INSTRUCTION MANUAL

13-CHANNEL, ROOM-TEMPERATURE SHIM SUPPLIES

MODELS 2313, AND 2314

OXFORD

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Note to Readers

The Shim Supplies Model 2313 and 2314 are designed to provide power for resistive shim-coil sets of up to 13 shims, fitted to either resistive or superconducting magnets. The shim sub-system provides fine adjustment of the magnetic field within the imaging system, so that the homogeneity of the field can be optimised over the working volume.

The two models provide the following outputs.

	Outputs
Model 2313	2 channels up to ±20A
	3 channels up to ±12A
	8 channels up to ±10A
Model 2314	5 channels up to ±20A
	8 channels up to ±10A

HIGH-VOLTAGE WARNING

Voltage in excess of 30 volts RMS can be lethal. Great care should be exercised when working on units requiring exposure to terminals carrying voltage of a higher value: a second person should always be in attendance.

1 GENERAL INFORMATION

1.1 PURPOSE OF EQUIPMENT

Models 2313 and 2314 are used to power the resistive shim-coil sets, which are fitted to either resistive or superconducting magnets to provide fine adjustment of the magnetic field within the imaging system.

Both power supplies have 13 independently adjustable channels (one per shim coil), each one a bipolar constant-current source. The channels are water-cooled and fed from a common DC supply.

Each output-current can be adjusted in either of two ways:

1 By front panel control.

2 Remotely, by means of a differential analogue input that produces an output-current proportional to the input voltage. This allows rapid shimming of the magnet under computer control.

A 4½-digit LED display may be switched to monitor any channel's output-current and voltage.

1.2 PHYSICAL FEATURES (see diagram 1)

The power supply is water-cooled and housed in a 19-inch rack cabinet on casters. Flexible hoses provide limited freedom in the positioning of the unit.

The Control and Security PCBs are accommodated in a separate rack module, known as the control crate, which may be removed complete from the cabinet.

1.3 SAFETY FEATURES IN DESIGN

The load resistance of each channel is internally monitored to prevent over-dissipation of the output devices.

The temperatures of the heatsink and various other locations within the supply are monitored, together with the cooling-water flow; the system switches off if overheating is likely to occur.

In the event of mains failure, the unit closes down and water ceases to flow in the cooling circuits.

1.4 SPECIFICATIONS

Model 2313

Output:	2 channels up to ±20A 3 channels up to ±12A 8 channels up to ±10A
Maximum Output Voltage:	±40V all channels
Minimum Load Resistance for full current operation:	1.3 ohm for 20A and 12A channels, 3.1 ohm for 10A channels.
Maximum Load Resistance for full current operation:	2.0 ohm for 20A channels, 3.33 ohm for 12A channels, 4.0 ohm for 10A channels.
Ripple and Noise:	Less than 0.1% RMS of full output.
Current Settability:	2 parts in 1000 of full output using the calibrated 10-turn potentiometers.
Current Thermal Stability:	100 ppm/°C typical (after 30 minutes warm-up).
Remote control:	Differential analogue inputs with 5V common mode range. ±5V signal

10A 3.1 to 4.0
12A 1.3 to 3.33
20A 1.3 to 2.0

	swings current over full bipolar range. Open-collector output for fault indication.
Cooling:	Maximum operating pressure is 7 bar. Maximum inlet temperature is 25°C. Minimum inlet temperature must not be below dewpoint temperature. For a 10°C temperature rise, Flow rate is 7 litre/min, Pressure drop is 2 bar.
AC supply:	Three phase and earth, no neutral required, Voltage selected by tap changes: 200, 208, 380, 400, 415, 440, 480, +10%, -15% 47 to 63Hz.
Power Consumption:	12kVA maximum.
Overall Size:	Height 1840mm. Width 600mm. Depth 800mm.
Weight:	Approx 270kg.

Model 2314

Output:	5 channels up to ±20A. 8 channels up to ±10A. Total output 157A maximum.
Maximum Output Voltage:	±40V all channels.
Minimum Load Resistance for full current operation:	1.3 ohm for 20A channels. 3.1 ohm for 10A channels.
Maximum Load Resistance for full current operation:	2.0 ohm for 20A channels. 4.0 ohm for 10A channels.
Ripple and Noise:	Less than 0.1% RMS of full output.
Current Settability:	2 parts in 1000 of full output using the calibrated 10-turn potentiometers.
Current Thermal Stability:	100 ppm/°C typical (after 30 minutes warm-up).
Remote control:	Differential analogue inputs with 5V common mode range. ±5V signal swings current over full bipolar range. Open-collector output for fault indication.
Cooling:	Maximum operating pressure is 7 bar. Maximum inlet temperature is 25°C. Minimum inlet temperature must not be below dewpoint temperature. For a 10°C temperature rise, Flow rate is 7 litre/min, Pressure drop is 2 bar.
AC supply:	Three phase and earth, no neutral required, Voltage selected by tap changes: 200, 208, 380, 400, 415, 440, 480, +10%, -15% 47 to 63Hz.
Power Consumption:	12kVA maximum.
Overall Size:	Height 1840mm. Width 600mm. Depth 800mm.
Weight:	Approx 270kg.

2 INSTALLATION AND COMMISSIONING

2.1 INSTALLATION (see diagrams 1 and 2)

Make the AC power and protective-ground connections at the circular, four-pin connector on the panel below the rear door. Ensure that the correct fuses are installed in the main and auxiliary fuseholders on the Input-Fuse and Terminal plate.

Make the shim-coil assembly connections at the circular, multi-pole connector on the panel below the rear door.

Make the external current-control connections at the 37-way connector on the panel below the rear door.

Connect the water supplies at the panel below the rear door, taking care to observe the correct indication of flow as marked. Some seepage of anti-freeze fluid may be observed when the connectors are unscrewed. This is not important; anti-freeze is added to the cooling system for transit purposes.

2.1.1 Operating-Mode

Ensure that the switch on the service panel is set to the correct position, i.e. static-field or XYZ pulsed.

2.1.2 AC Supply-Voltage Adjustment

The equipment is supplied for a specified voltage (+10%, -15%). To change the operating-voltage, it is necessary to retap both the main and auxiliary transformers and to replace the phase-drop relay. Supply fuses F4 to F8 must also be changed if the input changes from 200 - 208V to 380 - 480V, or vice-versa, as follows:

200V, 208V	F4 32A (Motor type T1A 32M63)
	F5 32A (Motor type T1A 32M63)
	F6 32A (Motor type T1A 32M63)
	F7 1A (FNQ1)
	F8 1A (FNQ1)
380V - 480V	F4 32A (T1A32)
	F5 32A (T1A32)
	F6 32A (T1A32)
	F7 0.5A(FNQ½)
	F8 0.5A(FNQ½)

Tap changing on the main transformer is carried out by setting the three bolted-on links to the appropriate voltage studs on the transformer top-plate. Access is gained by removing the front panel.

Tap changing on the auxiliary transformer requires either series or parallel connection of the primaries, as follows (access is via the rear door):

Supply Voltage	Primary Settings
200	0 - 200, 0 - 200 in parallel
208	0 - 208, 0 - 208 in parallel
380	0 - 190, 0 - 190 in series
400	0 - 200, 0 - 200 in series
415	0 - 208, 0 - 208 in series
440	0 - 220, 0 - 220 in series
480	0 - 240, 0 - 240 in series

2.1.3 Connector-Pin Assignments

Tables 2.1, 2.2 and 2.3 detail the pin-assignments for the connectors on the service panel beneath the rear door.

Table 2.1 *AC-Supply Connector*

Pin	Function
BODY	Protective ground
X	Phase 1
Y	Phase 2
Z	Phase 3

Table 2.2 *Output Connector*

Pin	Function
3, B	Z_0 +
4, 5	Z_0 -
6, 7	Z_1 +
8, 9	Z_1 -
10, 11	Z_2 +
12, 13	Z_2 -
14, 15	Z_3 +
16, 17	Z_3 -
18, 19	Z_4 +
21, 22	Z_4 -
23	X +
24	X -
25	Y +
26	Y -
27	ZX +
28	ZX -
29	ZY +
30	ZY -
31	XY +
32	XY -
33	X^2-Y^2 +
34	X^2-Y^2 -
35	Z^2X +
36	Z^2X -
C	Z^2Y +
37	Z^2Y -
2	Earth
A	0/Temp
1	0/Temp
38	Spare 1
39	Spare 2
D	Spare 3

Table 2.3 *Remote-Control Connector*

Pin	Function
1	Z_0 +
20	Z_0 -
2	Z_1 +
21	Z_1 -
3	Z_2 +
22	Z_2 -
4	Z_3 +
23	Z_3 -
5	Z_4 +
24	Z_4 -
6	X +
25	X -
7	Y +
26	Y -
8	ZX +
27	ZX -
9	ZY +
28	ZY -
10	XY +
29	XY -
11	$X^2 - Y^2$ +
30	$X^2 - Y^2$ -
12	Z^2X +
31	Z^2X -
13	Z^2Y +
32	Z^2Y -
37	Chassis
*16	Open collector fault signal
17, 36	OV Signal Earth
35	+ 15V via 10k ohms pull up

* Max Volts = 20, max current = 10mA

All current control inputs are ±5 volts for ± Full Shim Current.

2.2 COMMISSIONING

On initial receipt of the equipment, no adjustments should be necessary, but adjustment procedures are given in Section 6.

2.2.1 Use of Open Collector Fault Output Facility

A recommended circuit for interface between this output and external systems is given in Fig. 2.2.

3 OPERATING INSTRUCTIONS

3.1 SWITCHING ON

To apply power to the control circuits turn the O/I rotary switch clockwise to I; this switch is underneath, and to the right-hand side

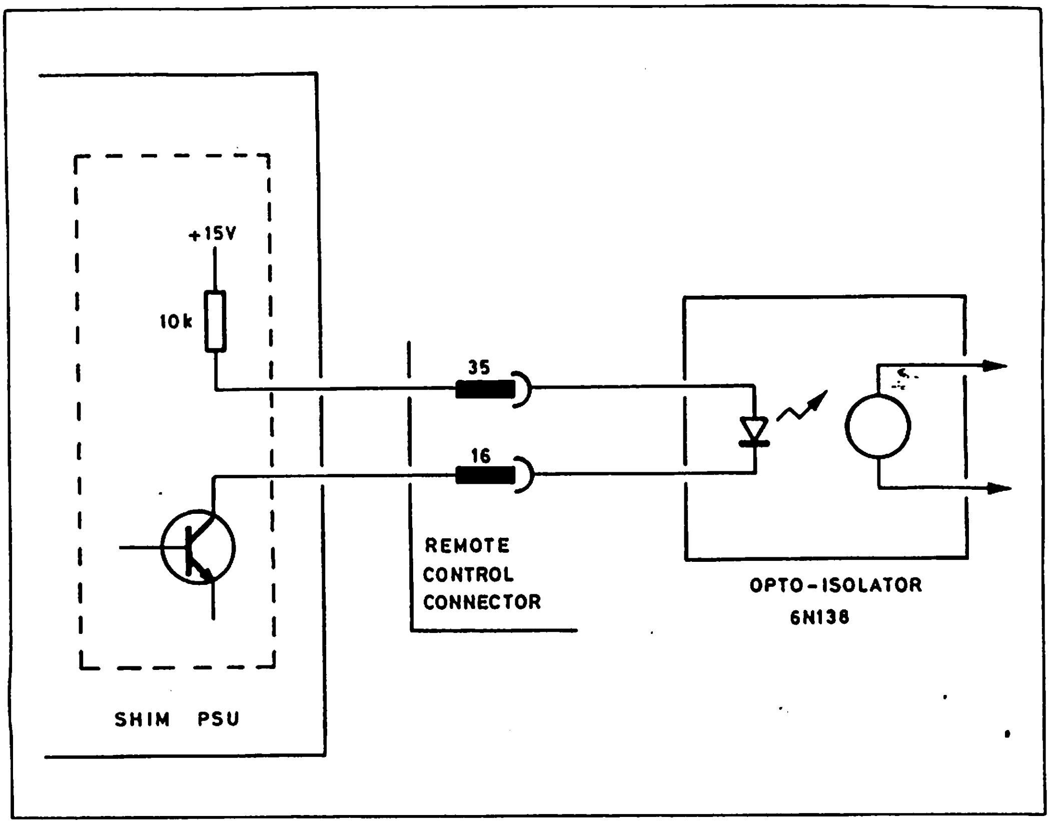

Fig. 2.2 *Interface Circuit (Recommended) for Fault-Signal from Remote Control Connector*

of, the control-crate front panel. The front panel meter and the appropriate status indicators will illuminate. At this point the high-current circuits are inoperative, and remain so until the contactor which controls power to those circuits is energised.

