MOTHERLOAD II

AN ELECTRONIC DIMMER CONTROL

by

Arthur Elliott Alvis, Jr.

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Approved by

David R. Batchelder

Thesis Adviser

APPROVAL PAGE

This thesis has been approved by the following committee of the Faculty of the Graduate School at the University of North Carolina at Greensboro.

Thesis Adviser David R. Batchelder

Committee Members

April 16, 1976
Date of Acceptance by Committee

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DEDICATION

This Thesis is dedicated to my father, Arthur Elliott Alvis, my sole instructor in the field of Electronics.

PREFACE

As a graduate assistant in technical theatre, I have had a unique opportunity to evaluate equipment in Taylor Building pertaining to technical production. My major interest in Theatre Arts is the field of Lighting Design, and after designing lighting for the Fall, 1974 production of Anything Goes in the Drama Department, I became very much aware of the inadequacies in the dimming equipment. Since that time, I have made repair and improvement of the dimming equipment an important part of my assistantship duties. I personally feel that this project is the final step in the improvement of that equipment.

The most important function of stage lighting is to illuminate the actor, but lighting design has developed to be an important branch of theatre arts on the premise that it can be a highly expressive medium. Artistic lighting in Taylor Building is particularly difficult because the stage is unusually large and this is compounded by the low wattage output of the present dimming equipment. Since basic illumination is of primary importance, artistic expression must suffer. This project will not solve the

the problem but it will allow a designer more freedom by reducing the number of dimmers now absorbed in the task of basic illumination. The designer can then utilize these freed controls toward a closer fulfillment of his invisioned design.

This project is an important contribution to the theatre facility. With the addition of this project to the existing dimming equipment, there is an effective 25 per cent increase in total usable wattage. This project is designed to maintain its value in the event of the replacement of the present dimming equipment since it is essentially a modification of the house light system, which is a permanent part of the theatre facility.

The nature of this thesis is technical, and necessarily the specifications for the controls will seem incomprehensible to readers unfamiliar with electronic terminology. But, the non-technical aspects of this thesis are designed to provide the reader with information necessary to efficiently operate the control while giving him a basic understanding of the actual processes taking place in the unit.

This is the first project MFA thesis done in the UNC-G Drama and Speech Department, and I wish to thank Dr. David Batcheller for allowing me to pursue it. I would also like to thank Robert

Thurston for his assistance in all aspects of this thesis.

CHAPTER I

PURPOSE OF THESIS

The existing dimming systems in Taylor Building are inefficient. The purpose of this thesis is to identify the inefficiencies, propose a solution and realize that solution in the form of a project.

Inefficiencies

The house dimming bank, located in the dimmer room of Taylor Building, consists of four 50 ampere (or 5,500 watt[1]) electronic dimming units. Of these four dimming units, only three are used in house light control. The remaining unit was installed without being connected to a load.[2] The three units that are used function only to dim the house lights; whereas, comparable house dimming systems studied serve a dual dimming function, that of the house and stage lights.

The operation of the house light control panel is awkward in its present position. In the control booth, the operator sits facing the stage with the stage dimming controls in front of him. The existing house dimming control panel is located at his left shoulder and slightly back of him. Fortunately, few shows require a simultaneous operation of house and stage lights, so this awkward location is more of an inconvenience than a problem. The location of the

panel causes a major problem; that is, control status[3] is not readily apparent to the operator; therefore, the process of rendering the system to a functionable mode is often forgotten. This oversight may supply some anxious moments for the operator upon discovery; but, if an audience is present, a late change of control status produces the undesirable noise of the dim/direct relay and the system power relay banging into place.

Inadequacy of Stage Dimming Equipment

Executing a lighting design in Taylor Building is limited by the existing dimming equipment. The stage dimming equipment consists of four units, three are electronic dimmers manufactured by Electronics Diversified, Inc., the other is an autotransformer type, manufactured by The Ariel Davis Company. The total number of dimmers is thirty-six, which is sufficient for most needs, but, the problem which concerns the lighting designer is the low wattage per dimming unit. Even the indicated wattage rating is misleading; the thirty 2.4Kw dimming units are actually 2.2Kw and the 4.8Kw units are 4.4Kw.[4] In fact, this lower rating is still not a true evaluation of capacity, because approximately 25 per cent of the dimming units can not withstand a full load without tripping a circuit breaker.

