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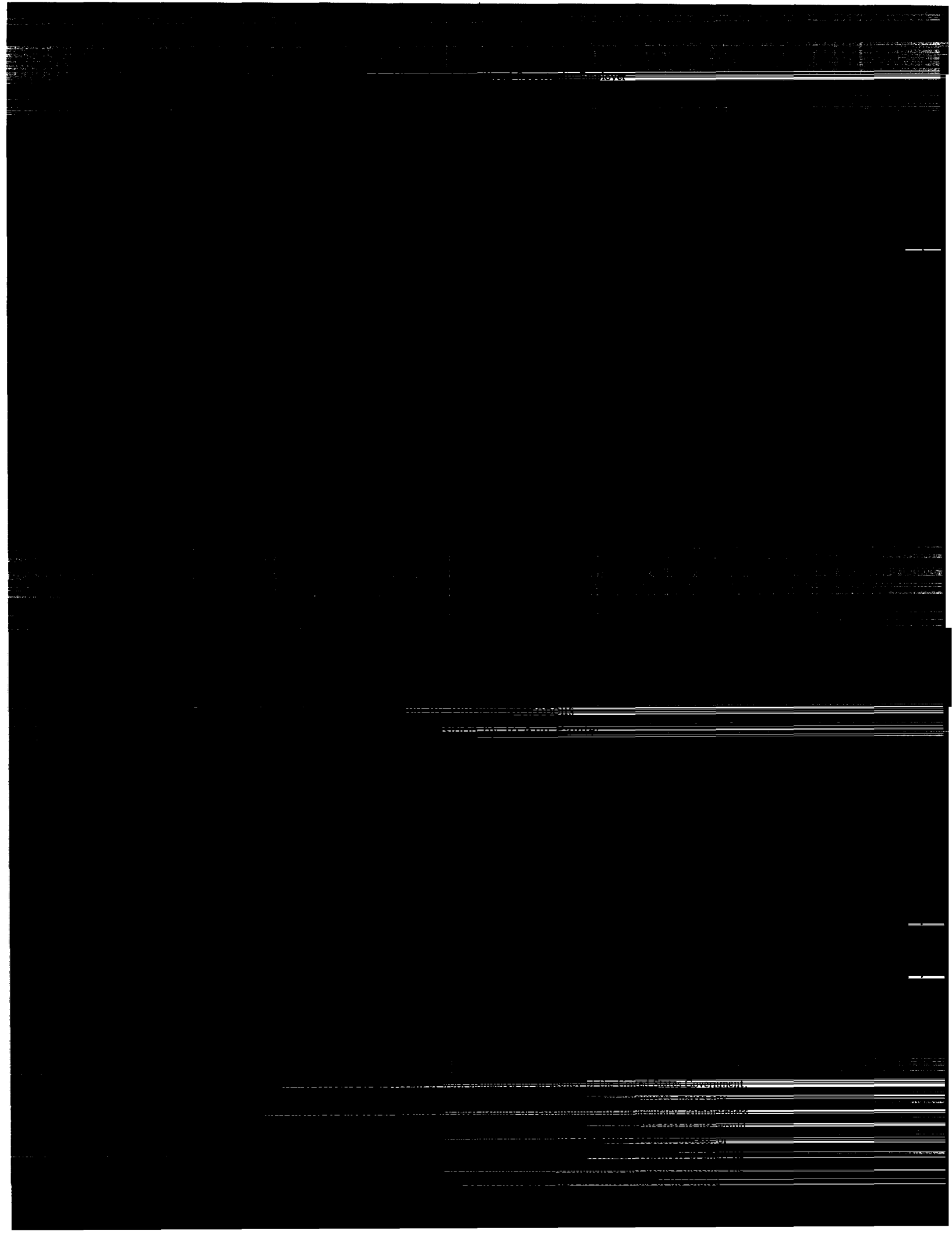
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High Explosives Test Facility

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HIGH EXPLOSIVES TEST FACILITY

by

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ABSTRACT

This report describes a high explosives test facility that makes efficient use of equipment and combines utility, convenience, and safety in a modest amount of space. It is a dedicated facility for exploratory development efforts that previously were conducted in a single room having very limited capabilities. Two explosives testing areas are now available and several projects are supported concurrently.

I. INTRODUCTION

The new high explosives (HE) test facility has two explosives testing areas that are operated from a single control room; therefore, only a few pieces of additional equipment are required for the operation of both areas.

The most notable feature of the new facility is that diagnostic and control equipment is available to either area at the flip of a switch in a central control room. Also, systems designs assume that some individuals will be assembling HE experiments in one test area while others are firing HE in the other area, so interlock control and monitoring systems ensure the safety of personnel working in both test areas.

We describe the various safety, control, and diagnostic systems that make this facility possible.

II. FACILITY DESCRIPTION

Figure 1 is a floor plan of the facility. Chamber 1 comprises Rooms 110 and 110A. Room 110A is a 100-g firing tank that allows optical access from Room 110 where diagnostic cameras are mounted. Room 107/108 (Chamber 2) is a smaller firing chamber with a camera mounted to focus into a portable boom box. Both chambers are controlled from Room 109, which has nine

equipment racks containing all control and electronic diagnostic equipment. All equipment in Room 109 (except for high-voltage power supplies) is shared by both chambers.

Room 111 is the VISAR (Velocity Interferometer System for Any Reflector) firing chamber. A patch panel between the VISAR Room and Chamber 1 allows the performance of VISAR experiments that contain up to 100 g of HE.

III. SAFETY INTERLOCK SYSTEM

The safety interlock system serves two purposes: (1) it prevents accidental entrance into an area where HE tests are in progress and (2) it provides interlocked power to one chamber while keeping power from the other. Figure 2(a) is a diagram of the safety interlock system, with dark lines denoting the Chamber 1 safety interlocks. Because Chamber 1 has an explosive limit of 100 g and is vented to the outside, a considerable concussion can be experienced on the north side of the building during a test; therefore, all doors and gates permitting access to this area are interlocked to prevent HE from being detonated while personnel are in the area.

Chamber 2 uses a portable boom box that adequately contains all allowable explosions, and only the doors in