Press START to energise the high-current contactor. Provided that no faults are preventing it, the supply will become fully operational and the START button will be illuminated. The START button may also be used as a reset to clear any fault indications once the faults have been cleared.

3.1.1 Standby Status

Pressing the STOP button de-energises the high-current contactor. This causes the unit to assume a standby condition (with the STOP button illuminated) until START is pressed again.

3.2 CONTROLS AND INDICATORS

3.2.1 Voltage/Current

This toggle switch sets the digital panel-meter to indicate either output-voltage or output-current. Meter resolution is either 1mA or 10mV.

3.2.2 Meter Selector-Switch

This 13-position rotary switch selects the channel to be monitored by the digital panel-meter.

3.2.3 **Output-Current Controls**
Each channel has a coarse control, ten-turn potentiometer to set the output current from negative full-output (dial 0.00) to positive full-output (dial 10.00), and a fine control ten-turn potentiometer to provide fine trimming of the output current.

3.2.4 **Remote Control**
A connector on the rear panel of the cabinet enables connections to be made for external control of the channel currents. ±5V input corresponds to ± full output-current.

> NOTE:
> *The remote-control inputs are added directly to any front-panel potentiometer inputs. There is no local/remote changeover facility.*

3.2.5 **Static Field/X, Y, Z Pulsed**
This rotary switch, mounted at the rear of the cabinet and adjacent to the output-connector, disconnects the X1, Y1 and Z1 channels from their respective shims and feeds them to an internal resistive load. In this condition the X1, Y1 and Z1 shim functions must be performed by the DC offsets in the gradient coils, rather than by the shims themselves, since coupling from the gradient to the shim coils may damage the shim power supply.

3.2.6 **Fault Indications**

Four LEDs indicate the following fault conditions:

1 OVER CURRENT. This indicator will illuminate if any of the channels attempts to supply more than a safe level of output to a load of too low a resistance.

2 PHASE FAIL. This indicator will illuminate whenever one of the AC power supply-phases or one of the AC supply input fuses has failed, or if the phase sequence is incorrect.

3 WATER FAIL. This indicator will illuminate when the cooling-water flow is either insufficient or in the wrong direction.

4 OVER TEMP. This indicator will illuminate if the output-bank heatsink or the main transformer has overheated, or if the external overtemp loop via the output connector is broken.

4 TECHNICAL DESCRIPTION

4.1 Principles of operation

Each unit consists of a common three-phase transformer, rectifier and smoothing set feeding each channel output via independent current-monitoring shunts and complementary transistor output-banks. The output-banks are driven by a control circuit which compares the monitoring-shunt voltage with a reference voltage set up by the local and external current controls, and adjusts the output-drive accordingly.

4.2 Functional Description

The main DC supplies are developed by two, six-phase star rectifier and choke input filter sets, driven from a common transformer. These supplies feed the 13-channel output via the output-bank heatsink-assembly and the current-monitoring shunts. Each output is individually fused.

The waterflow-control solenoid-valve is driven by the main contactor relay, so that water does not circulate when the supply is in either the OFF or STOP mode. Auxiliary contacts on the contactor-relay bypass the waterflow switch when the solenoid valve is closed, to prevent the signalling of WATER FAIL. The capacitor across these contacts provides sufficient delay for the waterflow switch to operate before WATER FAIL is sensed, when START is selected.

The switch on the service panel can disconnect the X1, Y1, Z1 channels from the shim set. This facility is used when pulsed gradients are used in the magnet assembly.

> **Caution:**
> *If this switch is not correctly operated, the shim supply could be damaged by induced currents, caused by mutual-coupling between shims and gradient coils.*

4.2.1 **Control PCBs** (see diagrams 8 and 9)

The shunt-voltage is buffered and amplified by the instrumentation-amplifier U3 (any common-mode signals being rejected). The gain of U3 is set for - 10V at its output at full positive output-current.

U7 and U11 provide a precision ±10V reference supply for the front-panel current-setting potentiometer, as well as for the trip-set and crossover-adjust circuits. U8 buffers and amplifies any external current-setting voltage-input, at the same time providing common-mode rejection.

The output-level from the current-setting potentiometer is filtered by R16/C6, added to the external current demand, and compared with the output from U3 (by U1). Feedback components C3, C4 and R15 tailor the loop frequency response to ensure stability. U2 discharges C3 and C4 when STOP is selected, to prevent current surges at main current switch-on.

U13 buffers the output of U1, and then feeds it (via the removable link) to bipolar drive-circuits consisting of U4, U6, U12, Q1 and Q2. U6/Q1 and U12/Q2 are voltage-to-current convertors providing current-drive to each polarity of the output transistor-bank.

R38, U2 and associated components inject a small offset-signal into U4, which is constrained by the action of the control loop to set up equal standing currents in both halves of the output transistor-bank. The level of this standing current is set high enough to overcome the crossover distortion inherent in the output-circuit (U2/C1 delay offset application after switch-on until the control loop has settled).

R26, R25, R27, R41, U13, U5, U9 and U10 form a trip circuit, where R27, U13, R41 and part of U5 provide a threshold level, below which the trip is inoperative. Inputs from R25, R26 and U14 (proportional to output current and voltage) are combined in U5 and U9, to provide a trip signal if the load resistance (i.e. the ratio of output-voltage to output-current) is too low. This trip signal is latched by U10 and fed to the STOP input, to the indicator D13, and to the Security PCB (via Q3).

U14 has a gain of 0.25, to reduce the ±40V maximum output-voltage to ±10V for use on the PCB.

Output-current metering is provided by R31 and R18, which scale the output from U3 to feed the digital panel meter.

Output-voltage metering is provided by R22, R23 and R24, which scale the output from U14 to feed the digital panel meter.

4.2.2 **Security PCB** (see diagrams 8 and 10)
Incoming fault-signals are buffered by U1 and latched by U4 or U5. The latched signals (via U7 and U3) are latched by U5, and then turn off the main contactor (via U2, U9 and the contactor actuating relay). A STOP-signal is developed by U6, U3 and U8.

Operation of the START button resets any non-persistent fault indications (via U3) and resets U5, to turn on the main contactor (via U2, U9 and the contactor actuating relay). A persistent fault indication, however, overrides all resets because the S inputs to U4 and U5 dominate. U6 produces a continuation of the STOP- signal (via U3 and U8) for approximately one second after START is selected, to enable supplies to stabilise before control loops are turned on.

Operation of the STOP button latches U5 (via U7 and U3) to turn off the main contactor (via U2, U9 and the contactor relay). It also generates a STOP- signal via U6, U3 and U8. At power-on, D8, R3, C1 and U2 produce a reset pulse of approximately 200ms which resets any non-persistent faults latched in U4 and U5. The reset pulse also sets U5 into STOP mode. U6 extends the STOP by a further one second to prevent START from being selected until all circuits have settled.

Q1 provides an open-collector output which is closed to 0V when the supply is not in START mode.

5 PREVENTIVE MAINTENANCE

5.1 ROUTINE MAINTENANCE

Where a shim supply is installed and operating satisfactorily, it is only necessary to ensure that the connectors are clean, dry and fully mated. Water connections should be tight and dry.

6 FAULT DIAGNOSIS AND CORRECTIVE MAINTENANCE

6.1 FAULT INDICATIONS

6.1.1 **Mains Power Fault**
If no illumination is seen when power is connected to the unit and the rotary switch below the front panel is turned to 1, inspect the main power fuses. These are located on the connection plate inside the rear door.

6.1.2 **Warning LEDs**
Four LEDs are fitted on the front panel to signal fault conditions, as follows:

1 OVER CURRENT illuminates if any of the channels attempts to supply more than a safe level of output to a load of too low a resistance.
2 PHASE FAIL illuminates if one of the supply phases or main fuses has failed, or if the phase sequence is incorrect.

3 WATER FAIL illuminates if the cooling-water flow is absent or in the wrong direction.

4 OVER TEMP illuminates if the output-bank heatsink temperature is too high, if the main transformer has overheated, or if an external loop is broken.

6.2 ACCESS TO PARTS (see diagram 1)

6.2.1 Cabinet

All components, except for the Control and Security PCBs, are mounted directly in the main body of the cabinet. Access to the interior of the cabinet is gained by means of either the rear door or the removable front and side panels.

Removal of the side panels entails the disconnection of internal grounding-braids: it is essential that the braids are reconnected on replacement of the panels.

The front panel is grounded by means of a special cage-nut assembly. When it is replaced, all of the fixing screws must be replaced and properly tightened.

6.2.2. Control Crate

The Control and Security PCBs are all plug-in Eurocard boards fitted in the control crate. Their location is (left to right when viewed from the front): Z_0, Z_1, Z_2, Z_3, Z_4, X, Y, ZX, ZY, XY, X^2-Y^2, Z^2X, Z^2Y, SECURITY.

After removal of the four fixing-screws, the control crate may be partially withdrawn from the cabinet. The front panel may then be lowered to gain access to the PCBs. Complete removal of the control crate from the cabinet rack requires disconnection of all of the plugs and sockets at the rear of the control crate: these may be reached through the rear door.

An extender-card for servicing is stowed inside the rear door.

6.3 REPAIRS AND REPLACEMENTS

6.3.1 Control Crate/PCBs (see diagram 4)

All PCBs are plated-through-hole types. If components are to be replaced, it is advisable to cut out the defective component first if possible, and then remove the leads singly afterwards. If this is not possible, then careful use of desoldering wick and solder pump is necessary, to ensure complete removal of solder before removal of the component is attempted.

Rear-panel connections are crimp types. The appropriate pin-extraction tool is therefore necessary to remove contacts.

6.3.2 Cabinet/Heatsink Assembly (see diagrams 6, 13 and 14)

Since the output-bank heatsink assembly incorporates the most highly-stressed components in the equipment, this area of the equipment is the most likely cause of failure. If one or more of the output transistors on a channel fail, the related DC supply fuse will blow. This will render the power-supply inoperative on the affected channel (possibly on only one polarity).

To remove a faulty output-transistor, first unsolder all connections to the device (i.e. two to the PCB and one to the collector solder-tag). Unscrew the two retaining screws and remove the transistor, taking care not to drop any of the fixings into the body of the power supply.

To refit a transistor, first position the new washer exactly in place on the heatsink assembly, using the insulated bush mounted from the printed-circuit side to locate it correctly. It is recommended that a new insulating washer is fitted with any replacement device, since the washers are easily damaged. Place the new transistor and its other insulating bush in position.

> **Caution:**
> *Great care is needed at this stage to avoid tearing the insulating washer with the insulating bush.*

Fit and tighten (without overtightening) the retaining screws.

When the new transistor is in position, first ensure that all its connections are open-circuit, taking special care to see that the collector tag is not touching any part of the heatsink wiring or circuits. Check the insulation between the transistor case and the heatsink plate with a 250V or 500V insulation-tester.