Under the pressure of a constant production schedule, repair and maintenance has been minimal. In almost all lighting designs for this theatre a large portion of the dimmers are assigned for basic illumination; few dimmers are available to meet the demanding requirements of controlled artistic lighting.

Summary

The existing dimming system in Taylor Building is barely sufficient to execute even a slightly demanding lighting design. This, compounded by the inefficiencies of the system, results in a facility which is very limiting to artistic expression through light.

Notes:

[1]Wattage in this thesis will be notated in terms of "Kw", meaning to multiply the number that precedes the "Kw" by one-thousand.

[2]Before work on this thesis began, Motherload I was installed to take advantage of the unused house light dimmer unit and convert its output for stage light dimming purposes.

[3]Control status, i.e. - Dim or Direct, Power On or Off, etc.

[4]If W=VA and the line feed is 110 VAC and the "2.4Kw" dimmers are load fused at 20 amperes, then W=20 X 110, or W=2,200.

CHAPTER II

PROPOSED CONTROL UNIT

Present Control

The Century Model 206 dimmer[1] requires a control triggering voltage of 0 to 30 volts, Direct Current (DC). The units utilize two General Electric 178B silicon controlled rectifiers (SCR), in a back to back configuration and load fused at 50 amperes. The output voltage (0 to 110 VAC) is approximately at a 1:1 ratio to the controlled input voltage. Control polarity may be either positive or negative.

The existing control system consists of a model 10B autotransformer varying the line input voltage on a Triad F202U transformer. The transformer has a secondary output voltage of 30 volts alternating current (AC) with a line input voltage of 110 VAC. A 1N1692 rectifier (RCA) is added, in series, with the number 8 pin on the secondary side of the transformer, the number 11 pin on the secondary side then becomes negative to the rectifier on pin #8. The result is a half-wave rectifier, capable of an output of 0 to 30 volts pulsating DC.

The control input terminals on the dimming units are connected in parallel and the present house control unit is connected to the

first unit in the bank. Therefore, all four units are controlled simultaneously.

Proposed Controls

The use of autotransformers in the proposed control unit is impractical because mastering four autotransformers to a single autotransformer produces voltage fluxuations which may result in a pulsating output of the dimmers. Furthermore, a linear control adaptor for the autotransformers is not available.

The required 30 volts will be produced by a Triad F202U transformer. The secondary of the transformer will feed four 4K Ohm potentiometers. The tap on the potentiometers will have a 1N1692 rectifier in series with it. This will be the positive to the #11 terminal on the transformer. To make the simultaneous control of the four potentiometers possible (mastering), a fifth 4K Ohm potentiometer will trigger a Delco 2N1159 power transistor which in turn supplies a controllable voltage to the four potentiometers, thus, varying their output voltage (See Figure 1). The four potentiometers are connected to the master control potentiometer by manually changing their voltage supply from the transformer to the power transistor which is controlled by the master potentiometer (See SW-2 - SW-5, Figure 1). Blackout is accomplished by manually