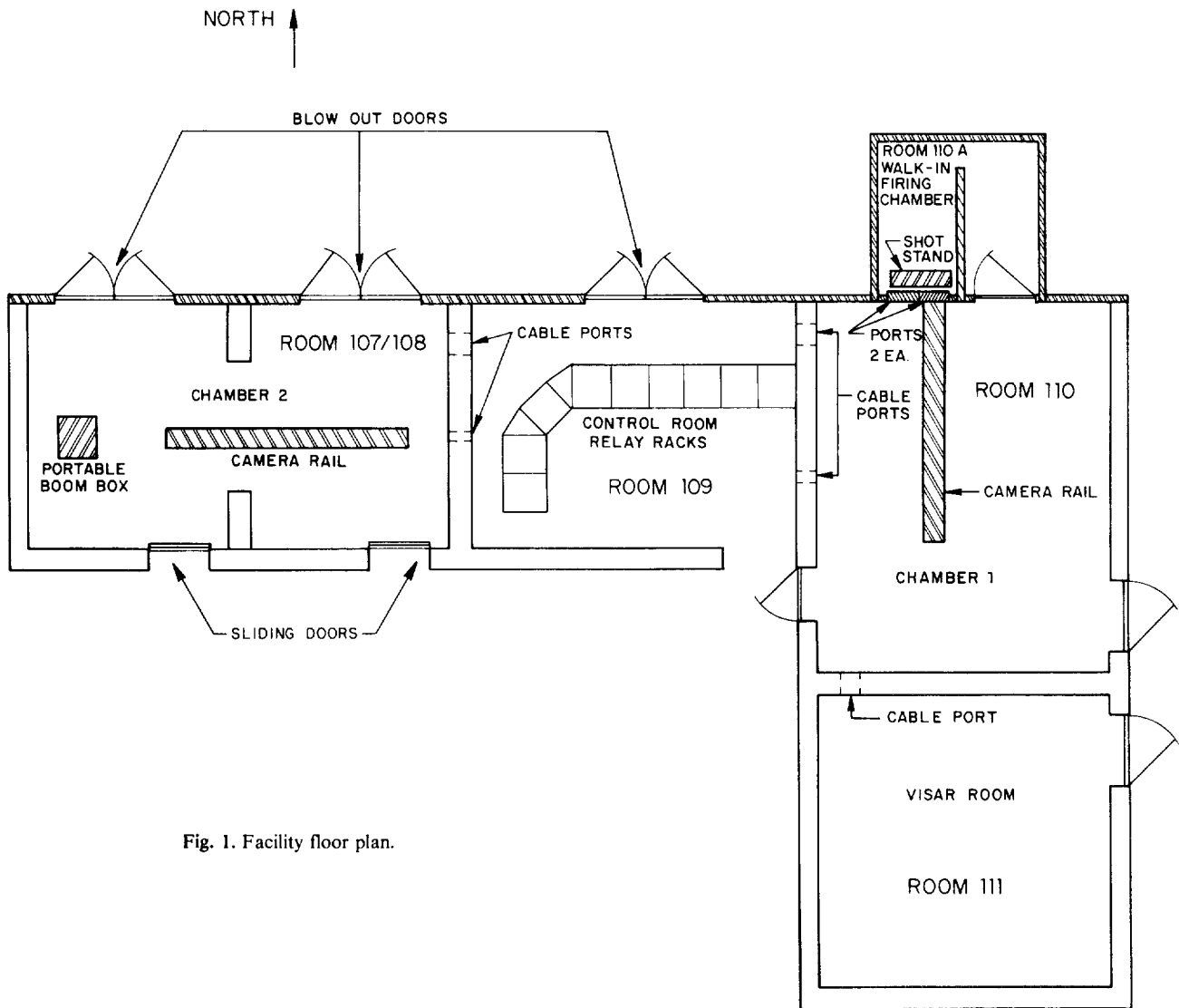


Fig. 1. Facility floor plan.

Room 107/108 and the door to the portable boom box are interlocked in this system. Figure 2(b) is the same diagram with dark lines denoting Chamber 2 safety interlocks.

As shown in Figs. 3(a) and 3(b), latching relays powered through the interlock systems turn on the interlocked power. The normally closed position of one relay closes a circuit to supply latch-up power to the other relay. To obtain interlocked power in a chamber, the appropriate relay is energized. When energizing occurs, a mechanical arm lifts the contacts from the normally closed position to the normally open position, closing the circuit to the proper interlock power system while opening the circuit that could energize the relay to the other chamber. The relay-control unit for each

chamber has both on and off push buttons, so that the on circuit must be turned off before the other circuit can be energized. It is highly unlikely that these mechanical relays could fail in such a way that interlocked power would be supplied to the two chambers at once.

Once turned on, the interlocked power goes to a power distribution unit, which, in turn, provides power to the high-voltage control unit and the fire-control unit. Special connectors employed nowhere else in the chamber are used on all power cords and instruments involved in the high-voltage system to prevent noninterlocked AC power from accidentally being connected to interlocked AC power. The special connectors are also different for the two firing chambers, to prevent cross connection between the two high-voltage systems.

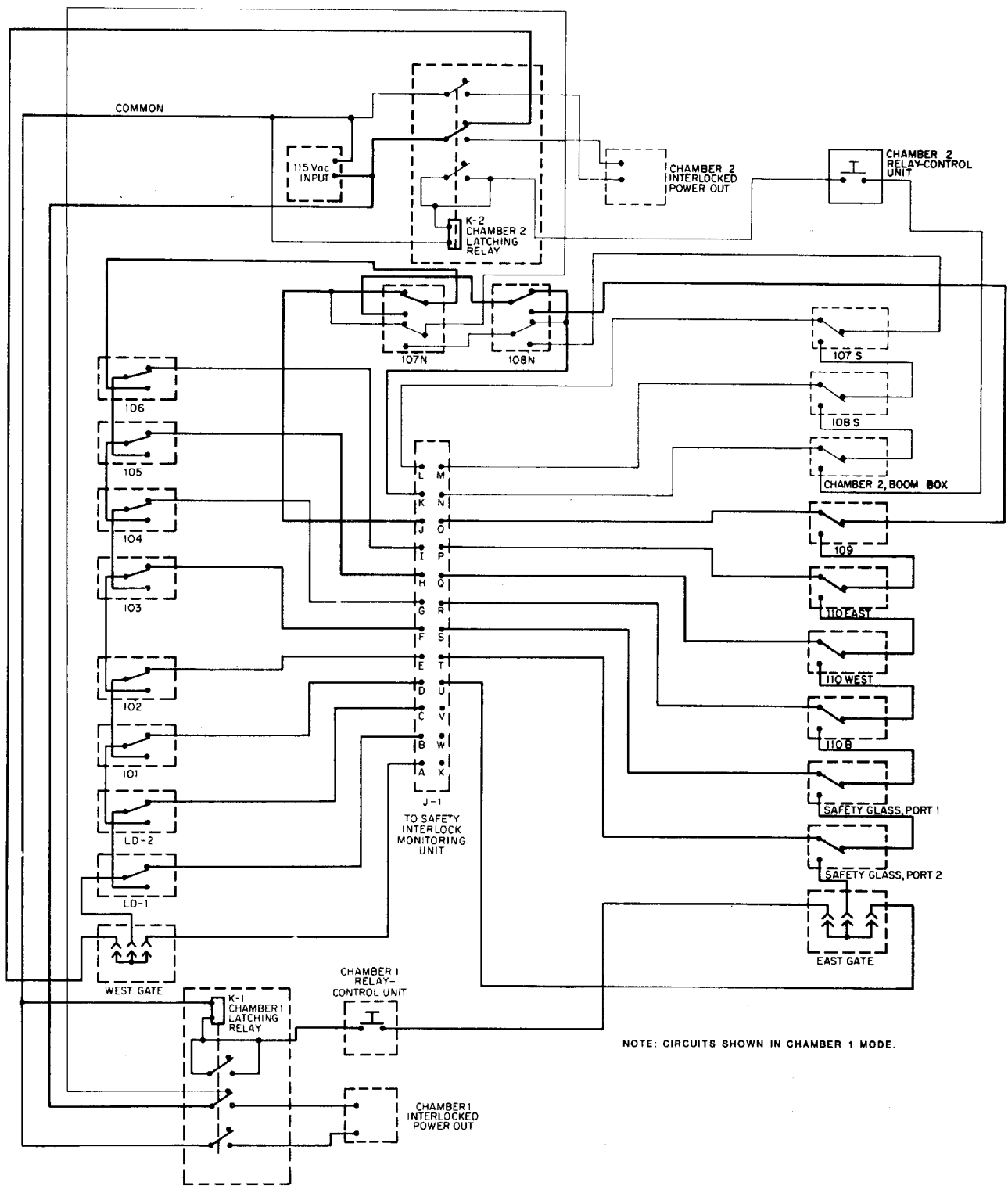


Fig. 2(a). Safety interlock entrance system with dark lines denoting Chamber 1 interlocks.

