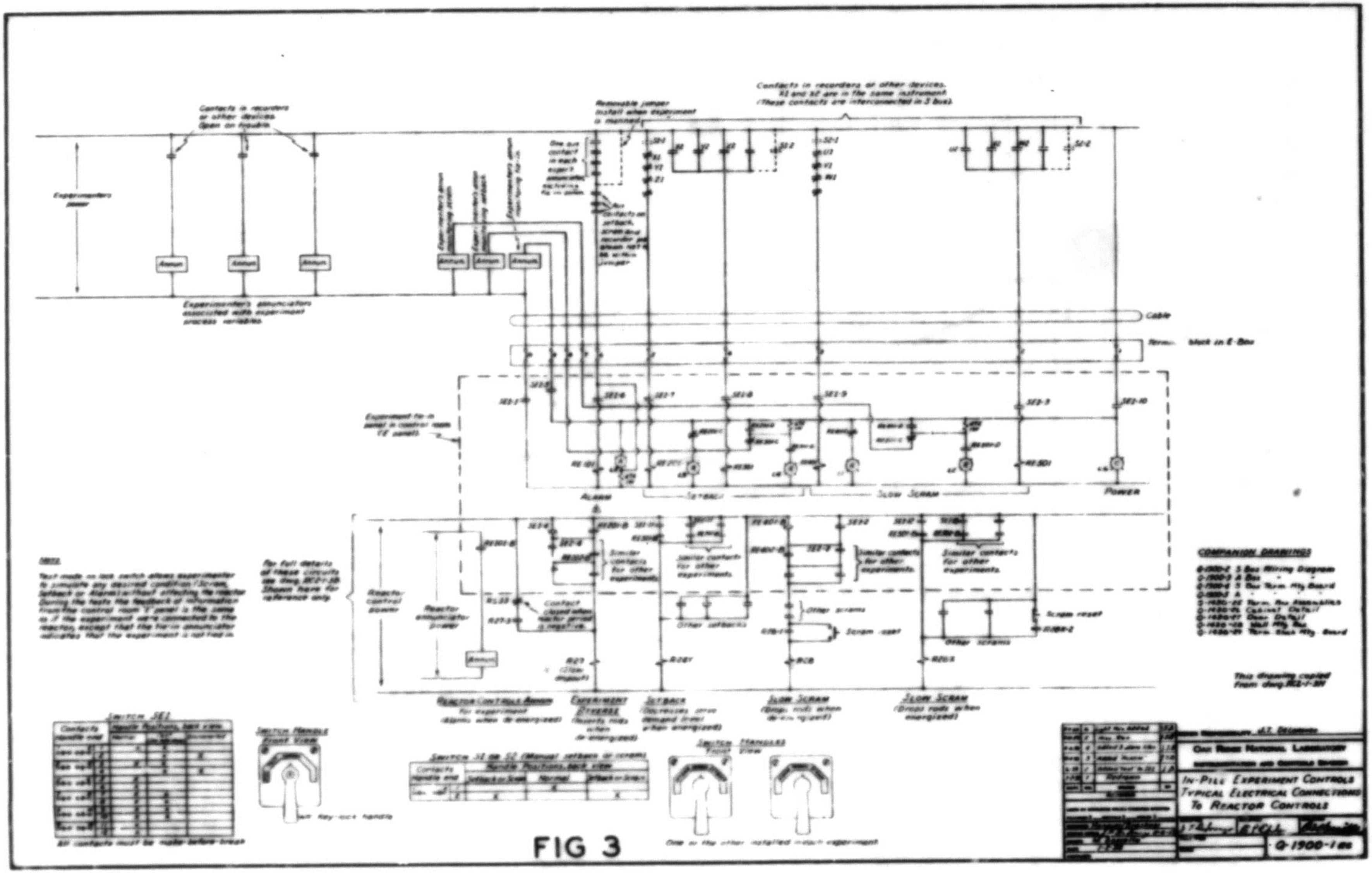
Step	Signal Contact	Red Light	White Light	Audible Alarm	Aux. Contact
1. Normal Condition	Closed	Dim	Dim	Off	Closed
2. Abnormal Condition, Before Acknowledged	Open	Bright	Bright	On	Open
3. Abnormal Condition, After Acknowledged	Open	Bright	Off	Off	Open
4. Normal Condition Returns, Before Reset	Closed	Off	Bright	Off	Closed
5. Normal Condition, After Reset	Closed	Dim	Dim	Off	Closed

NOTE 1: If after step 2, normal condition returns before acknowledge button is operated, the annunciator must remain in condition 2 until acknowledge button is operated, after which the annunciator should go to step 4.