> NOTE:
> *Any indication under 20M ohms probably indicates damage to the insulating washer which should then be replaced.*

When the insulation check is satisfactorily completed, solder the new transistor into circuit.

Once all faulty devices have been replaced, the DC supply fuses should be replaced (assuming that they have blown).

Before switching the equipment on again, ensure that any external faults which may have caused the original failure have been cleared. Check for, and replace, any overheated components on the PCB.

If the emitter-voltages of Q1 and Q2 on the Control PCB are outside the range ±4.5V to ±5.5V at full current output, select new S.O.T. resistors on the Control PCB as described below.

6.4 ADJUSTMENT PROCEDURES

Adjustments may be made on the channel-control PCBs and the front panel digital meter. Normally, adjustment should be necessary only after replacement of either of these items or the replacement of devices in the output-transistor bank.

6.4.1 Digital Panel-Meter

The accuracy of the panel-meter is determined by the accuracy with which the reference voltage is set. Use a digital voltmeter of at least 4½-digit capability to monitor the voltage between pins 7 and 13 of the panel-meter connector. Adjust R7 on the panel-meter signal PCB for 1.0000V.

6.4.2 Control PCB (see diagrams 8 and 9)

Each Control PCB is set up individually for the channel it drives, to take account of output-transistor variations. The values of R44 and R45 (S.O.T.) and the adjustment of potentiometer R38 must be reset whenever a new Control PCB is fitted or when replacement transistors are fitted to the output-bank. The complete procedure for setting up a Control PCB follows.

NOTES:
1 It is important that the values of R44 and R45 are determined before any other adjustment is attempted.
2 Use the extender-card mounted inside the rear door for access to PCB components.
3 All voltages quoted are with respect to TPO, unless otherwise stated.

6.4.2.1 **R44 and R45**
To determine the values of R44 and R45, proceed as follows:
1 Set potentiometer R38 (CROSSOVER ADJ) to OV.
2 In positions R44 and R45, fit 5K, 1W variable resistors, each set to 5K.
3 Remove the jumper link from the PCB.
4 Connect an adjustable DC supply between TP7 and TP0, set to zero output.
5 Monitor the voltage between TP4 and TP5, using a DVM.
6 Monitor the voltage at TP12.
7 Press START and adjust the DC supply to give + 5.00V at TP2.
8 Slowly reduce the value of R44 until the voltage between TP4 and TP5 is + 200mV.
9 Transfer the DVM from TP12 to TP16, and adjust the DC supply for - 5.00V at TP16.
10 Slowly reduce the value of R45 until the voltage between TP4 and TP5 is - 200mV.
11 Switch the equipment off.
12 Remove R44 and R45, and measure their values.
13 In each position, fit the nearest E24 value of 0.5W metal-oxide resistor.

6.4.2.2 **Shunt Amplifier Offset**
With the unit in STOP mode, monitor the voltage at TP1. Adjust R19 for 0.0mV ± 1mV max.

6.4.2.3 **Reference Supply**
Monitoring the voltage at TP9, adjust R17 for + 10.00V. Check that TP10 is at - 10.000V ± 0.05V.

6.4.2.4 **External-Input Amplifier**
Monitoring the voltage at TP6, with the unit in STOP mode and with zero external-input, adjust R40 for 0.0mV ± 1mV max.

6.4.2.5 **Crossover Adjustment**
Proceed as follows:
1 Fit the jumper link in the PCB.
2 Set the current-set potentiometer to 5.00.
3 Press START.
4 Monitor the voltage between TP4 and TP5, and finely adjust the current-set for 0.0mV
5 Monitoring the voltage across one of the emitter resistors of the corresponding output-bank, slowly adjust R38 for a voltage corresponding to a current of 40mA.

> NOTE:
> *Allow the current time to settle, since it is affected by the R7/C1 time-constant.*

7 DIAGRAMS

NOTES:

1 On circuit diagrams generally, component values are as follows, unless otherwise indicated:

Resistances in ohms
Capacitances in microfarads.

2 On Control PCB circuit diagram, certain resistance values vary as follows:

Version	R25	R26	R27	R41	R31	R18
10A	43.2K	13.7K	10K	8.2K	102K	11.3K
12A	10.2K	15.8K	1.3K	9.1K	110K	15K
20A	21K	11.3K	8.2K	9.1K	102K	25.5K

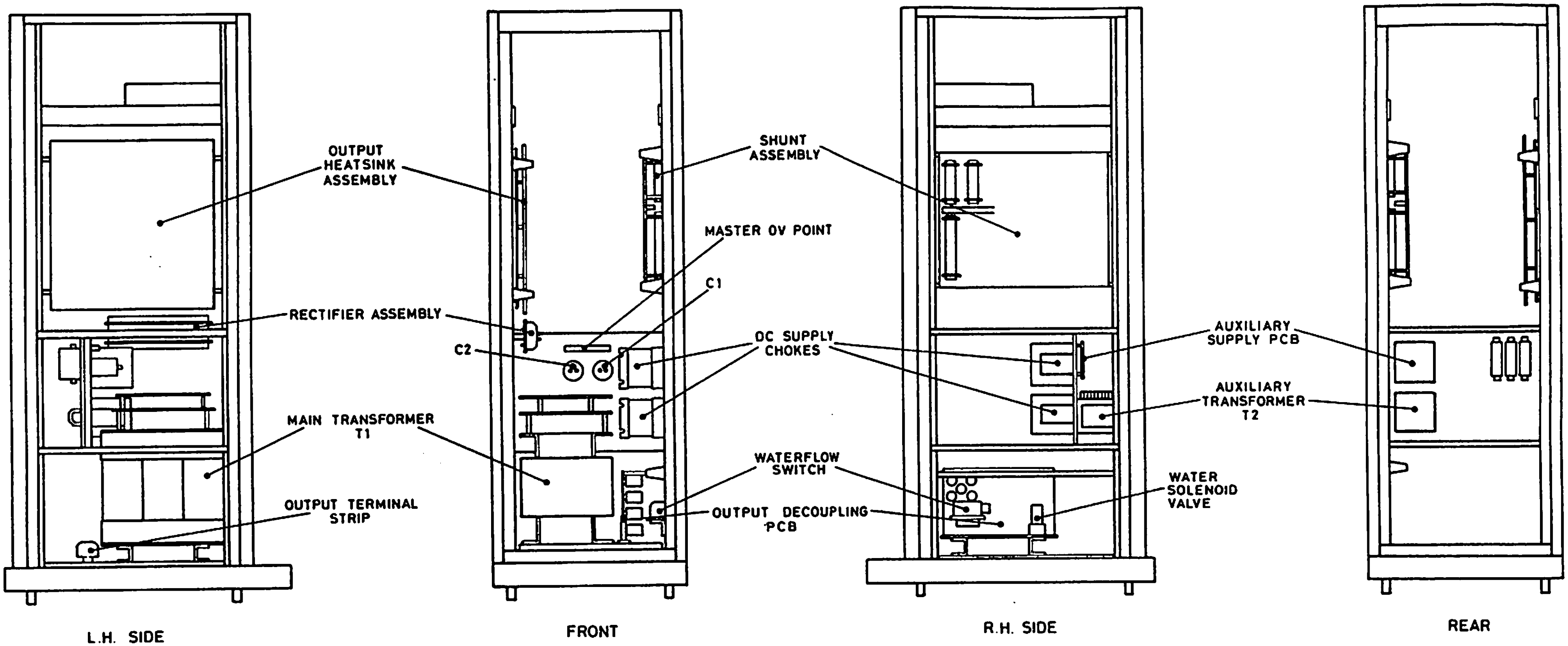

Diagram 1 Equipment Views (Covers Removed)

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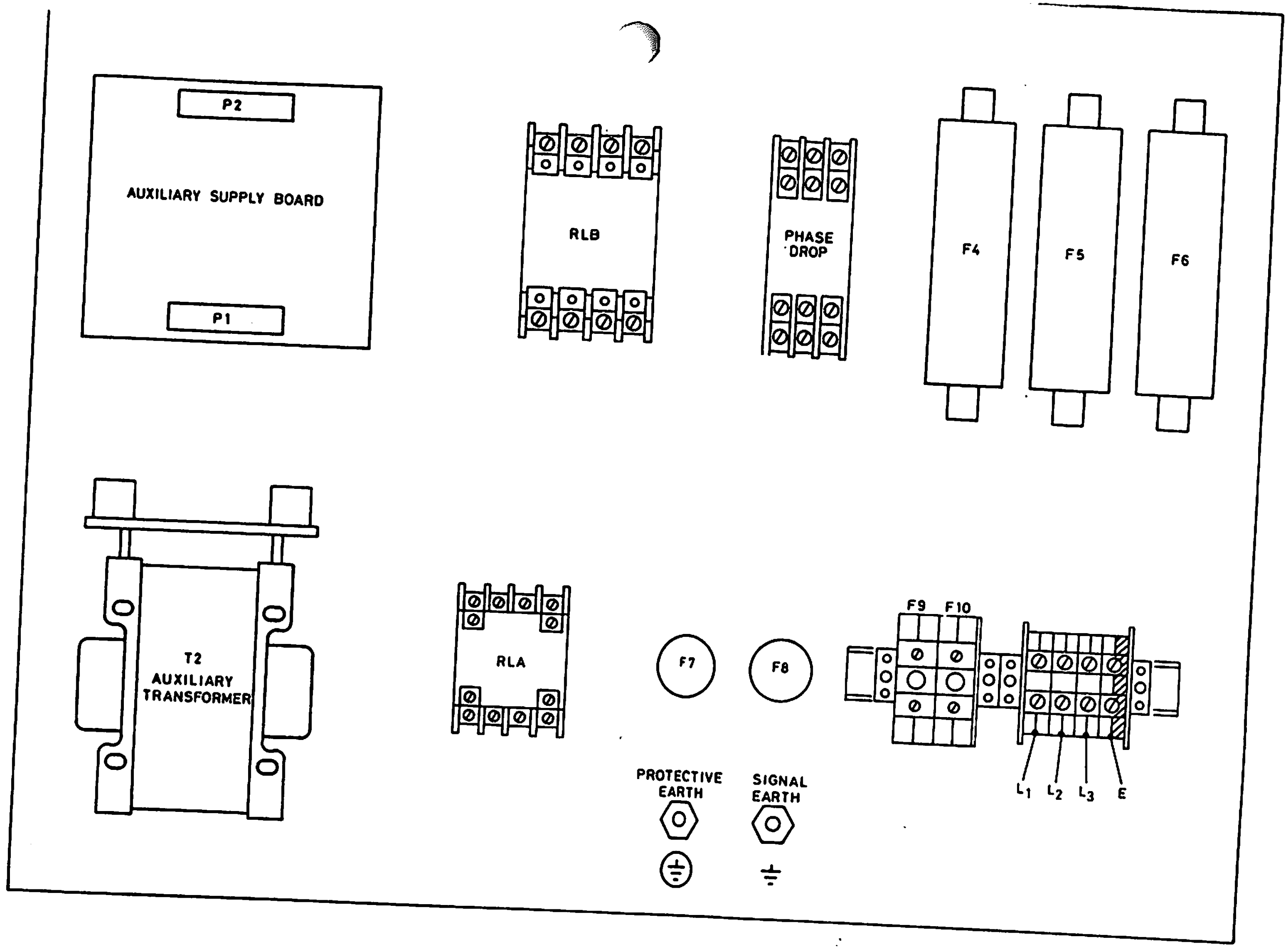