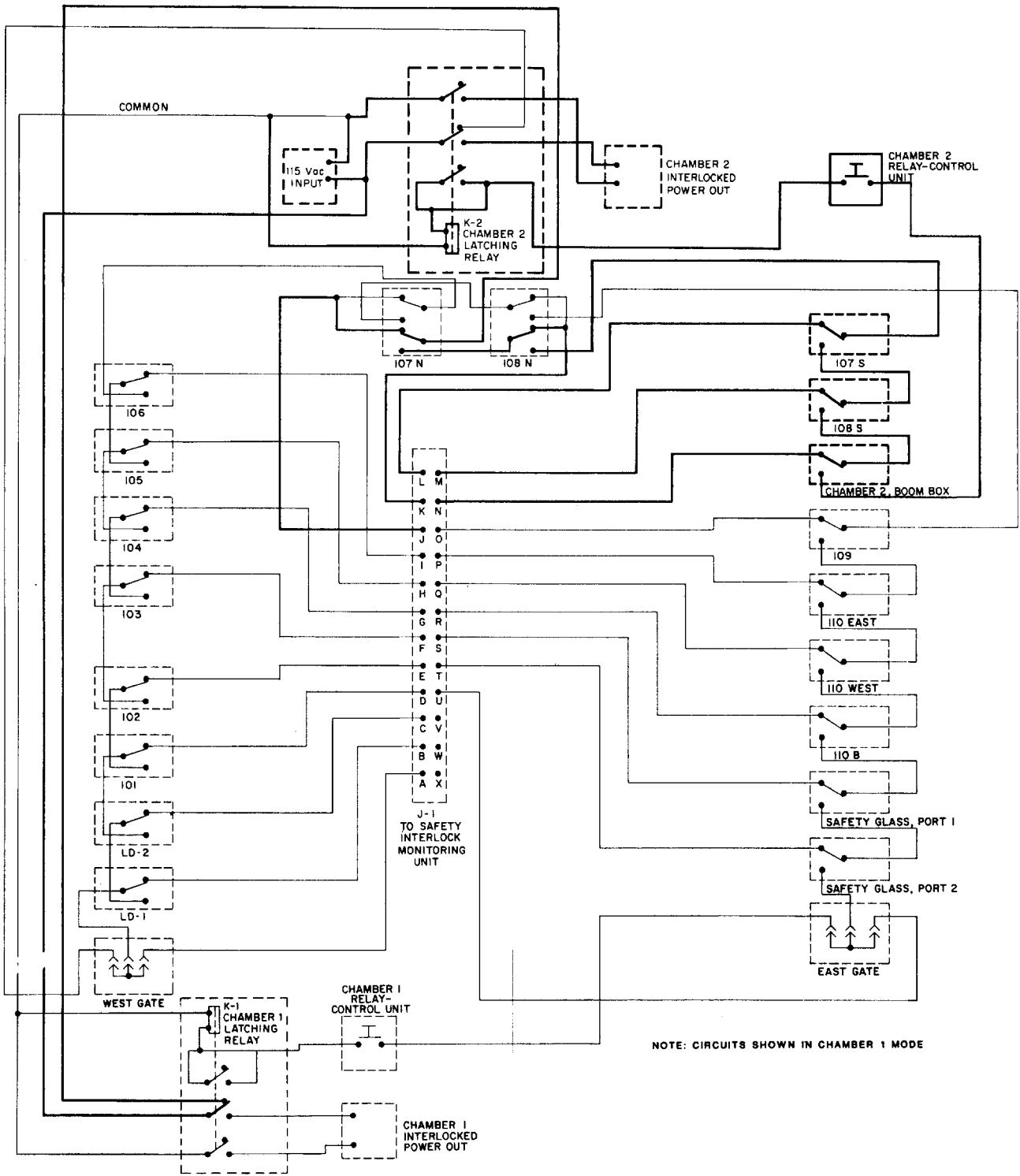


Fig. 2(b). Safety interlock entrance system with dark lines denoting Chamber 2 interlocks.

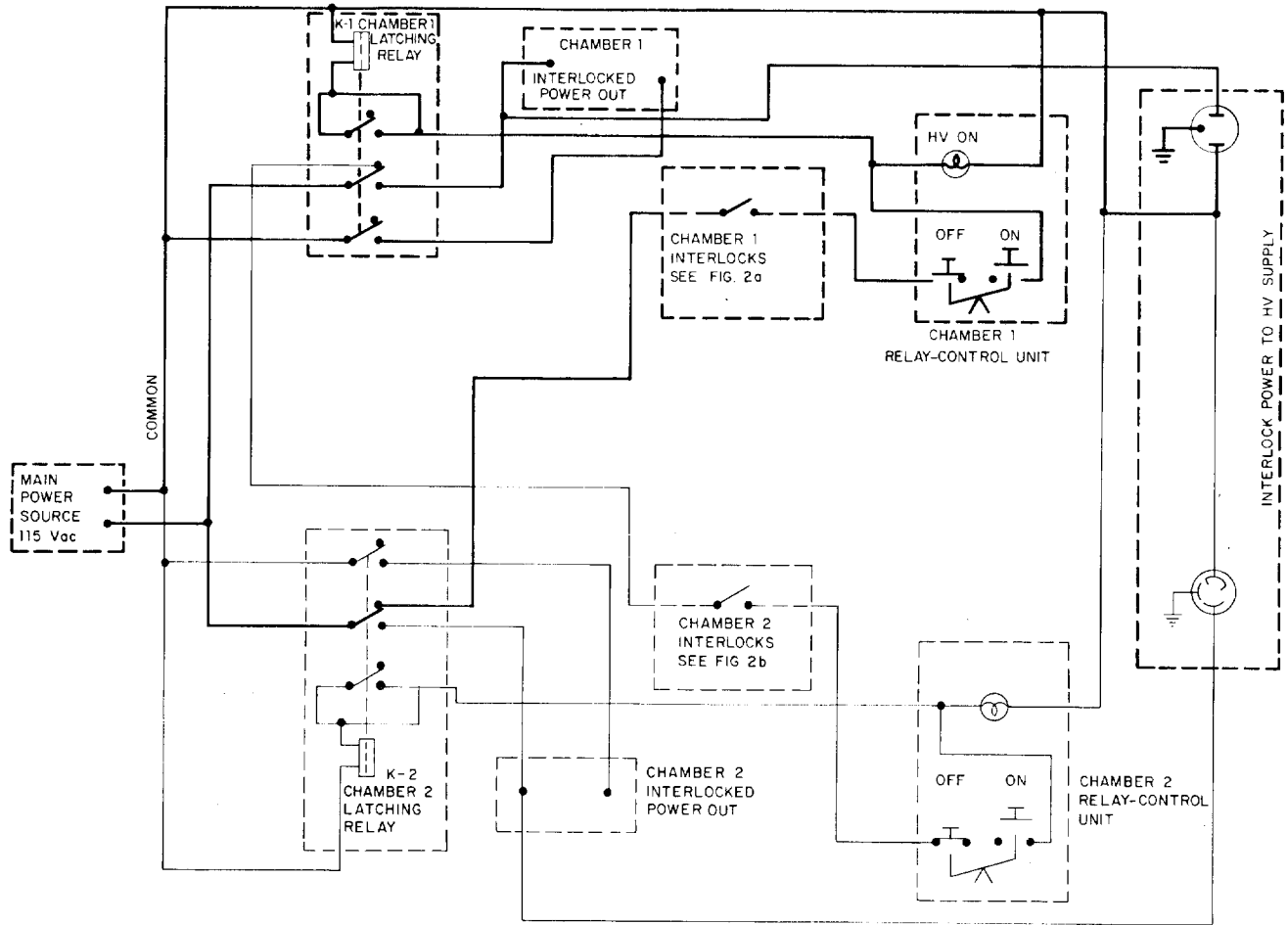


Fig. 3(a). Interlocked power system; dark lines denote Chamber 1 interlocks.

IV. POWER CONTROL AND CHAMBER SWITCHING

The rack power-control and chamber switching unit (Fig. 4) distributes AC power to the equipment racks (nine in the chamber control room and three in remote areas). A master switch allows the operator to select the firing area to which all equipment is connected.

Figure 5 is a diagram of this unit. Power to all equipment is controlled by the master power-control switch. In addition, there is an individual power switch for each rack so that those not in use can remain off. Each rack has both interlocked power (which is independent of the interlocked power used for high-voltage circuits) and noninterlocked power switched through a relay actuated by the rack power-control switches. A failure in these relays would not supply power to the wrong chamber.

The chamber-select switch, also located on this panel, permits shifting from Chamber 1 to Chamber 2. The unit contains a circuit that distributes power to sets of relays in equipment throughout the chamber. The relays, in turn, switch diagnostic signal cables and fire-control equipment to connections in either Chamber 1 or Chamber 2. With the chamber-select switch set to "Chamber 1," interlocked power to the racks comes through the Chamber 1 circuit; setting the switch to Chamber 2 sends power through that circuit.