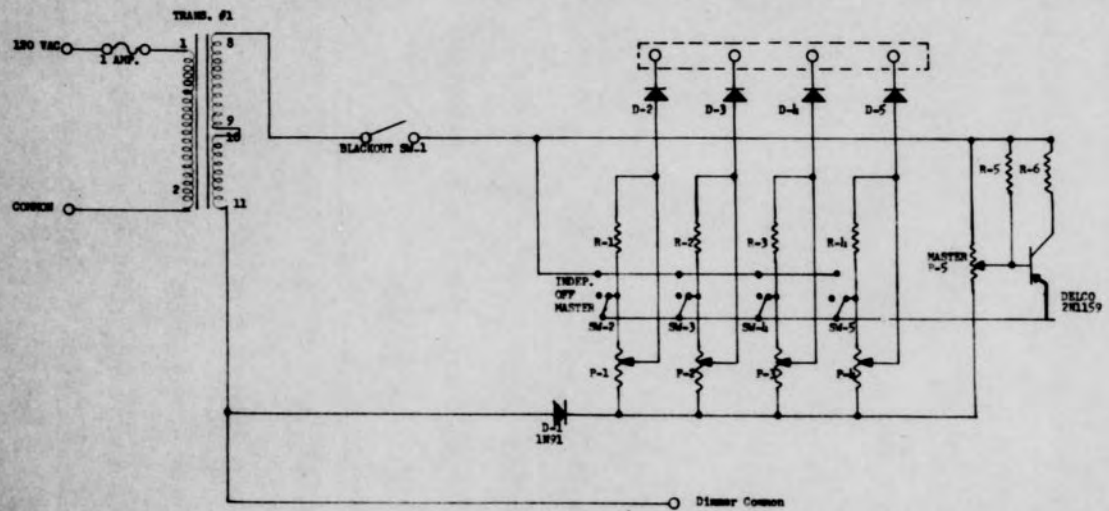

Figure 1

TRANS.# 1	TRIAD F-20FU
D-2--D-5	EM1690
P-1--P-5	1K OHM, 2W POT
SW-1	SPST 5 AMPS.
SW-2--SW-5	SPST 5 AMPS.
R-1--R-4	3.9K OHM, 1W ± 10%
R-5	1.5K OHM, 1W ± 10%
R-6	47 OHM, 1W ± 10%

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MOTHERLOAD II CONTROL SCHEMATIC	
DESIGNED BY:	
SCALE: N/A	DRAWN BY:
DATE:	APPROVED BY:

disconnecting the transformer feed from the potentiometers and the power transistor via a single pole, single throw switch.

These controls function as four half-wave rectifiers, each with an output of 0 to 30 volts pulsating DC.

Control Transfer System

The control transfer system is the system which will switch the dimming units from parallel operation (house light mode) to individual control for stage light dimming. This is accomplished by three double-pole, double-throw (DPDT) relays located inside of the control panel (See **Figure 2**).

The present parallel connection between the inputs on the dimming units is to be disconnected on the negative side allowing the positive side to remain common for all four units. The three negative control inputs on the units are connected to relays 2 and 3. The fourth dimming unit input is directly connected to the output of the fourth control potentiometer. This means that #4 dimmer is capable of stage light usage even if the other controls are in the house light mode.

The relays in an unactivated mode (pins 4 and 5 normally on to pins 1 and 8) combine the three positive inputs on the dimmer units for simultaneous operation. Pin 8 on relay #2 and pins 1 and 8 on

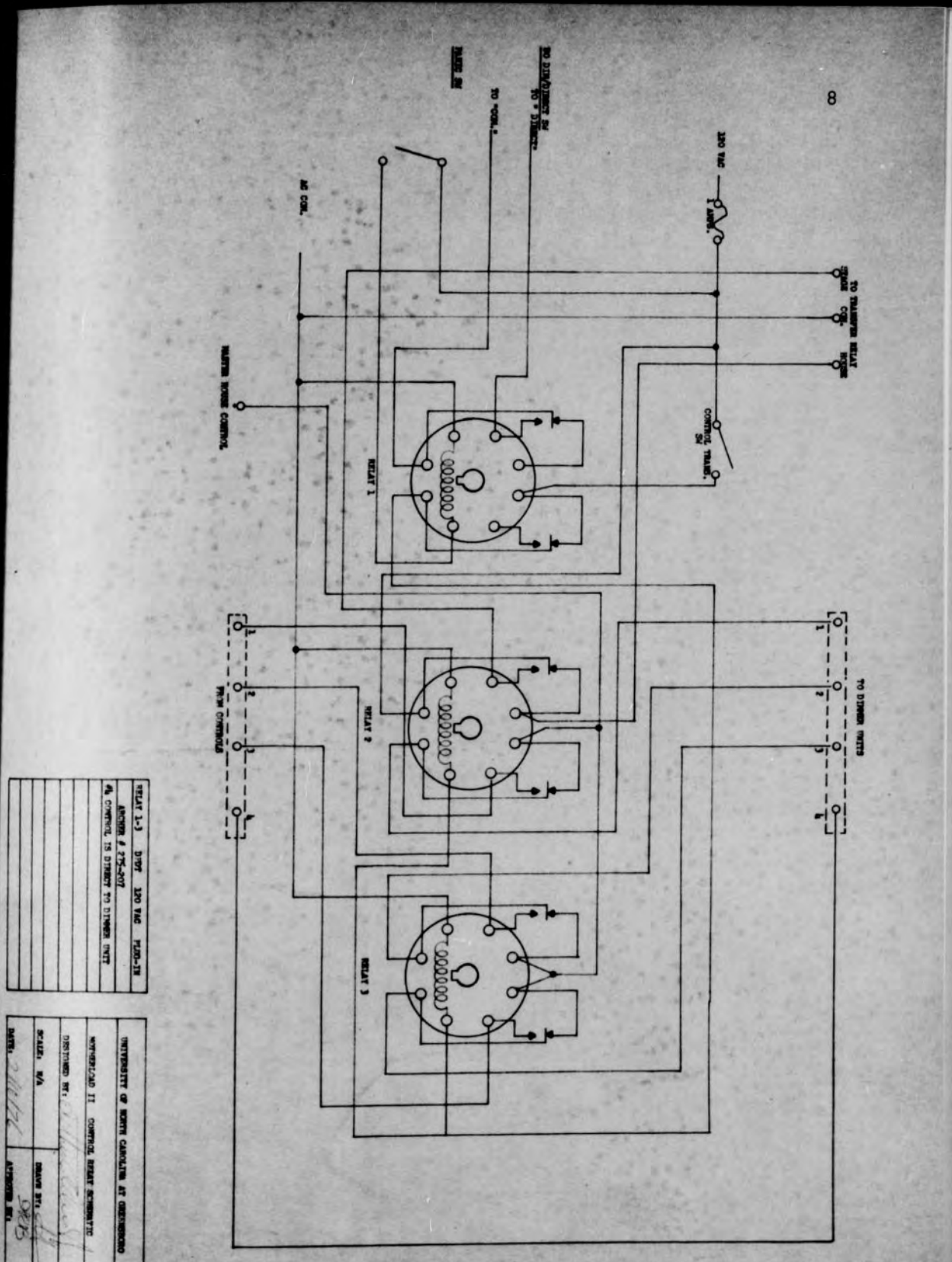
RELAY 1-3 DISP. 120 VAC PLUG-IN
ARCHER # 275-207
CONTROL IS DIRECT TO DINNER UNIT
UNIVERSITY OF NORTH CAROLINA AT GREENSBORO
WINTERLOAD II CONTROL RELAY SCHEMATIC
DRAWN BY:
SCALE: N/A
DATE:
ARCHER NO.
TO "COM."
AC COIL
TO DINNER UNITS
RELAY 1
RELAY 2
RELAY 3
CONTROL TRANS.
PUSH CONTROLS