ram 2 Fuse, Relay and Input-Connection Plate

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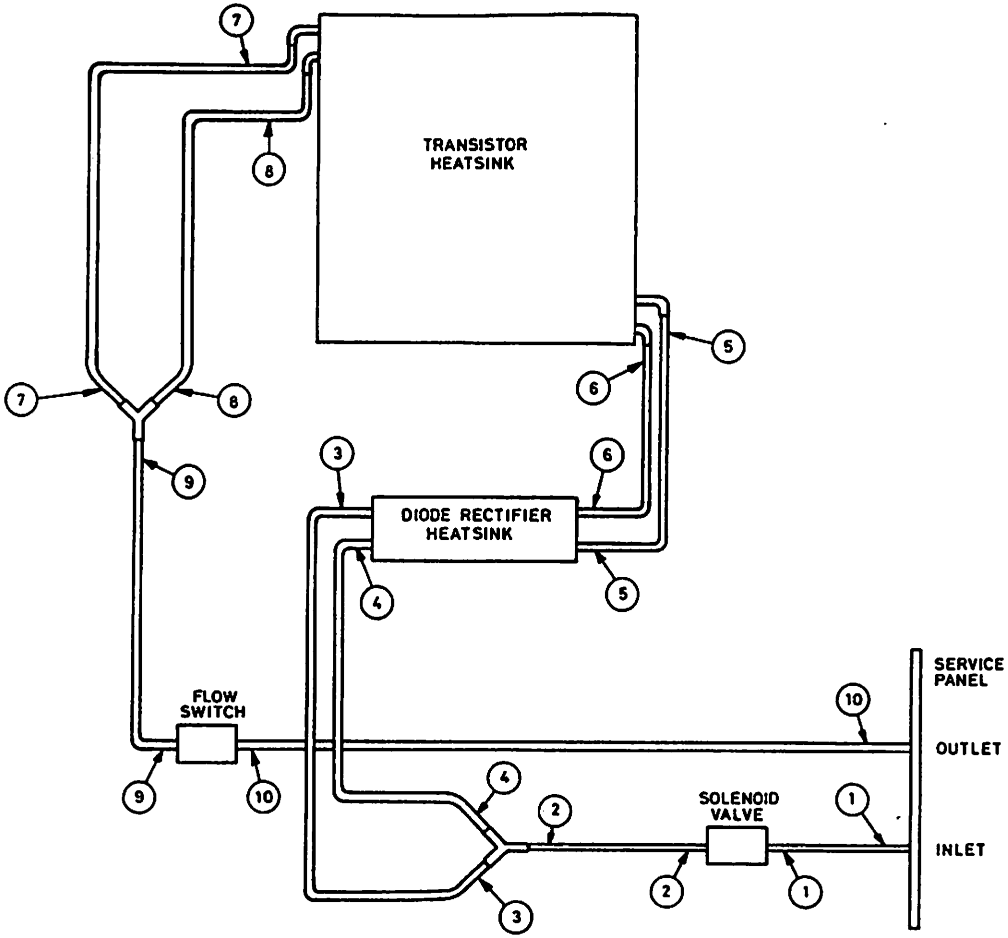
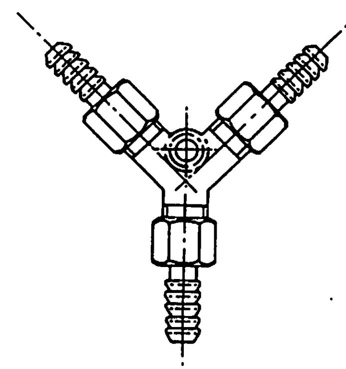
PIPE No.	PIPE LENGTH
1	470 mm
2	1270 mm
3	250 mm
4	200 mm
5	280 mm
6	280 mm
7	360 mm
8	360 mm
9	1450 mm
10	800 mm





8mm Y-PIECE

Diagram 3 Cooling-Water System

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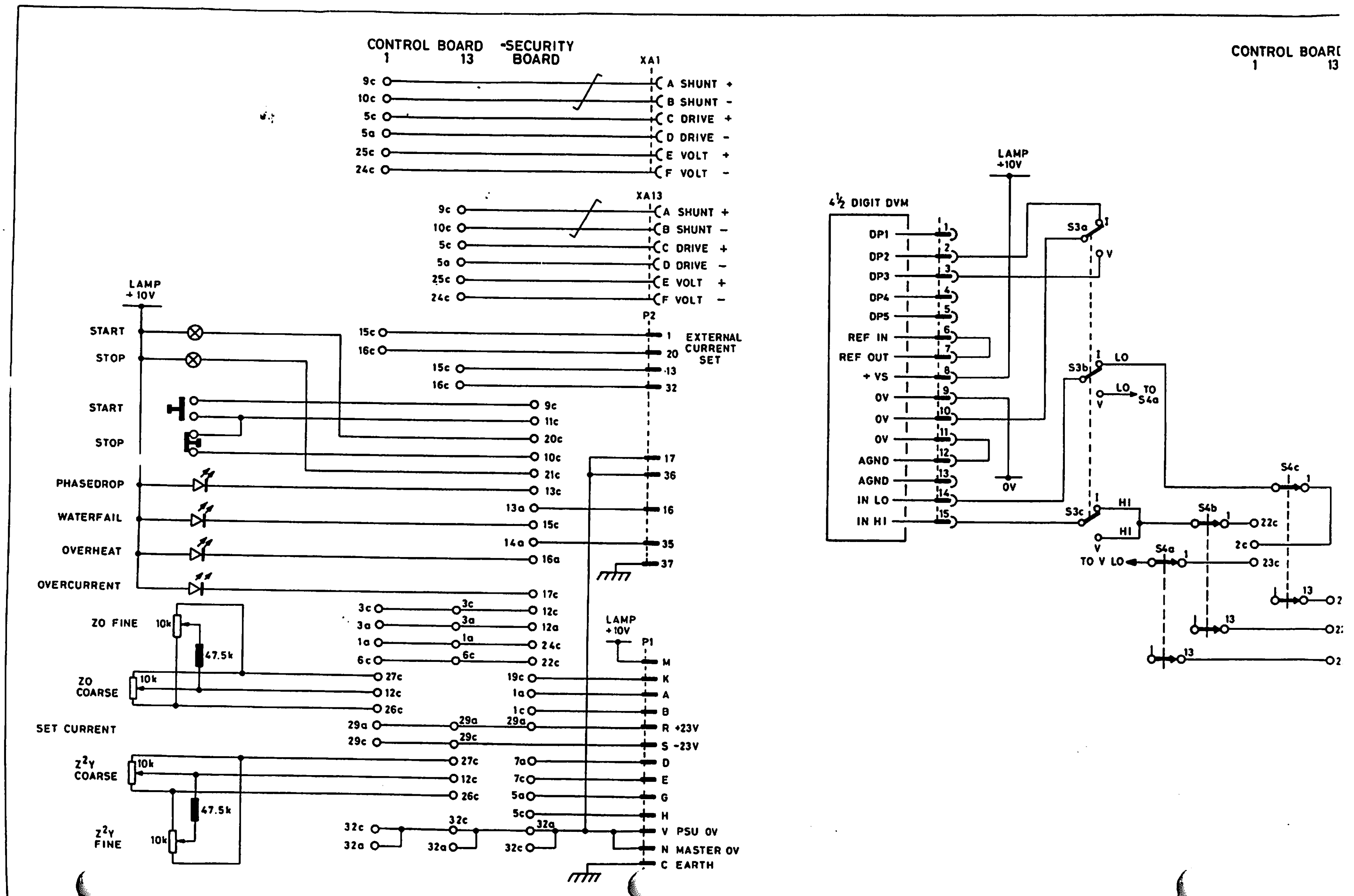
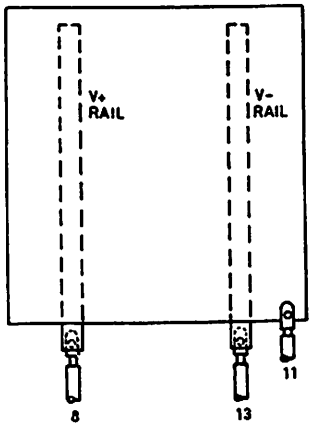
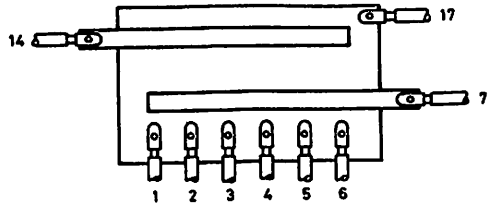


Diagram 4 ...ntrol Crate Interconnections

TRANSISTOR HEATSINK

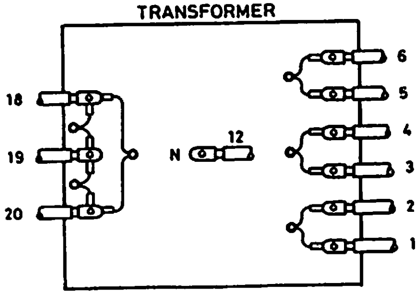


DIODE RECTIFIER HEATSINK



CABLE No	COLOUR	FROM	TO
1	RED	RED PHASE	RECTIFIER INPUTS
2	RED	RED PHASE	
3	YELLOW	YELLOW PHASE	
4	YELLOW	YELLOW PHASE	
5	BLUE	BLUE PHASE	
6	BLUE	BLUE PHASE	
7	BLACK	POS 300uH CHOKE	RECTIFIER +VE O/P
8	BLACK	POS 300uH CHOKE	HEATSINK V+ BAR
9	BLACK	SHUNT OV BUS BAR	MASTER OV BAR
10	BLACK	MASTER OV BAR	I/P FUSE PANEL EARTH FUNCTION
11	BLACK	HEATSINK PLATE	MASTER OV BAR
12	BLACK	TRANSFORMER NEUTRAL	MASTER OV BAR
13	BLACK	NEG 300uH CHOKE	HEATSINK V- BAR
14	BLACK	NEG 300uH CHOKE	RECTIFIER -VE O/P
15	RED	POS 300uH CHOKE	POS CAPACITOR
16	BLUE	NEG 300uH CHOKE	NEG CAPACITOR
17	GREEN/YELLOW	RECTIFIER HEATSINK EARTH	MAIN EARTH POINT
18	BLUE	TRANSFORMER	
19	YELLOW	TRANSFORMER	
20	RED	TRANSFORMER	
21	RED		
22	YELLOW		
23	BLUE		
24	RED		
25	YELLOW		
26	BLUE		
27	GREEN/YELLOW	TERMINAL BLOCK EK10	PROTECTIVE EARTH POINT