V. INTERLOCK LOGIC

The interlock logic unit monitors safety and data interlocks for both chambers, which prevent hazards to personnel and loss of experimental data. Figure 6 shows the front panel of the logic unit. Lights indicate which

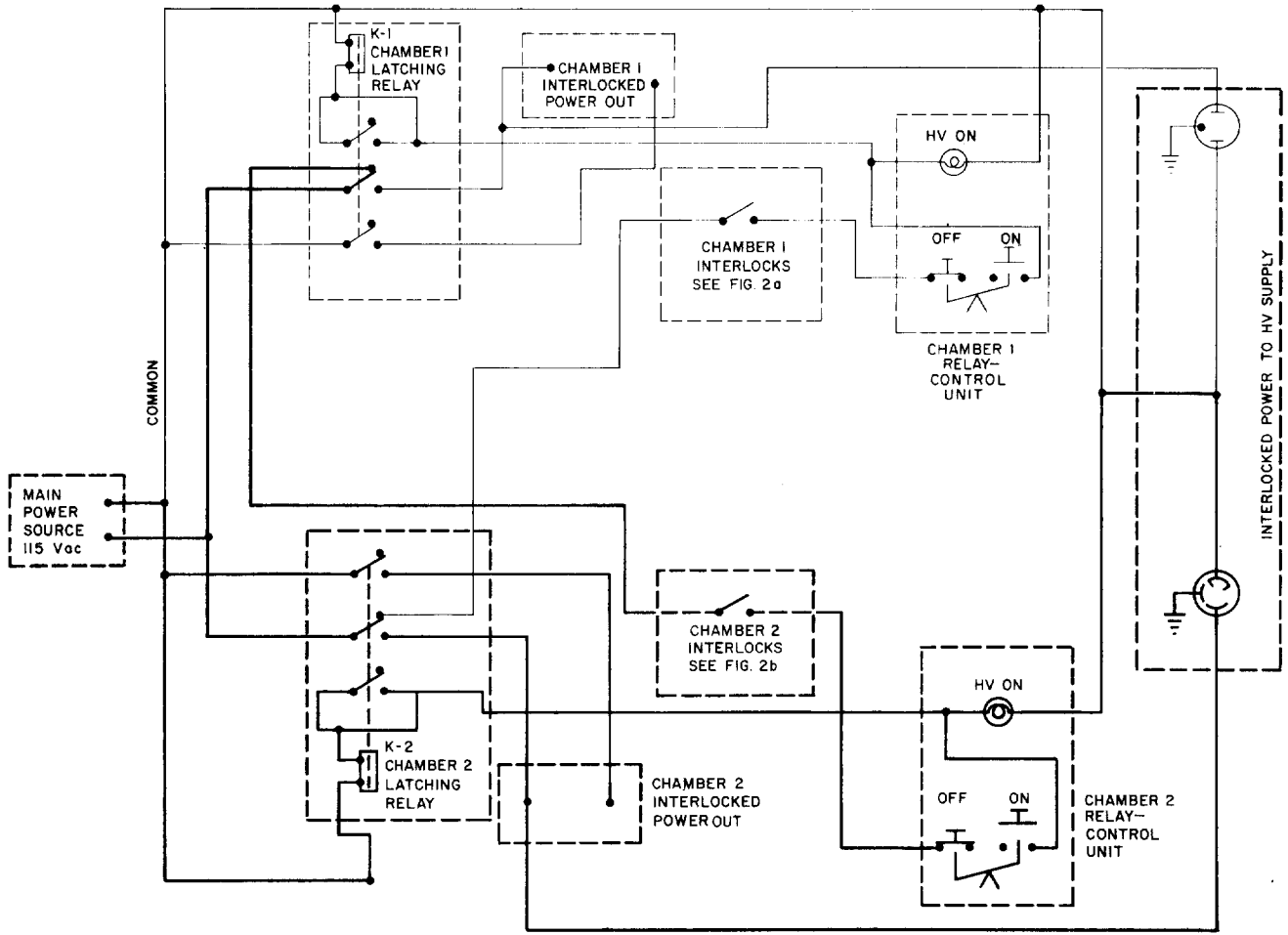


Fig. 3(b). Interlocked power system; dark lines denote Chamber 2 interlocks.

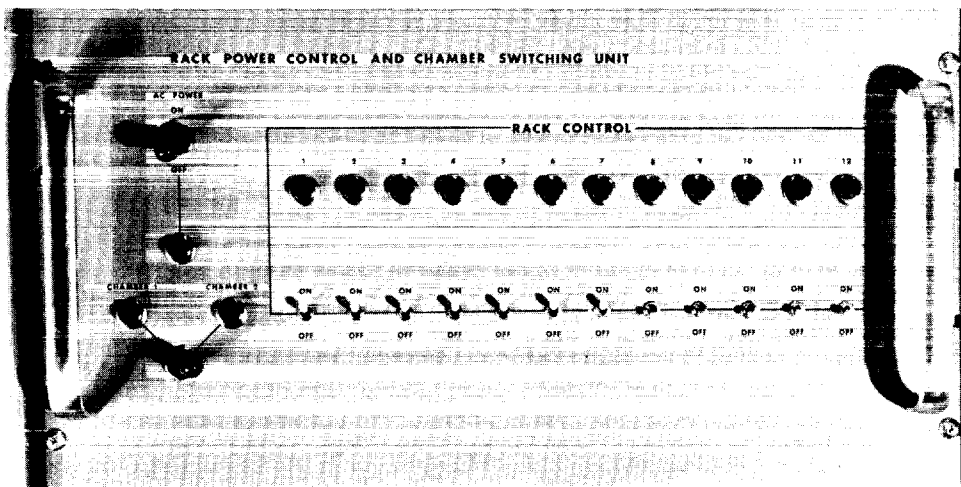


Fig. 4. Rack power-control and chamber switching unit.

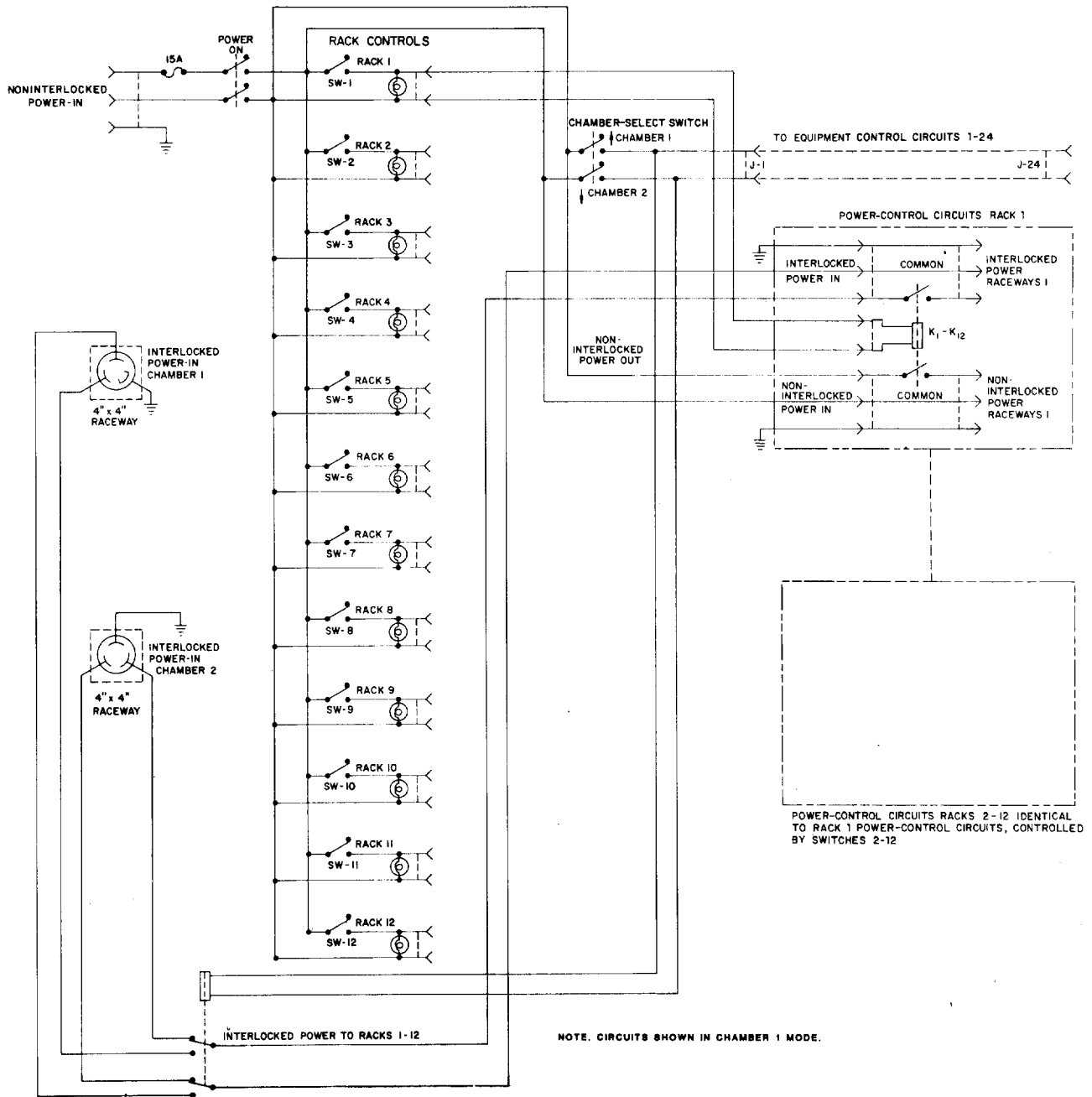


Fig. 5. Diagram of the power-control and chamber switching unit.

interlock or set of interlocks is not satisfied. Interlocks are divided into several categories, and the unit provides a switch closure to a circuit in the fire-control unit for each group. A closure from each group is required by the fire-control unit to power the fire button.