Figure 2

relay #3 are the dimmer inputs. In the unactivated position control voltage is supplied by the autotransformer system of the present house light control system, which is connected to pin 5 on relay #2 and pins 4 and 5 on relay #3. Pin 4 on relay #2 is connected to pin 1 and this serves as a pilot relay to the load transfer relays which directs the load output of dimmers to the house lights. Thus, in an unactivated position the dimming units are in the house light mode.

When the mode switch is activated ("stage" position), relays #2 and #3 magnetically disconnect pins 4 and 5 from 1 and 8 and connect pins 1 and 8 to 3 and 6. This redirects the dimmer input to the output of potentiometers 1, 2, and 3. As this occurs, the parallel connection between the dimmers is broken down into individual control inputs. The dimming units then respond to potentiometers 1 through 4. When the connection between pins 1 and 4 on relay #2 is changed to pins 1 and 3, the load transfer relay is triggered to disconnect the load output of the dimming units from the house lights and connect the output to the patch-panel for stage light usage. This process should take place in less than a second.

Panic System

Relay #1 is used as a defeating relay to relays #2 and #3, and is activated by a single pole single throw push button switch marked "Panic." When the panic switch is activated, pins 8 and 5 are disconnected on relay #1, breaking the circuit between the control mode switch and relays #2 and #3, thus, returning the system to the house light mode. Also, pins 1 and 3 are connected on relay #1 which activates the Dim/Direct relay to the direct mode. This, in one step, brings the house lights to full intensity in the event of an emergency.

Load Transfer System

So that the output of the three dimming units used for house light dimming may serve the dual purpose of house and stage lights, a load transferring system is designed to direct the output either to the house lights or the patch-panel. When the "House/Stage" switch is placed in the "Stage" position, the load transfer relay directs the dimmers output to the patch-panel. In the "House" position the output is directed to the house lights.