TRANSFORMER



SHUNT PLATE

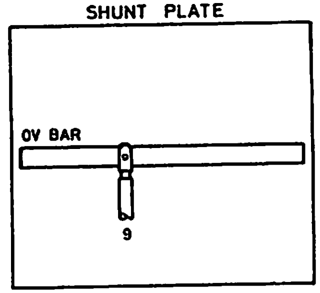
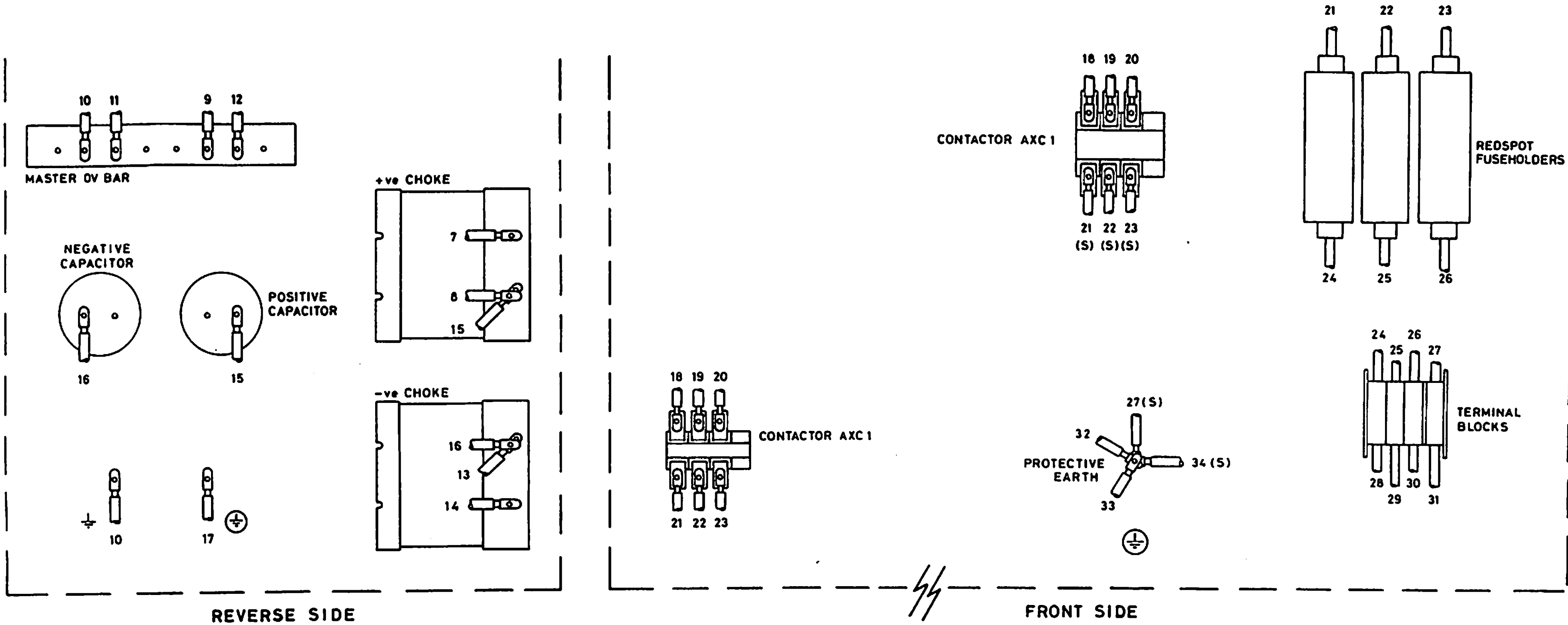


Diagram 5 Heavy-Wiring Diagram (sheet 1)

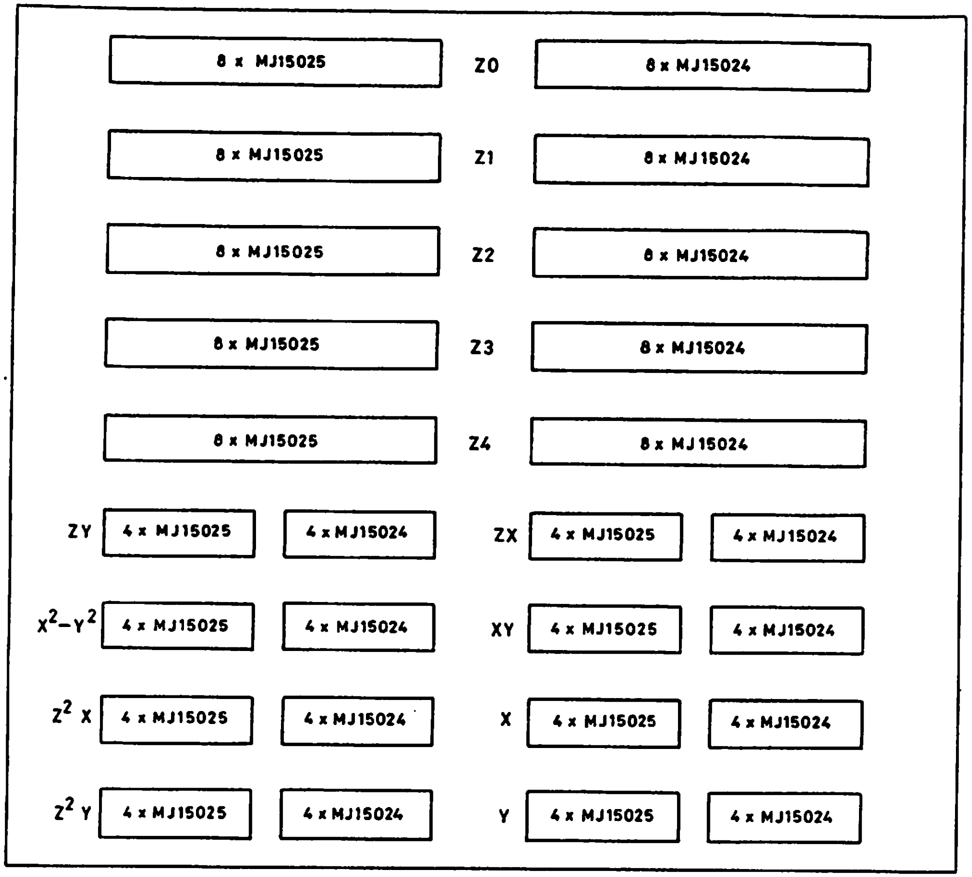
ORIGINAL ISSUE DATE	REVISION No						OXFORD
	REVISION CODE						
	DATE						



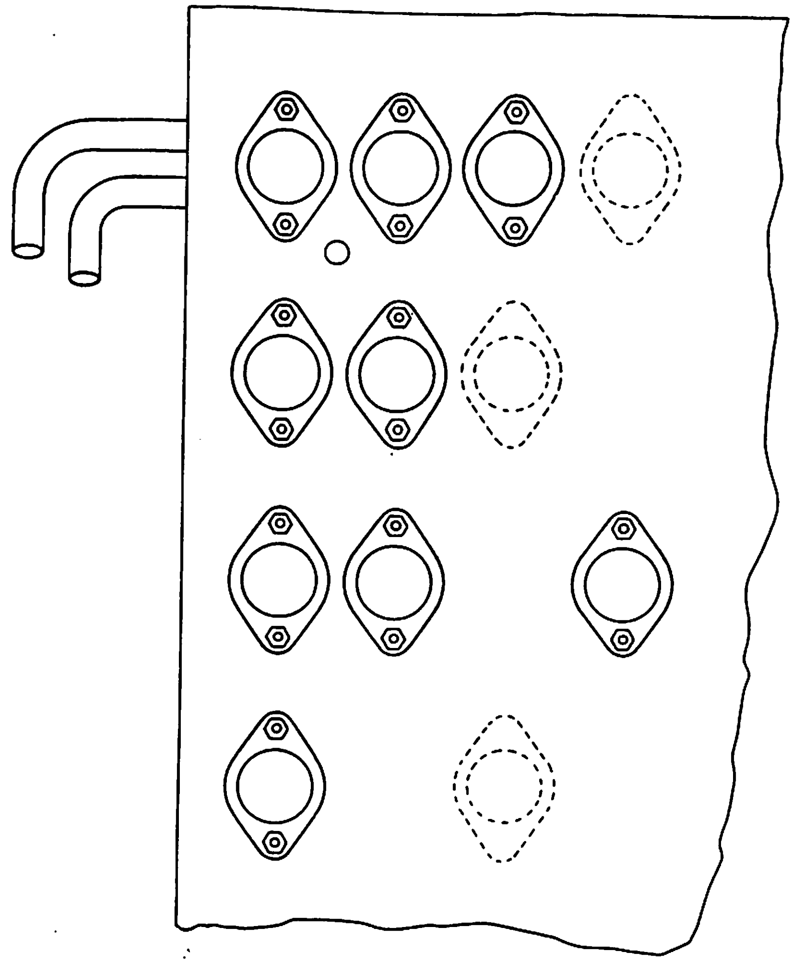
NOTE SEE SHEET 1 FOR WIRING DETAILS

...agram 5 Heavy-Wiring Diagram (sheet 2)

...RIGINAL ...SUE DATE	REVISION No						OXFORD
	REVISION CODE						
	DATE						



VIEW FROM TRANSISTOR SIDE



gram 6 Transistor-Bank Assembly

'GINAL UE DATE	REVISION No						OXFORD
	REVISION CODE						
	DATE						

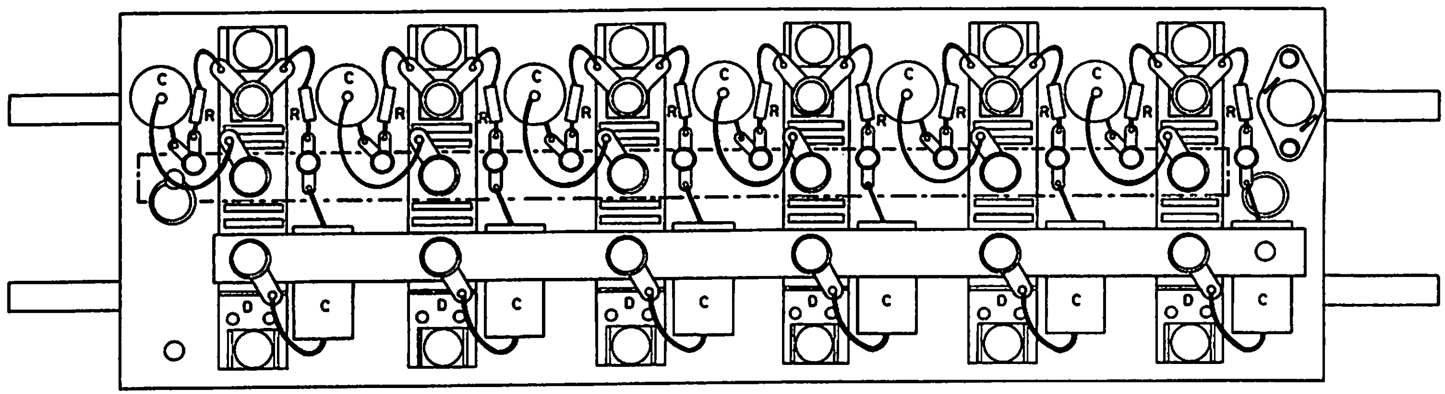
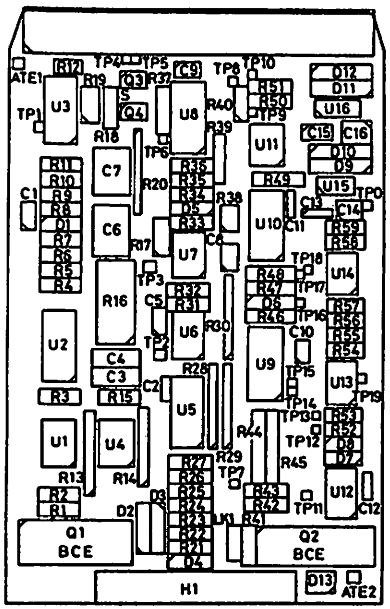
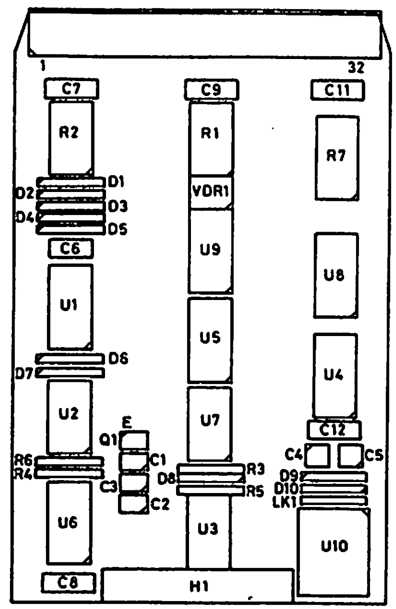