Figure 7 shows how the interlocks are connected to the fire-control panel, where summary indicators show when each of the interlock categories is satisfied.

Figure 8 is a schematic of safety interlock monitoring. Each safety interlock has a relay that is actuated through the interlock switches. When an interlock is open, power through the normally closed contacts on the switch energizes the relay, closing a set of contacts that indicates an open interlock on the logic panel. Each safety interlock has a number for identification on the logic panel.

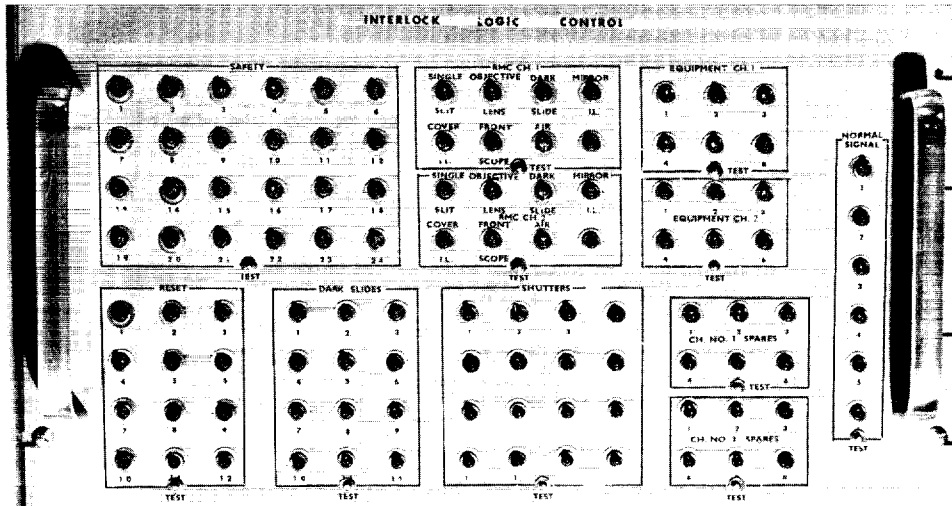


Fig. 6. Front panel of the logic unit.

Both chambers share the safety interlock logic. When a switch is made from one chamber to another, the safety-interlock-bypass relays for the chamber not in use are energized by the chamber-select switch. These interlocks look like closures to the logic panel even though the interlocks themselves may be open.

VI. HIGH-VOLTAGE AND HIGH-VOLTAGE MONITORING SYSTEMS

The high-voltage control unit grounds high-voltage firing sets through dump resistors, provides interlocked AC power to the high-voltage power supplies, and switches high-voltage monitors and capacitor-discharge-unit (CDU) trigger-signal inputs from one chamber to the other. Figure 9 shows the high-voltage control system in detail.

The normally closed position of the key switch to one chamber provides a closed circuit that supplies interlocked power to the other chamber. At least two key switches, connected in series, have to be turned on before high voltage is available to charge a firing set. Initial power from the high-voltage control switch turns on power to the high-voltage power supply and also to the high-voltage dump relay. Four high-voltage power supplies can be used at once in either chamber. Each requires a separate key switch. Figure 10 shows the front panel on the high-voltage control unit.

For safety purposes, the chambers do not share high-voltage power supplies. Each chamber has separate high-voltage supplies, turned on with separate sets of key

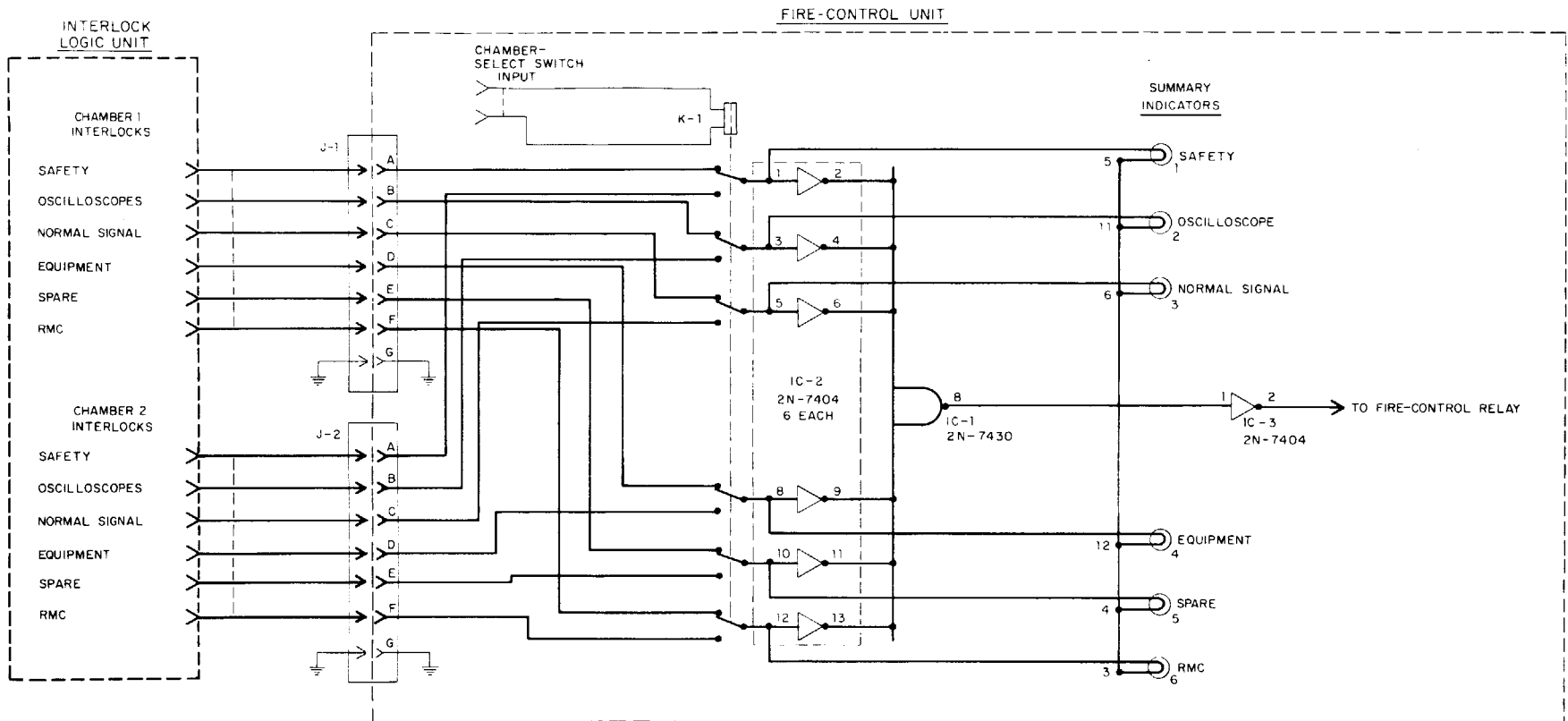
switches and operating on interlocked AC power, which is turned on through the safety interlock system. It is impossible for an operator to turn on the wrong power supply because the wrong set of keys will fit only high-voltage supplies that have no power. Also, the high-voltage control key switch on one circuit prevents power being applied to the other high-voltage control key switch. In addition, high-voltage supply power input connectors are different in each chamber to prevent wrong power supply connections.

CDU high-voltage monitors and CDU trigger signals are shared and switched by the chamber-select switch. The high voltage is monitored through a relay, and no foreseeable malfunction of this relay can lead to high voltage being transmitted from one chamber to the other through the monitoring system.