NOTE 2: If after step 4, abnormal condition returns before the reset button is operated, the annunciator should return to step 2.

NOTE 3: Numbers in circles refer to pin numbers of octal plug.

Figure 2



Cable
Annun
Alarm
Setback
Slow Scram
Power
Companion Drawings
Oak Ridge National Laboratory
In-Pile Experiment Controls
Typical Electrical Connections
To Reactor Controls
Q-1900-1

FIG 3

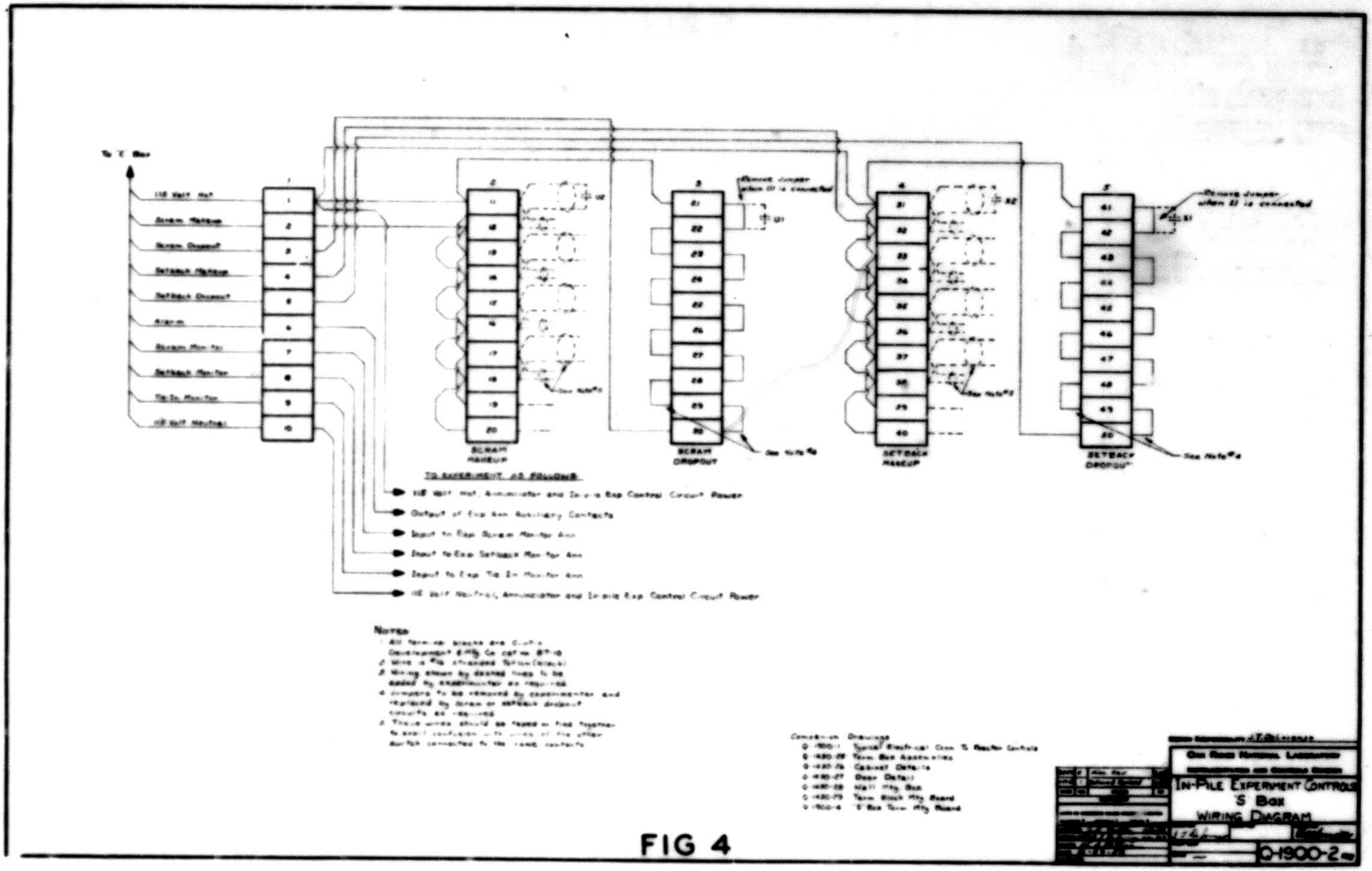
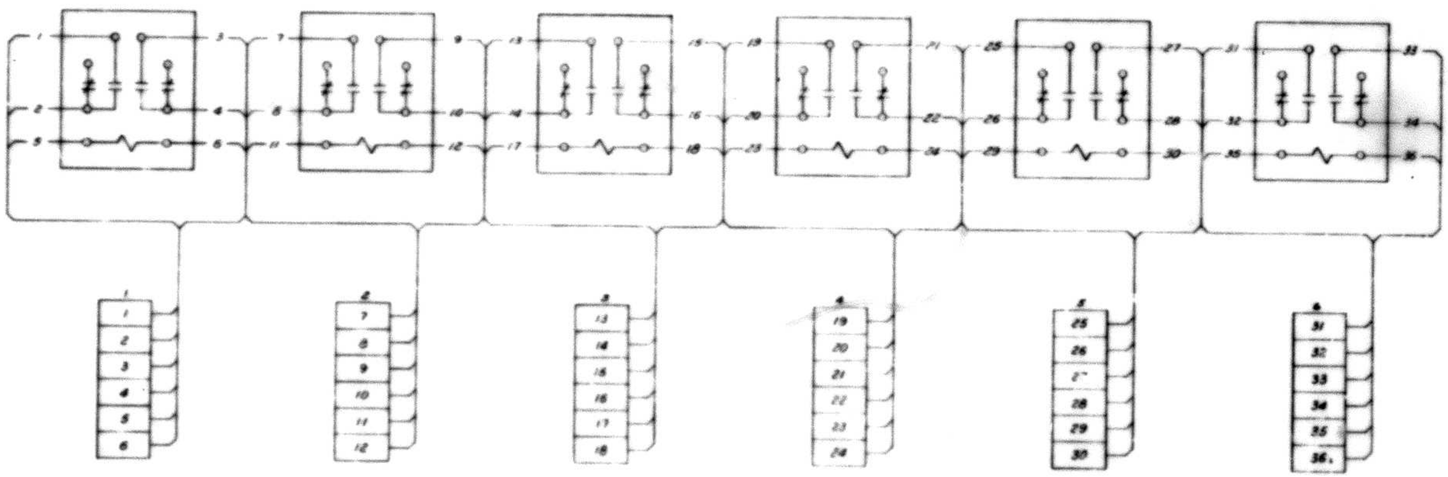