The load transfer system consists of two 60 ampere per contact lighting contactors (See Figure 3). These relays are mechanically linked together to make the simultaneous activation of both impossible, which avoids the possibility of the system overloading the dimmers beyond their

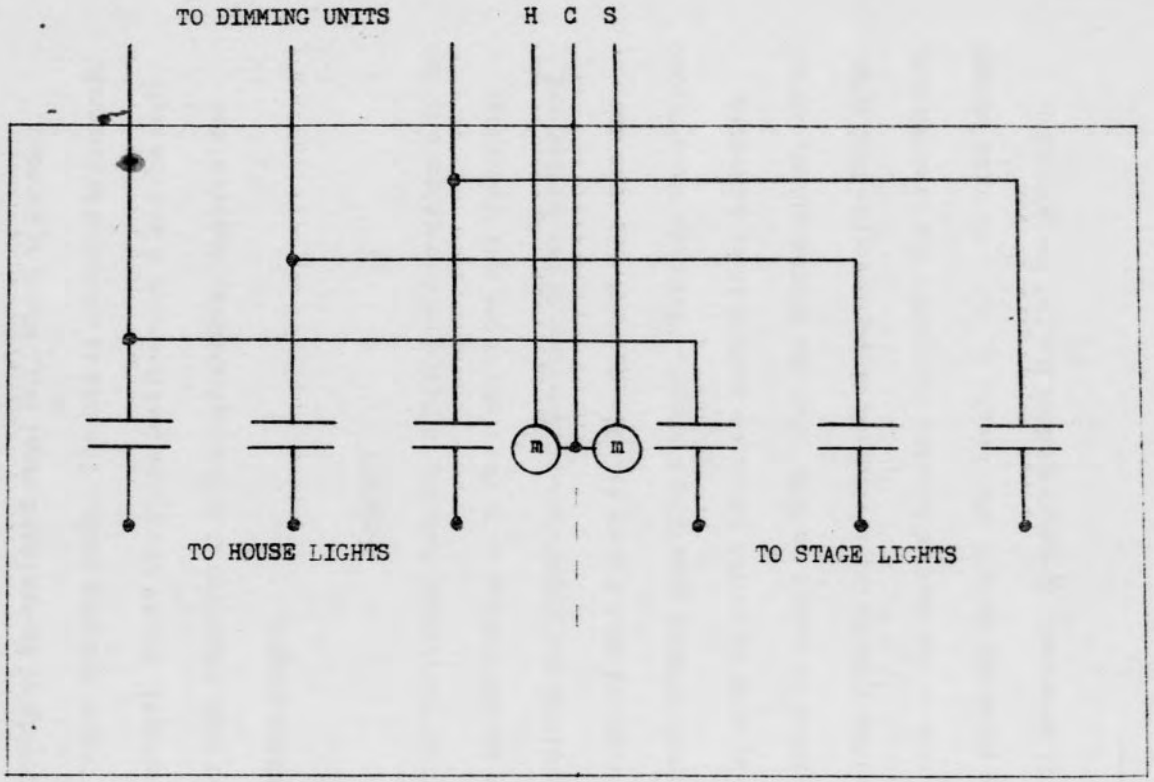

Figure 3

Two lighting contactors
NEMA size 2
Mechanically interlocked
m- electromagnetic field

MOTHERLOAD II
LOAD TRANSFER RELAY
DESIGNED BY: Arthur E Klein Jr.

rated output. The two relays that make up the load transfer system are mounted inside of an enclosed steel box, which is located inside of the house dimming bank. The box is anchored to concrete with a fire resistant, sound absorbing pad between it and the wall. Because of the high amperage it is accommodating, unauthorized tampering is discouraged.

Housing

The design of the control housing is based on convenience to the operator. The master control is to the right of the four individual controls to facilitate the simultaneous operation of the Motherload and Scrimmer controls (See Figure 4). The operator may then use the master control without upsetting a preset. Switches are arranged in a left to right order as to the sequence each is to be activated, i.e., control power is turned on first, then the system power, switch from Direct to Dim; turning the system off simply reverses this order.

The panel size of the control housing is roughly the same as that of the existing Scrimmer system (See Figure 5), but it is three inches deeper. This is necessary to accommodate the two transformers.

Notes:

[1]Schematic of C. C. R. Dimmer Model 206 is in the Appendix.