VII. FIRE CONTROL

Figure 11 shows the fire-control unit, which contains a high-voltage trigger circuit, controls for our standard rotating mirror cameras (RMC), and several interlock control and monitoring systems.

A timer starts when interlocked power is turned on for either chamber and provides a 1-min delay before voltage is supplied to the trigger circuit. Automatic delays in the firing sequence are a standard safety practice to prevent hasty mistakes and provide time for CDUs to charge to full voltage and warning systems to alert personnel in the area. Different warning systems are used for the two different chambers. For example, an



NOTE: RELAY K₁ SHOWN IN CHAMBER 1 MODE

Fig. 7. Diagram of connections between interlock and fire-control panel.

operator-controlled switch labeled "siren" is provided on the fire-control panel. When the switch is in the "on" position, an external siren turns on with interlocked power to Chamber 1 only. After 1 min, the "ready" light comes on and the voltmeter on the panel indicates the trigger voltage level.

Six lights in the upper left-hand corner of the panel provide a visual check of interlock systems. These indicators are tied to systems in Chamber 1 or Chamber 2, and each turns on when its respective interlocks are satisfied. Normally, when the operator begins to use the fire-control unit, four indicators (including a spare for future use) are lit. A foot switch on the floor below the fire-control unit controls shutters to fast cameras and oscilloscope cameras. These are ordinarily opened at the last possible instant in the firing sequence, and there is an interlock light on the fire-control panel for both systems. Depressing the foot switch activates RMC and oscilloscope camera shutters, which in turn give "satisfied" indications on the fire-control panel. When all six interlock indicators are glowing, power is supplied to the "fire" button.

Depressing the fire button closes a relay in the fire-control unit. This relay remains closed for ~ 0.5 s and allows the proper low-voltage fire pulse (normally from the RMC synchronizer) to pass to the CDU trigger circuit shown in Fig. 12. The fire pulse turns on the trigger circuit and a drop in voltage on the panel meter indicates that the trigger pulse was delivered. To correspond to routine needs, pickoffs from the trigger voltage provide 2000, 400, or 28 V. These are selected with the appropriate switch setting on the panel.

VIII. ELECTRICAL DIAGNOSTIC HOOKUP

Electrical signals are recorded with oscilloscopes. Separate sets of signal cables run from each of the two chambers to the control room. These cables are connected to the desired scopes through the system, as shown in Fig. 13.

In normal use, signals from Chamber 1 and Chamber 2 are patched from the control room "signal switching unit." The signal switching unit connects inputs from Chamber 1 or Chamber 2 to the scope signal unit mounted under each scope in the racks. From these units, the signals can be connected directly to the scopes. A single sequencer steps through baseline, voltage, and time mark calibrators for both chambers.

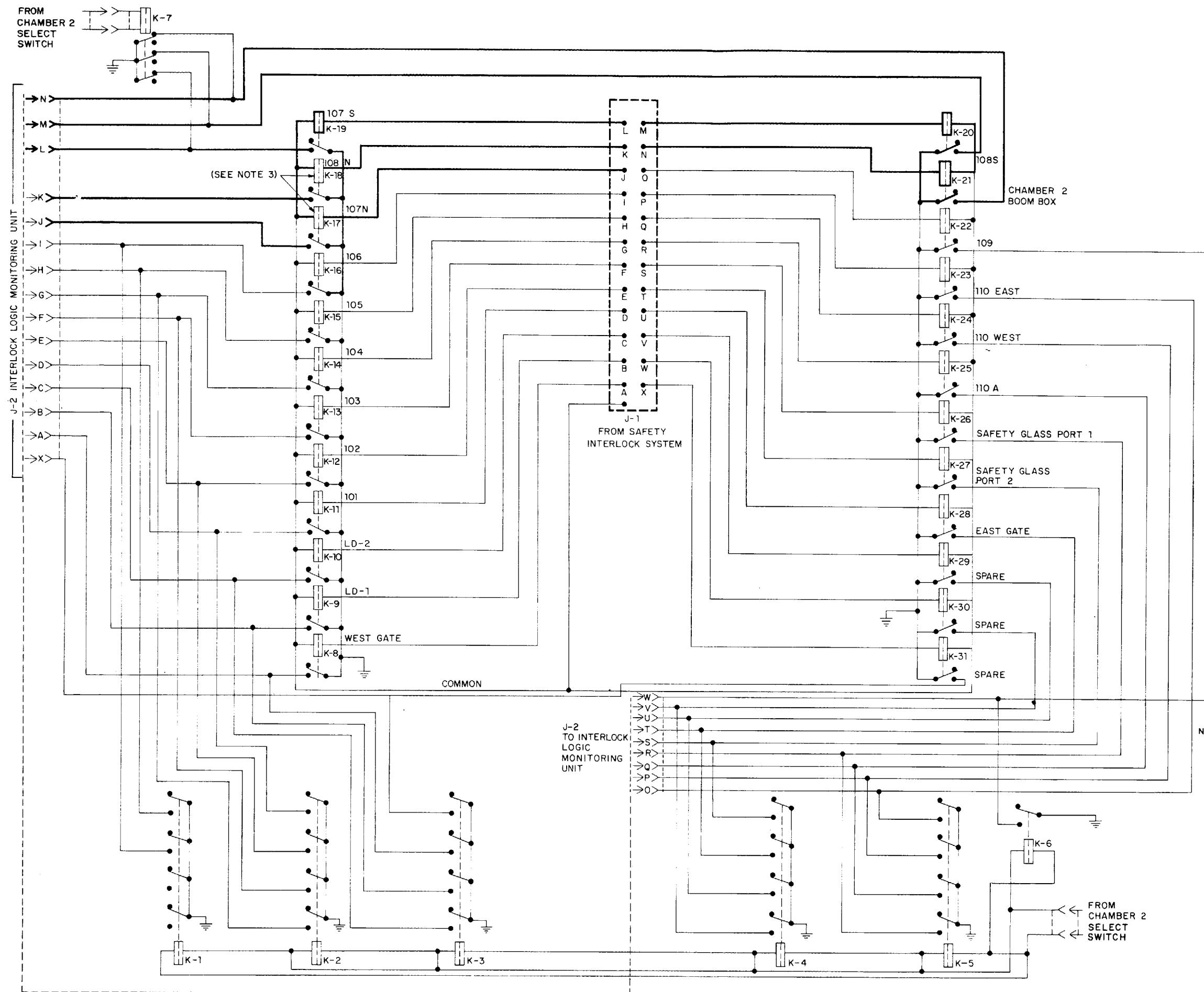
In addition to normal use, it may happen that two experimenters working in different chambers may want to perform signal cable checkout operations at the same time. The signal switching unit (Fig. 14) provides a manual override to the chamber selector switch for each pair of inputs (Chamber 1, Signal 1; Chamber 2, Signal 1) to the signal switching unit. Thus, an experimenter in Chamber 1 can use some signal inputs while an experimenter in Chamber 2 is using others. So that data are not lost because an override was inadvertently left on, the signal switching unit is interlocked to prevent firing an actual shot with any signal cables in the override position. Indicator lights provide a quick visual check on the position of these switches. When either Chamber 1 or Chamber 2 is being used with all cables in the normal mode, the white indicators are on. If a manual override is being used, a green lamp for Chamber 1 or blue lamp for Chamber 2 is lighted next to the signal input that is overridden. This color scheme is maintained throughout the control room where manual overrides are provided.

In some instances it may be desirable to bypass the coaxial relays in the signal switching unit, so auxiliary cables on the signal switching unit are hard-wired to the scope signal panels. These auxiliary signal lines may be used by either chamber and are not switched.

Rarely will all twelve data channels available to each chamber actually be used by either chamber. It is likely, therefore, that experimenters in one chamber will be using one group of scopes and experimenters in the other chamber will be using another group. To prevent one effort from interfering with the other, a scope control unit is provided. This unit can be used to assign priority for a particular scope to one chamber or another. Thus, oscilloscope interlocks necessary to fire a shot in one chamber need not be satisfied by a scope in use only by the other chamber. The same color-coded indicator light system described above is used on these priority switches, providing a quick check of the system.

IX. CONCLUSIONS

This system has been operating for two years now and has met or exceeded our expectations. The amount of time that the controls are actually needed for most of our tests is 2-10 min, and since our experiments generally take 0.5 h to several hours to set up, it is rare that an operator has to wait for his turn at the controls.