Diagram 7 Rectifier Heatsink Assembly

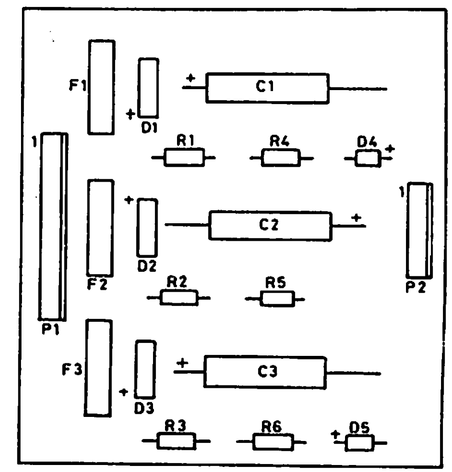
ORIGINAL ISSUE DATE	REVISION No						OXFORD
	REVISION CODE						
	DATE						



CONTROL PCB



SECURITY PCB



AUXILIARY SUPPLY PCB

ıgram 8 PCB Component-Layout Diagrams

IGINAL UE DATE	REVISION No						OXFORD
	REVISION CODE						
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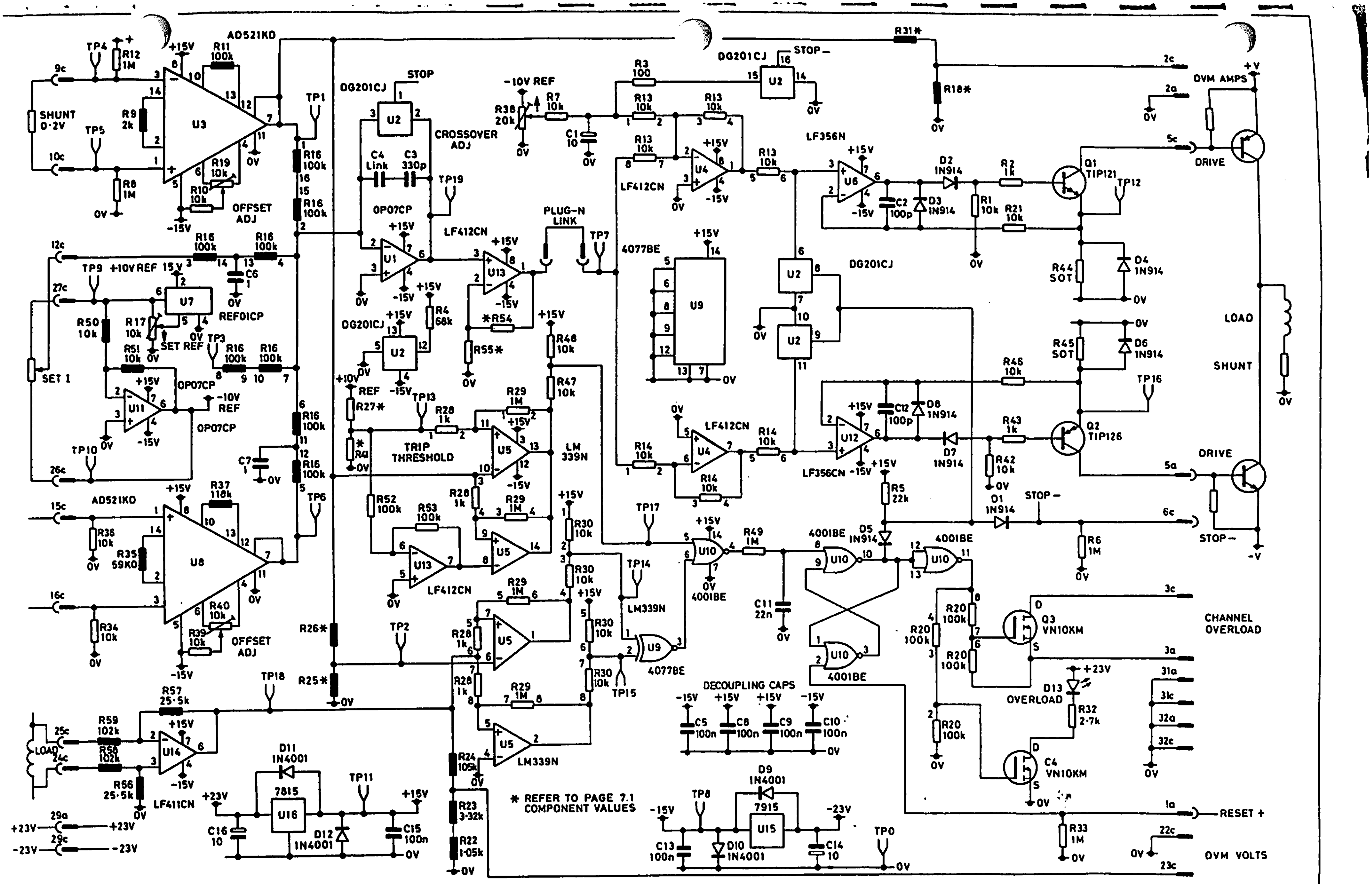


gram 9 Control PCB Circuit Diagram

GINAL UE DATE	REVISION No / REVISION CODE / DATE					OXFORD

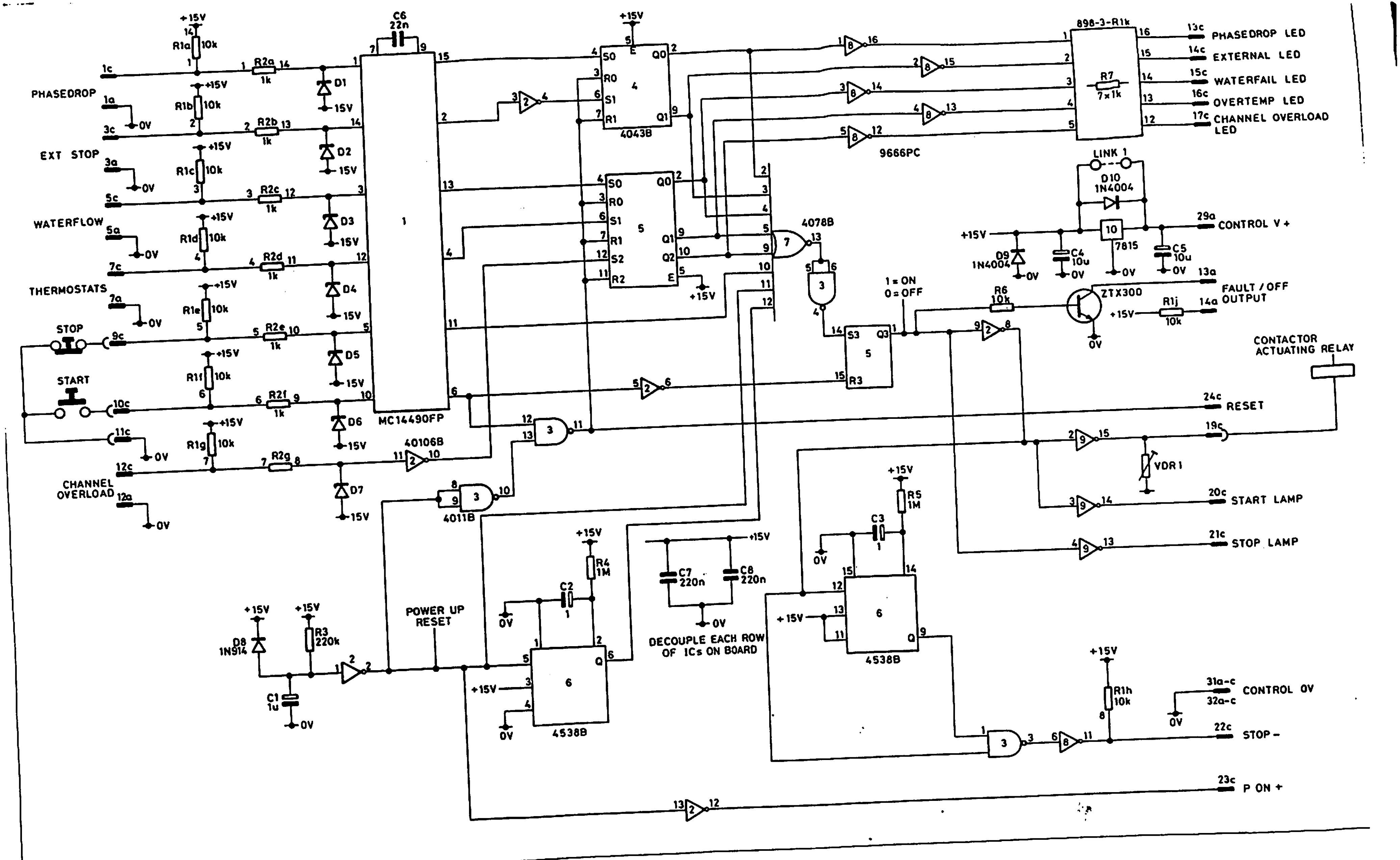
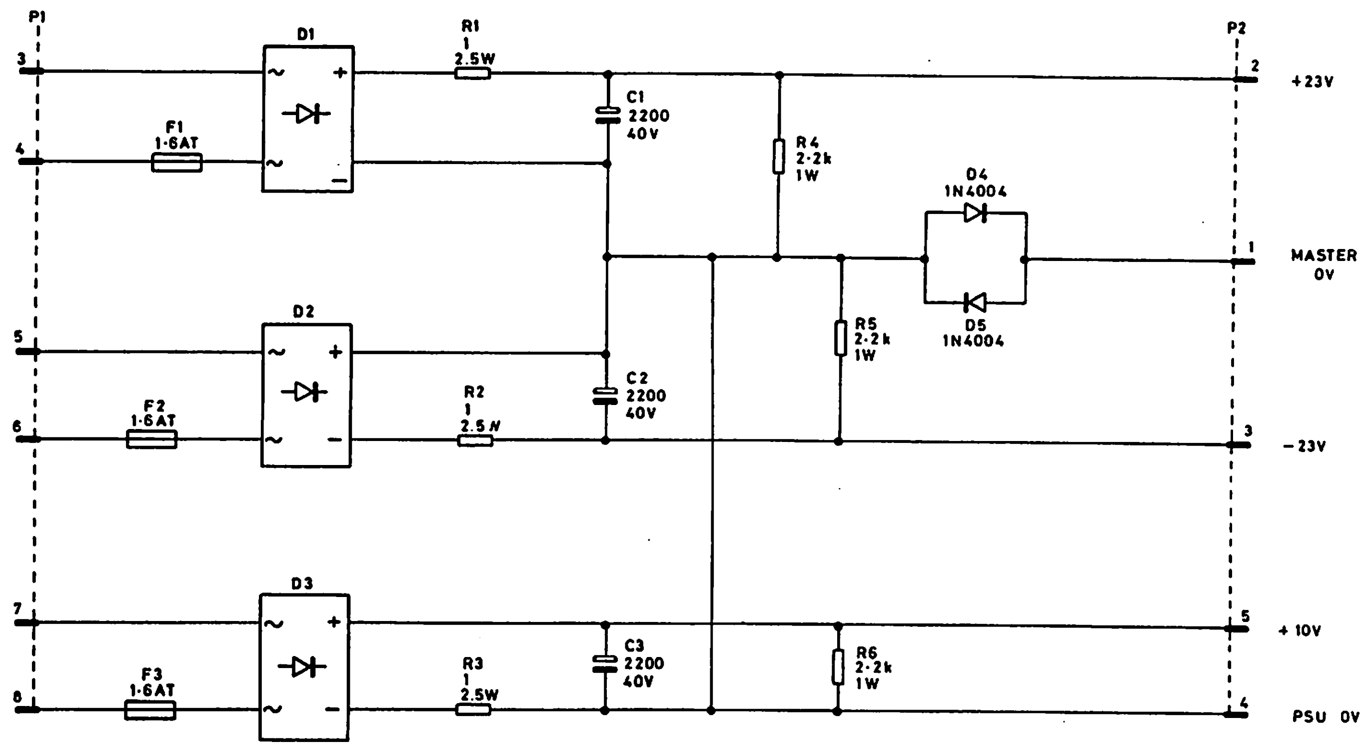