SCRAM MAKEUP
SCRAM DROPOUT
SETBACK MAKEUP
SETBACK DROPOUT
Notes
IN-PILE EXPERIMENT CONTROLS
'S' BOX
WIRING DIAGRAM
Q-1900-2

FIG 4



Notes:

1. Relays are 10Amp. DPDT with 115VAC 60~ operating coil, General Electric CR2790E100A2.
2. All Terminal Blocks are Curtis Development & Mfg. Co. Cat. no. BT-6.
3. Wire is #16 stranded Teflon (black)

Companion Drawings

Q-1900-1 Typical Electrical Con. To Reactor Controls

J. T. DeLorenzo

Oak Ridge National Laboratory

IN-PILE EXPERIMENT CONTROLS
"A" BOX
WIRING DIAGRAM

Q-1900-3

FIG 5

REFERENCES

1. C. Brashear, S. H. Hanauer; Safety Procedures For In-Pile Experiments in the LITR and the ORR, ORNL CF57-12-58.

2. Minutes of the In-Pile Instrumentation and Controls Review Committee; General Meeting to Discuss Recent Problems Associated with Experiments in the ORR, July 17, 1959.

3. Minutes of the In-Pile Instrumentation and Controls Review Committee; Instrumentation for GCR Fuel Element Capsule Test Prototype for the ORR, November 13, 1958.

4. Electrical and Electronic Drawing Standards Wiring and Device Coding and Applications, ORNL CF-58-12-141.