- NOTES:
1. DARKENED LINES DENOTE INTERLOCK CIRCUITS THAT MUST BE SATISFIED TO OPERATE CHAMBER 2. IN CHAMBER 2 MODE RELAYS K-1 THROUGH K-6 BYPASS INTERLOCKS REQUIRED ONLY FOR OPERATION OF CHAMBER 1.
 2. IN CHAMBER 1 MODE K-7 BYPASSES INTERLOCKS REQUIRED ONLY FOR CHAMBER 2 OPERATION.
 3. TWO INTERLOCK CIRCUITS MARKED NOTE 3 ARE REQUIRED FOR BOTH CHAMBER 1 AND CHAMBER 2 OPERATIONS.
 4. K1-K7 SHOWN IN CHAMBER 1 MODE.

Fig. 8. Safety interlock monitoring system.



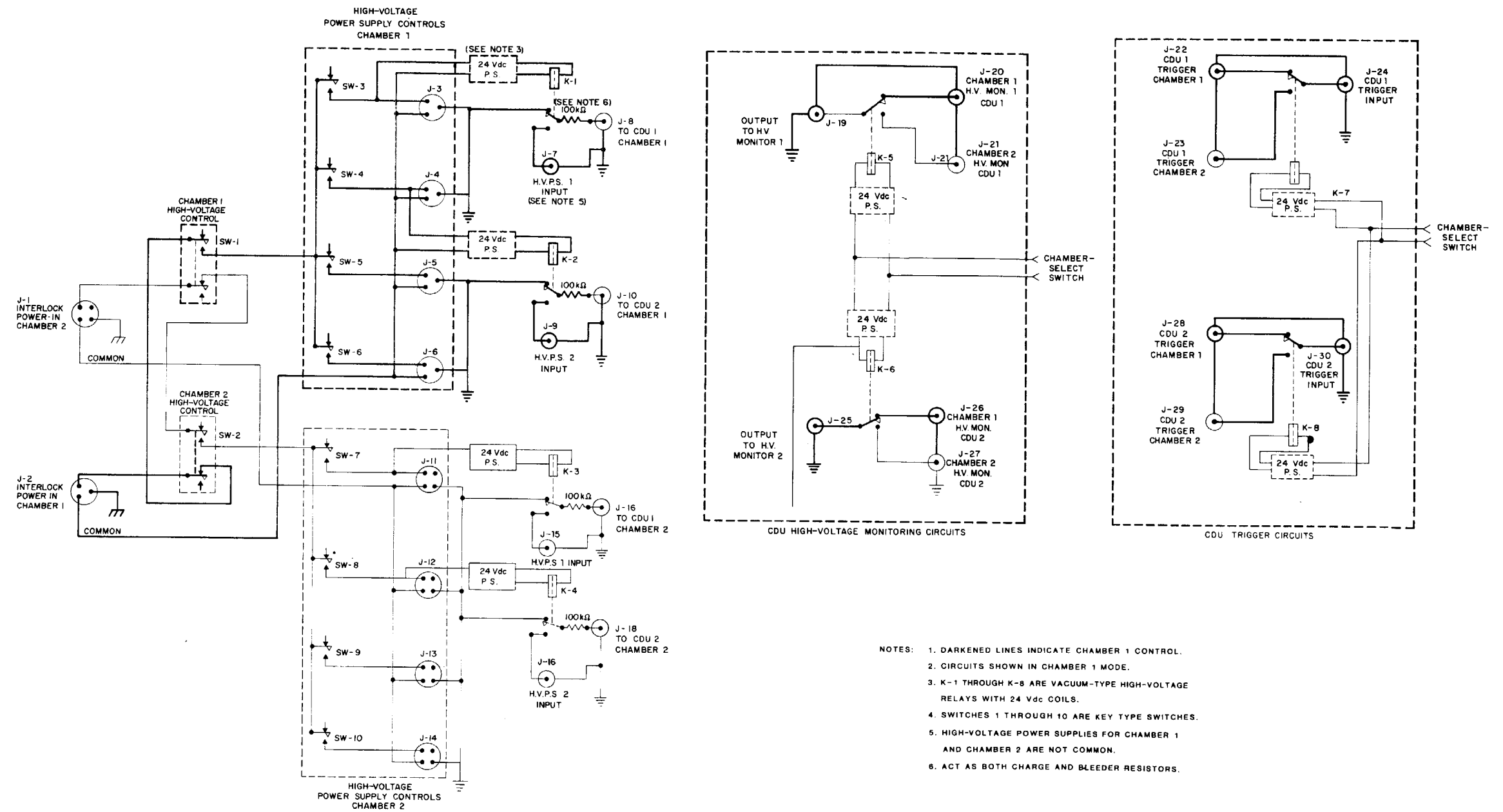


Fig. 9. High-voltage monitor and CDU trigger control system.

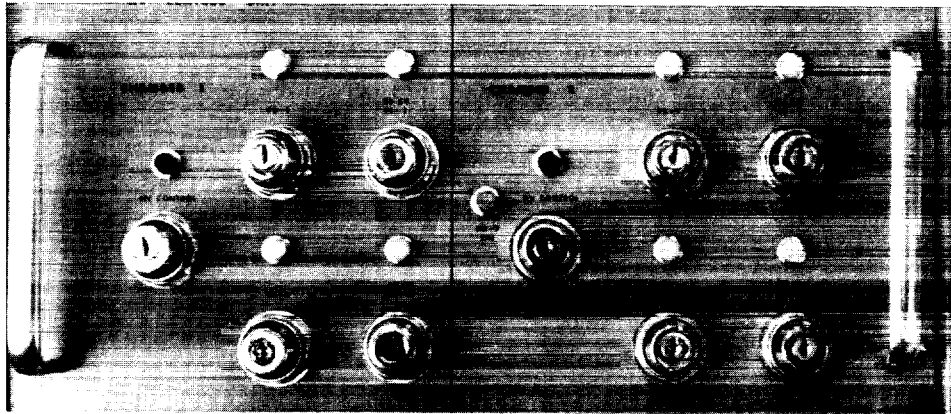


Fig. 10. Front panel of the high-voltage control unit.

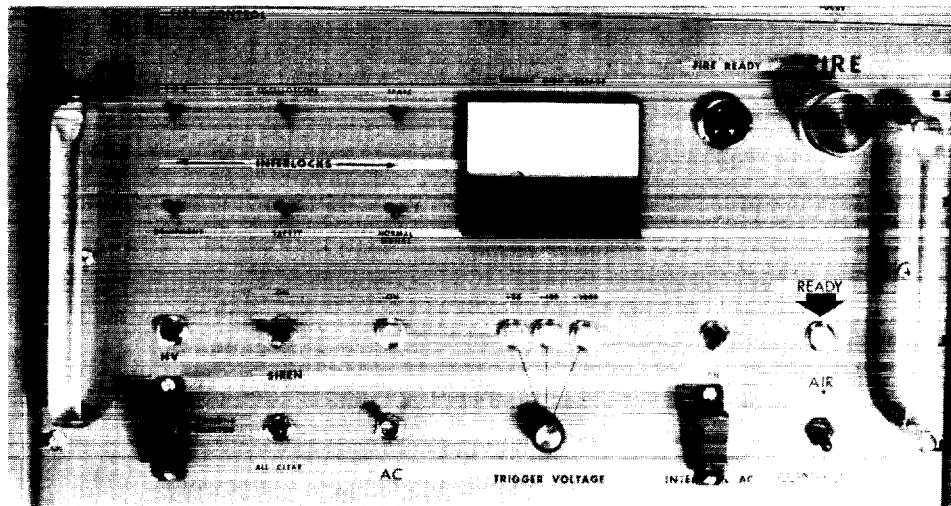


Fig. 11. The fire-control unit.

Some amount of extra learning time is no doubt required to master the extra complexity of this facility. However, we feel that this is a small price to pay for the added number of experiments that we can do with the equipment we have.

ACKNOWLEDGMENTS

The authors wish to thank W. H. Meyers for his constant support and W. F. Hemsing for many helpful discussions and suggestions and for allowing us to use the drawing of the CDU trigger circuit (Fig. 12). We also wish to thank the people in the section of J. D. Griffin, Sr., who helped us assemble components into working modules.