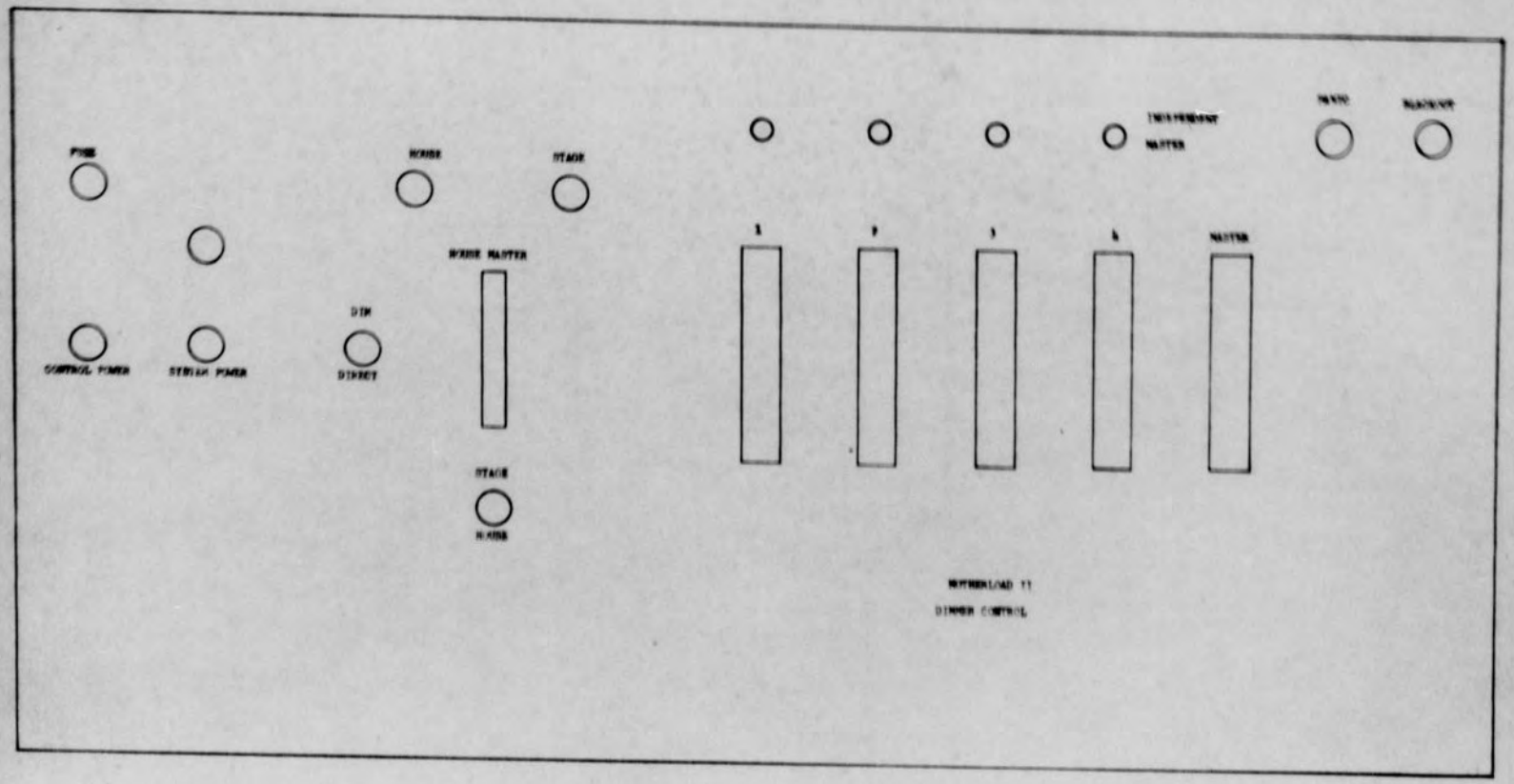

Figure 4

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MOTHERLOAD II CONTROL PANEL	
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SCALE: 1" = 1"	DRAWN BY:
DATE:	APPROVED BY:

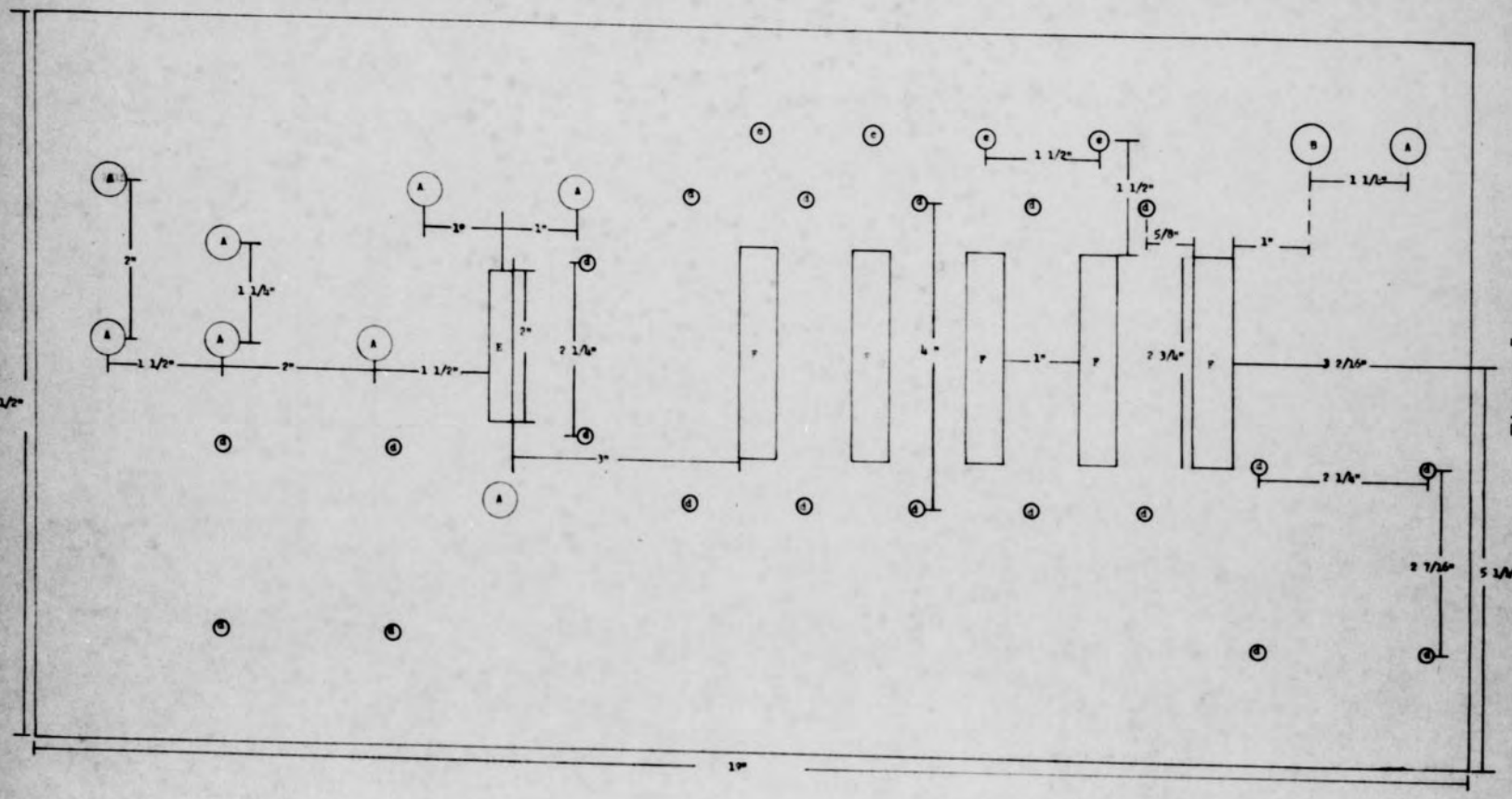


Figure 5

A		7/16"
B		1/2"
C		1/4"
D		3/16"
E	SLOT	2" X 5/16"
F	SLOT	2 3/4" X 1/2"

UNIVERSITY OF NORTH CAROLINA AT GREENSBORO	
MOTHERLOAD II CONTROL PANEL	
DESIGNED BY:	
SCALE: 1=1	DRAWN BY:
DATE:	APPROVED BY:

CHAPTER III

REVISION

Control Schematic Corrections

The polarity of diodes two through five (D-2 through D-5, Figure 1) is the reverse of the indicated polarity in the control schematic. This is done to change the output from positive to negative control voltage. Also, it was noted during testing that resistor five (R-5, Figure 1) heated up abnormally. To correct this, two ten watt, fifty Ohm resistors are installed; one to replace resistor five and the second is installed between potentiometer number five and terminal eight of the transformer. The output voltage is uneffected and the resistors operate at a normal temperature.

A pilot light has been added to indicate that the panic system is on. This was done because a lighted, push button switch is not available.