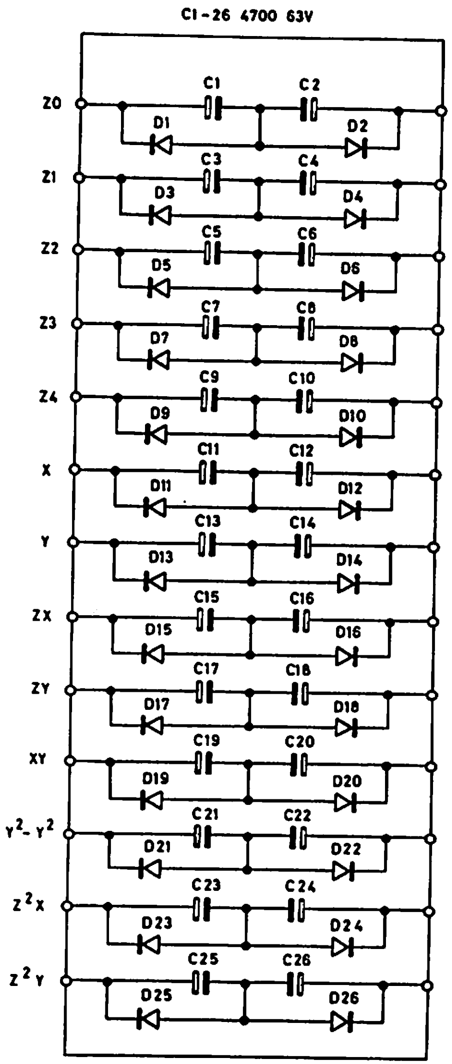
Diagram 10 Security PCB Circuit Diagram

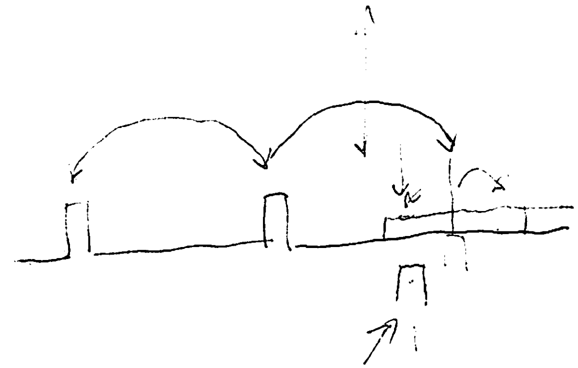
ORIGINAL ISSUE DATE	REVISION No REVISION CODE DATE						OXFORD

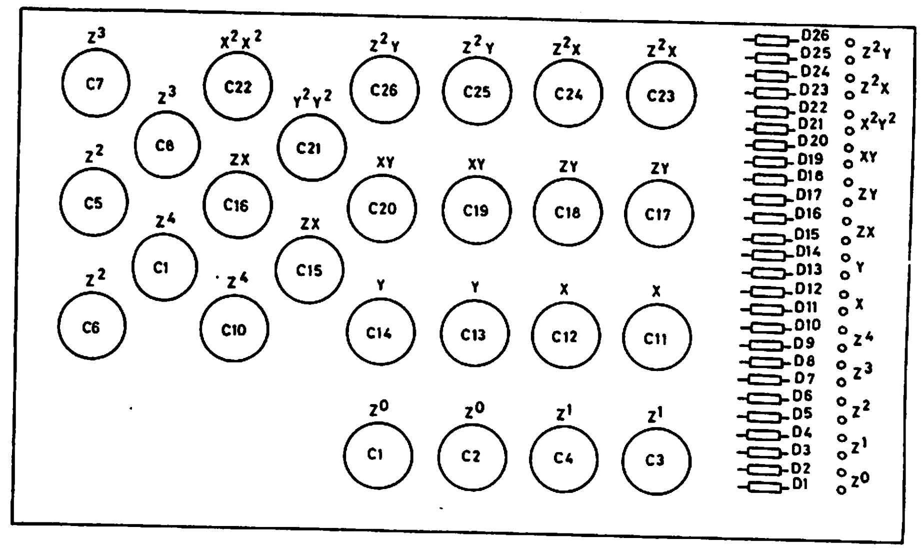


ram 11 Auxiliary Supply PCB Circuit Diagram

INAL. E DATE	REVISION No						OXFORD
	REVISION CODE						
	DATE						







ram 12 Output Decoupling PCB: Circuit and Component-Layout Diagrams

INAL	REVISION No						OXFORD
E DATE	REVISION CODE						
	DATE						

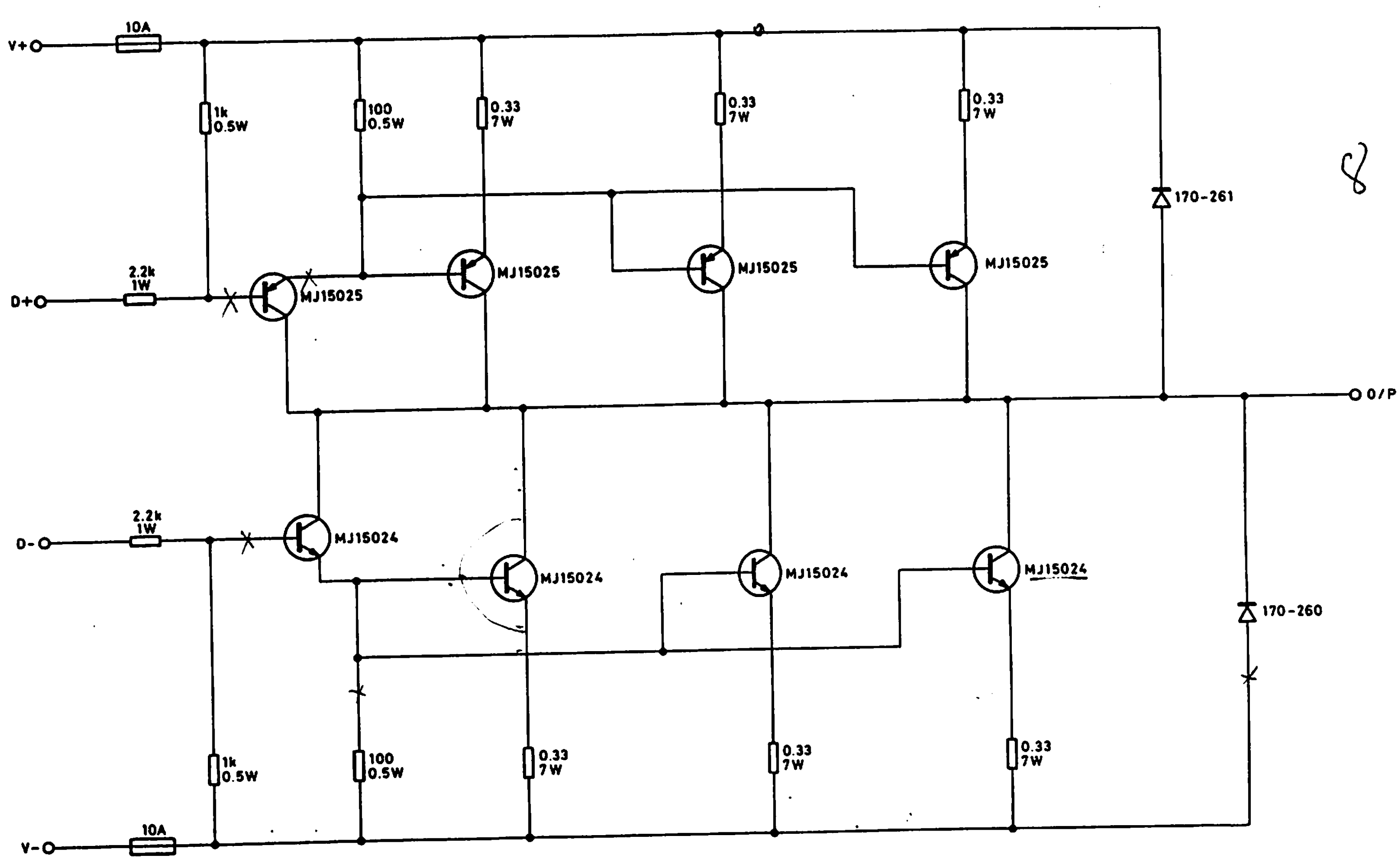


Diagram 13 Part of Heatsink Assembly (10A Channel)

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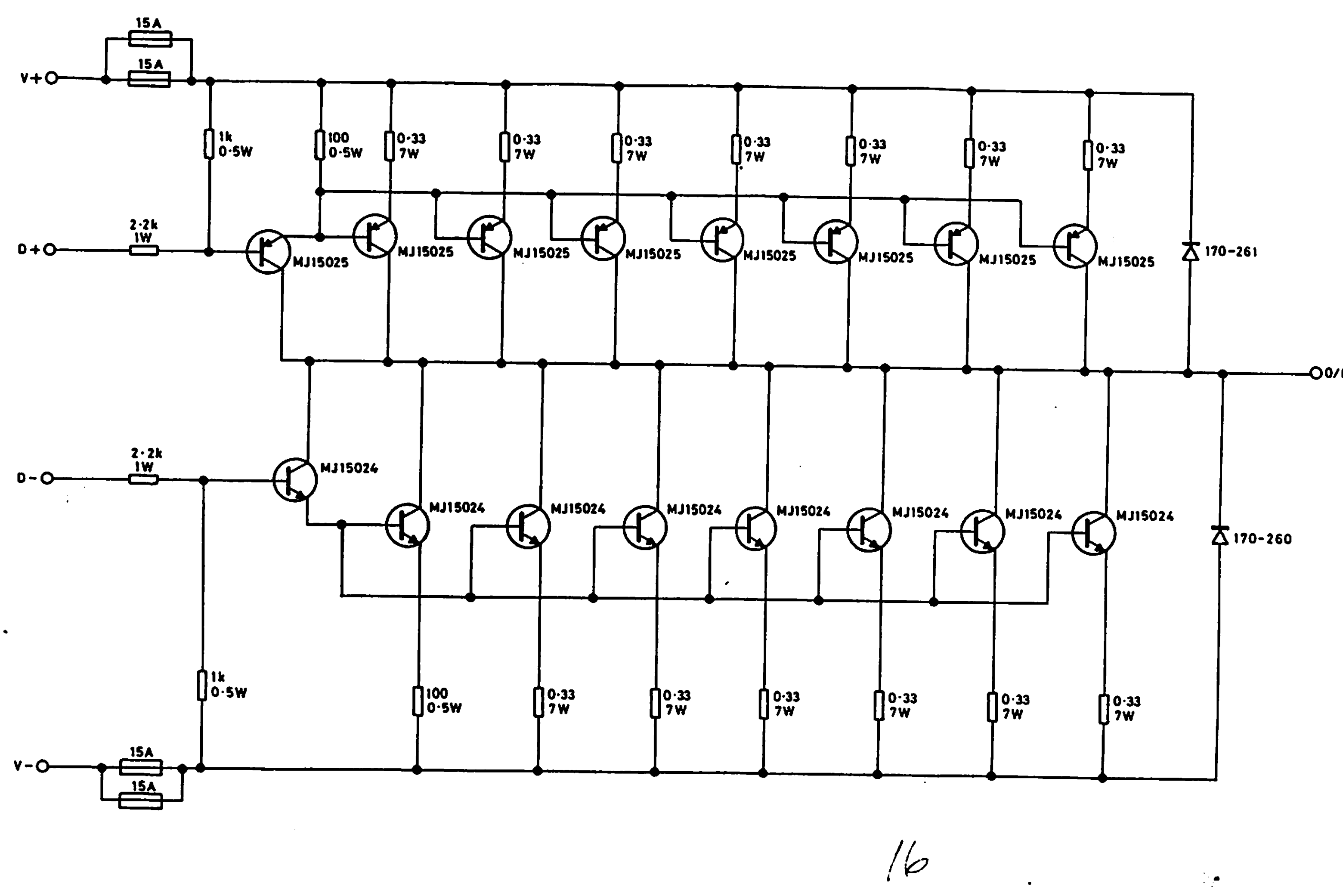

gram 14 Part of Heatsink Assembly (12/20A Channels)