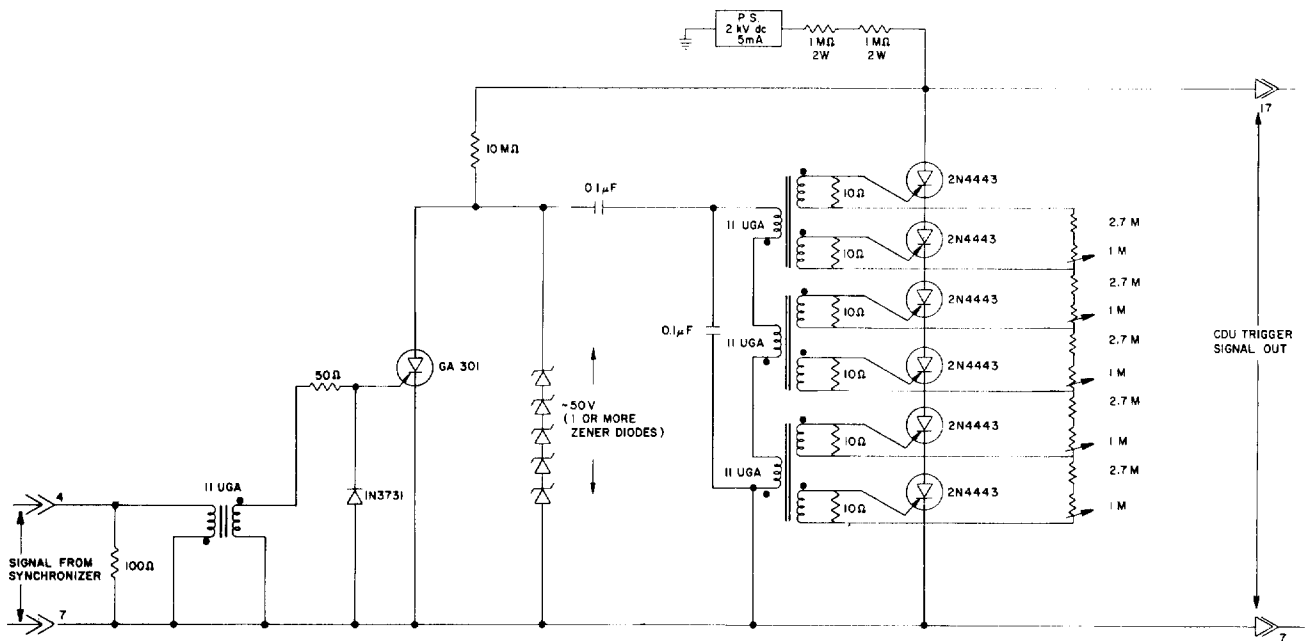


Fig. 12. CDU trigger circuit.

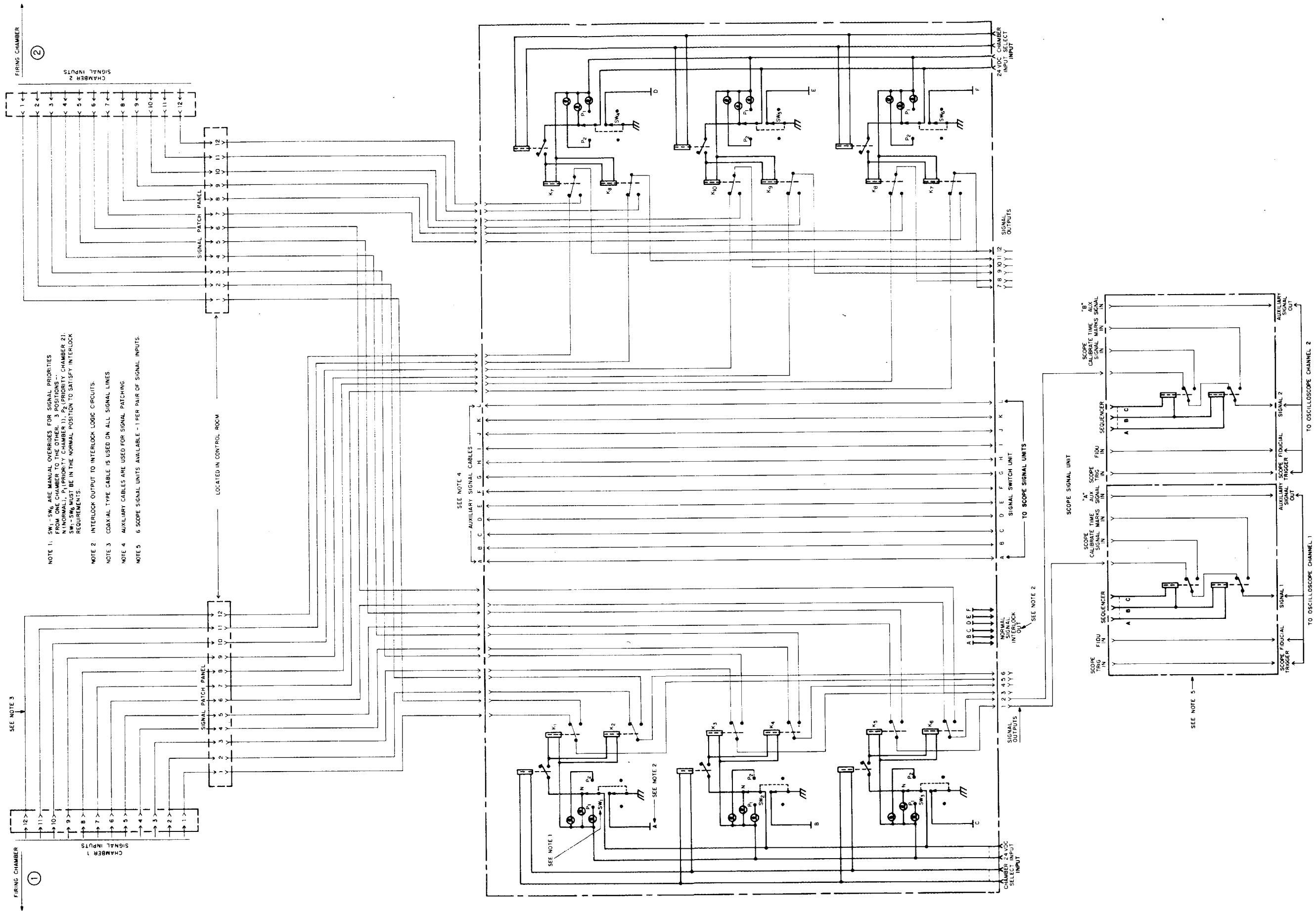


Fig. 13. Signal block diagram showing cable connections to oscilloscopes.



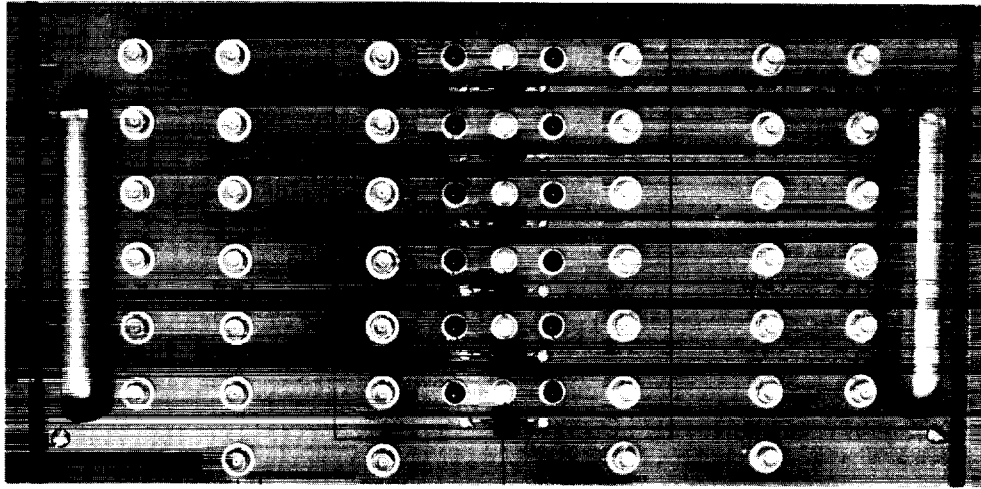


Fig. 14. Signal switching unit.

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