OPERATION

For House Light Control[1]

1. Put Stage/House switch in the "House" position.

2. Turn Control Power on.

3. Turn System Power on.

4. Put the Dim/Direct switch in the "Dim" position.

5. Use House Master control.

To Turn System Off

1. Put Dim/Direct switch in the "Direct" position.

2. Cut System Power off.

3. Cut Control Power off.

For Stage Light Control[2]

1. Put Stage/House switch in "Stage" position.

2. Turn Control Power on.

3. Turn System Power on.

4. Put Dim/Direct switch in "Dim" position.

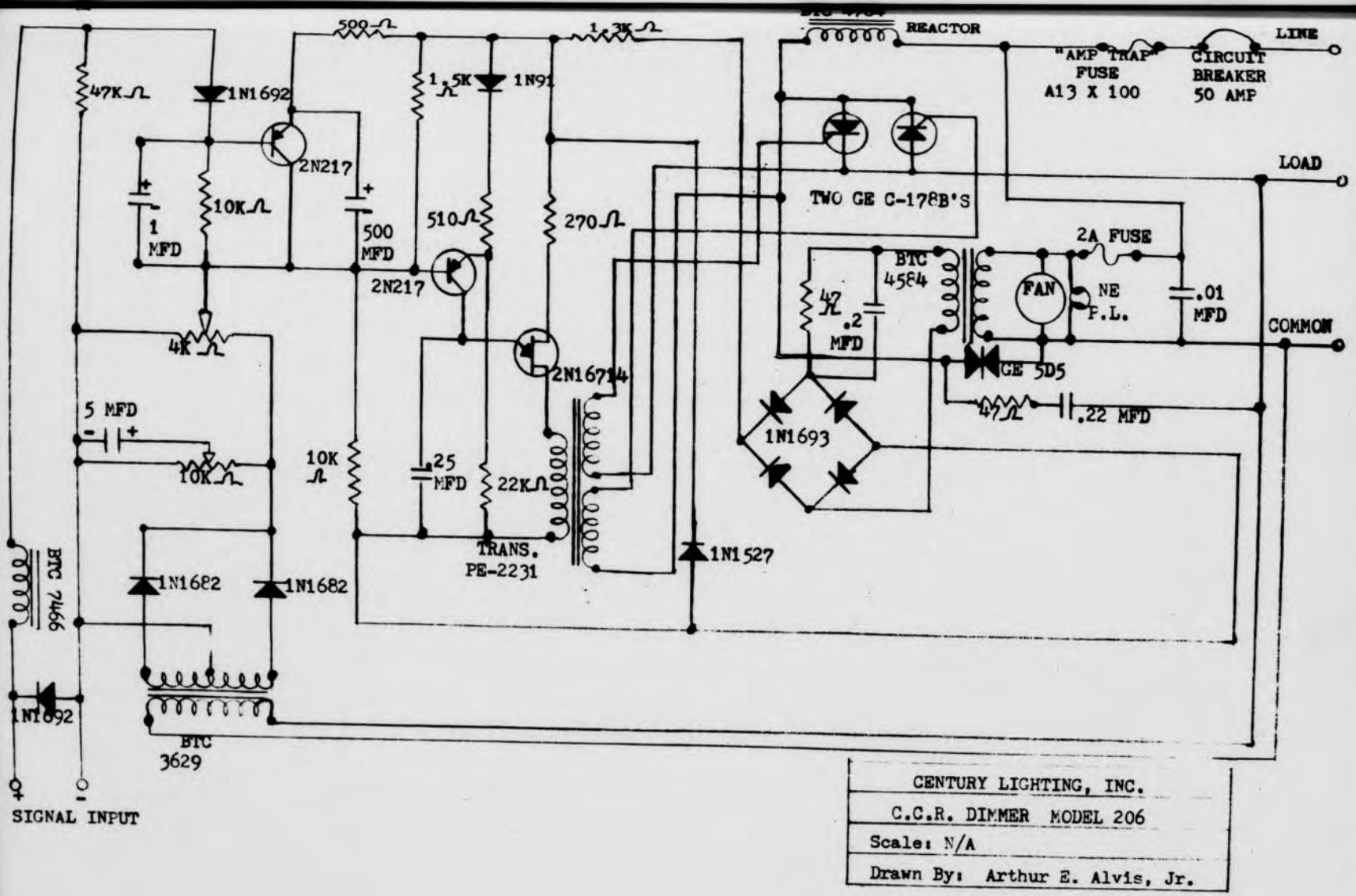
5. Use controls numbered one through four.

Notes:

[1]Have the House Master down when transferring from Direct to Dim. The sudden connection of a heavy load to the dimming units will shorten their lives and will cause deterioration of the contacts on the relay.

[2]The number four control may be used for stage lighting purposes even if the system is in the house dimming mode.

APPENDIX



CENTURY LIGHTING, INC.
C.C.R. DIMMER MODEL 206
Scale: N/A
Drawn By: Arthur E. Alvis, Jr.