:INAL	REVISION No						OXFORD
JE DATE	REVISION CODE						
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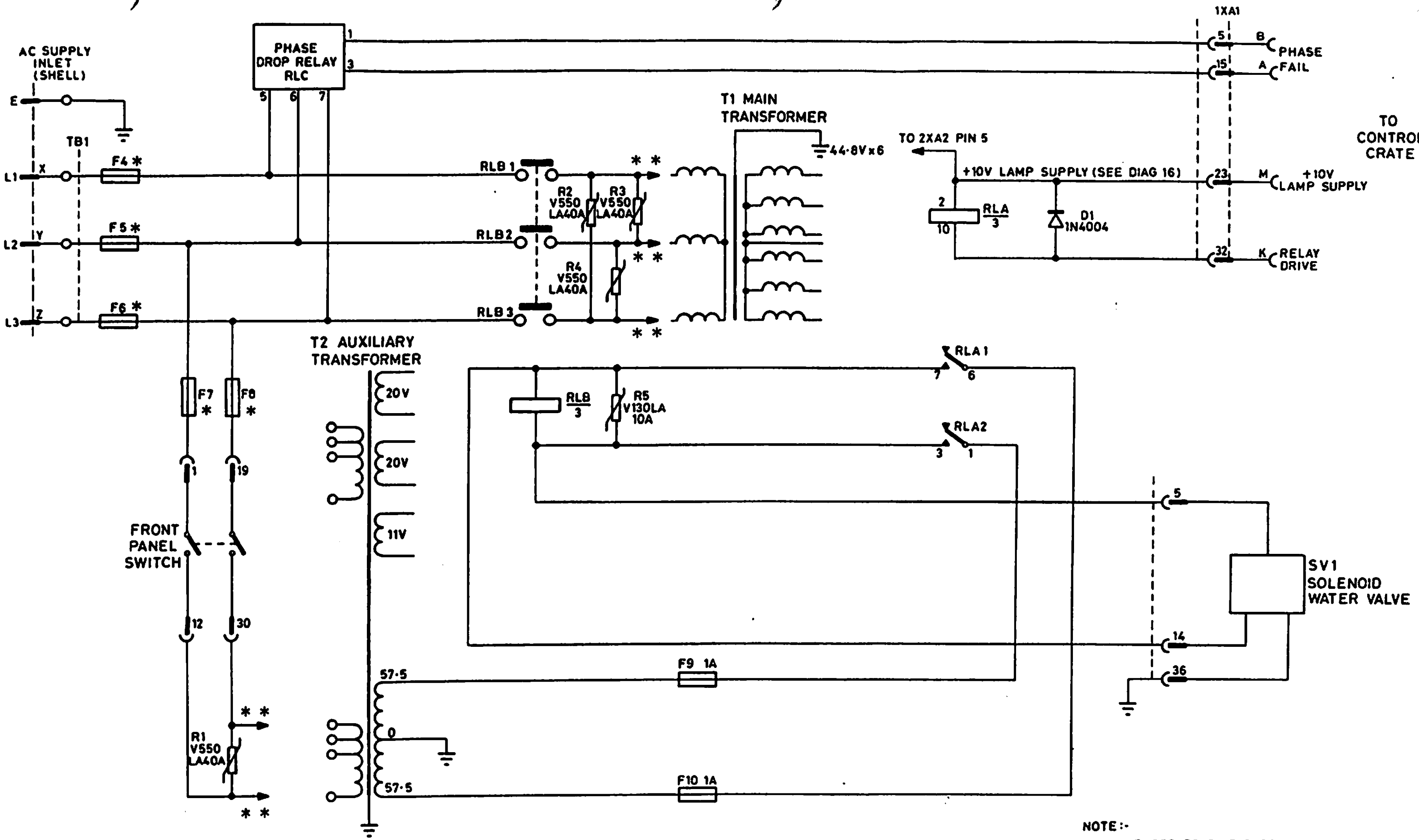

NOTE:-

* FUSES TO SUIT SUPPLY VOLTAGE (SEE PARA 2.1.2)

* * TRANSFORMER TAPS TO SUIT SUPPLY VOLTAGE (SEE PARA 2.1.2)

gram 15 Cabinet Wiring (Mains Side)

...GINAL ...UE DATE	REVISION No						OXFORD
	REVISION CODE						
	DATE						

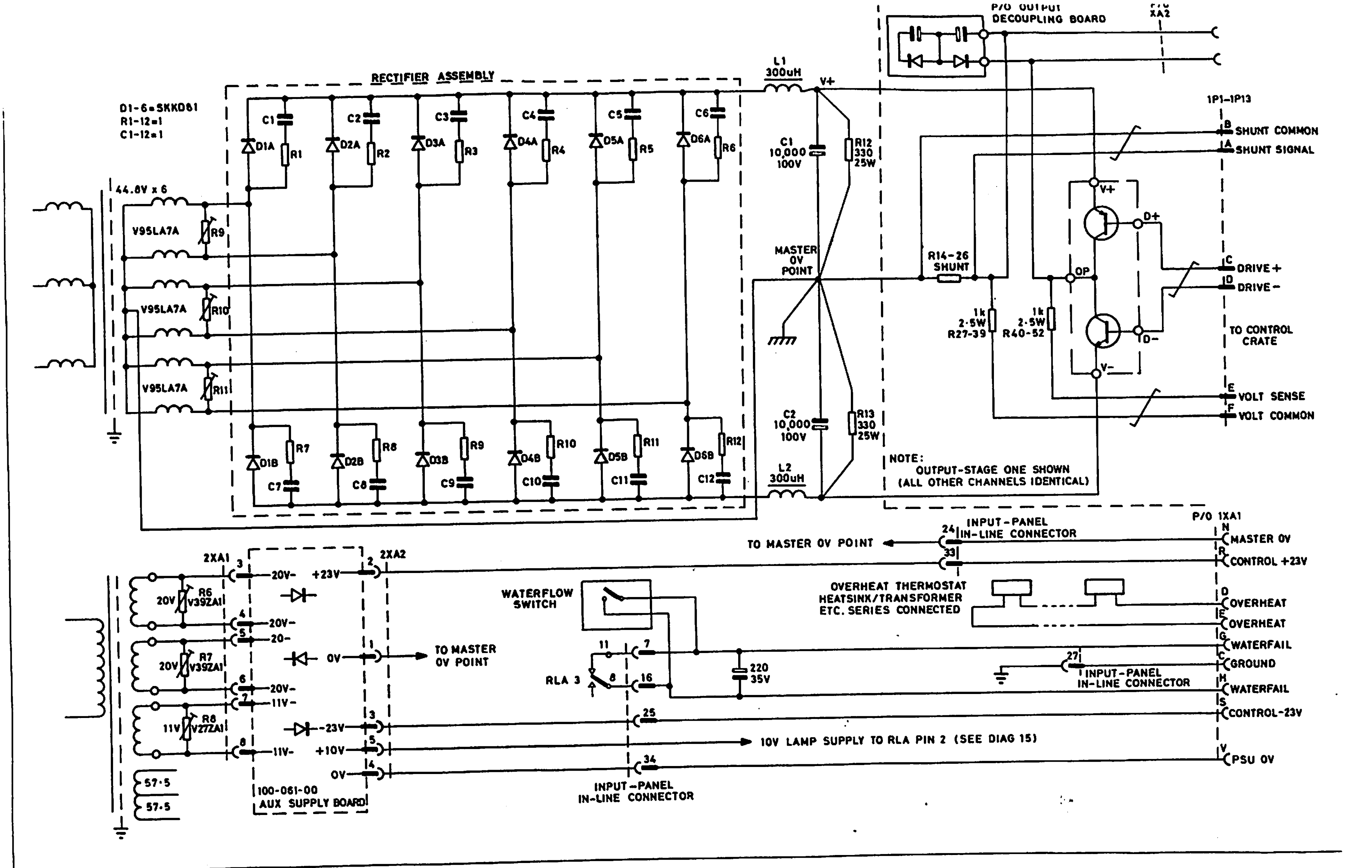

Diagram 16 Cabinet Wiring (DC and Output)

ORIGINAL ISSUE DATE	REVISION No						OXFORD
	REVISION CODE						
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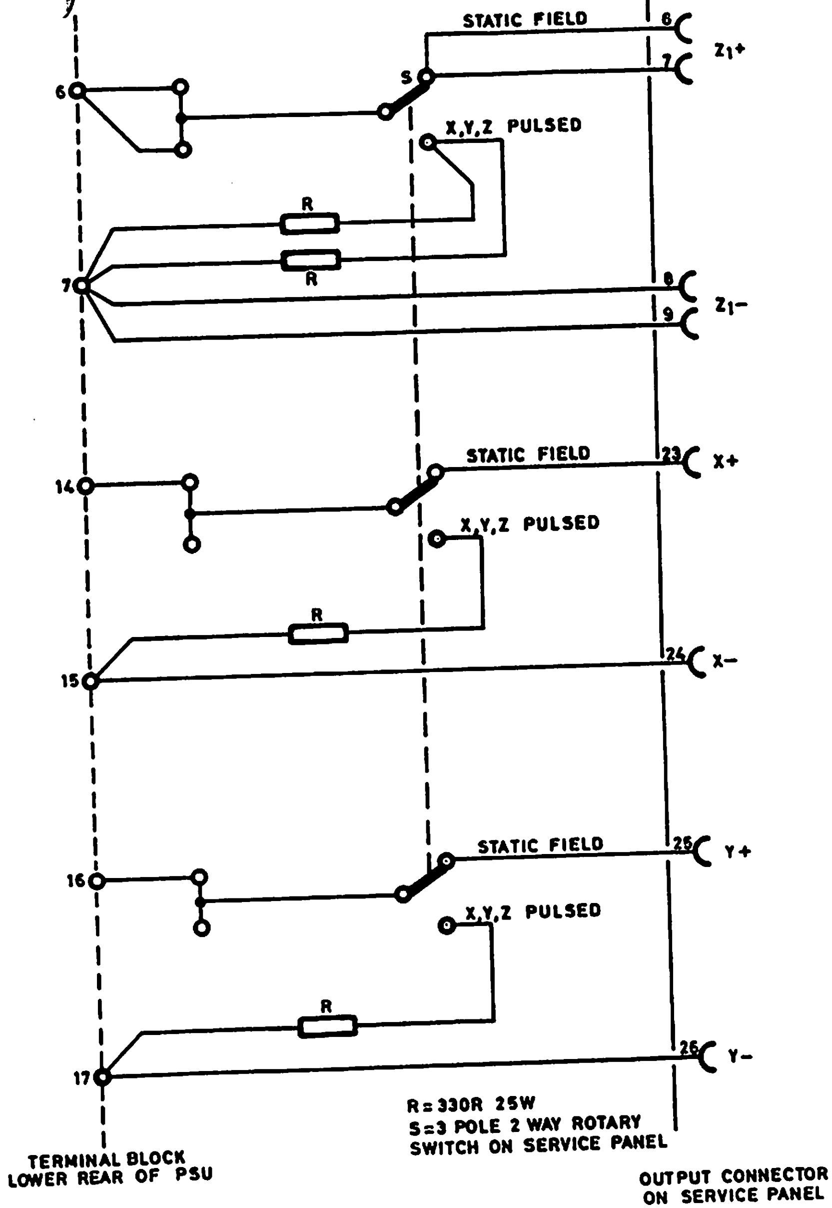

Diagram 17 Static Field/Pulsed Gradient Switch Circuit Diagram

ORIGINAL ISSUE DATE	REVISION No						OXFORD
	REVISION CODE						