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Instruction No 2450
Issue 2
(April 1986)

Installation, Commissioning and Service

R500 Series 2

INSTRUCTION 2450

While every care is taken to ensure the accuracy of the description and illustrations in this publication we reserve the right to make any modifications in the design of the apparatus considered to be in the interest of our customers.

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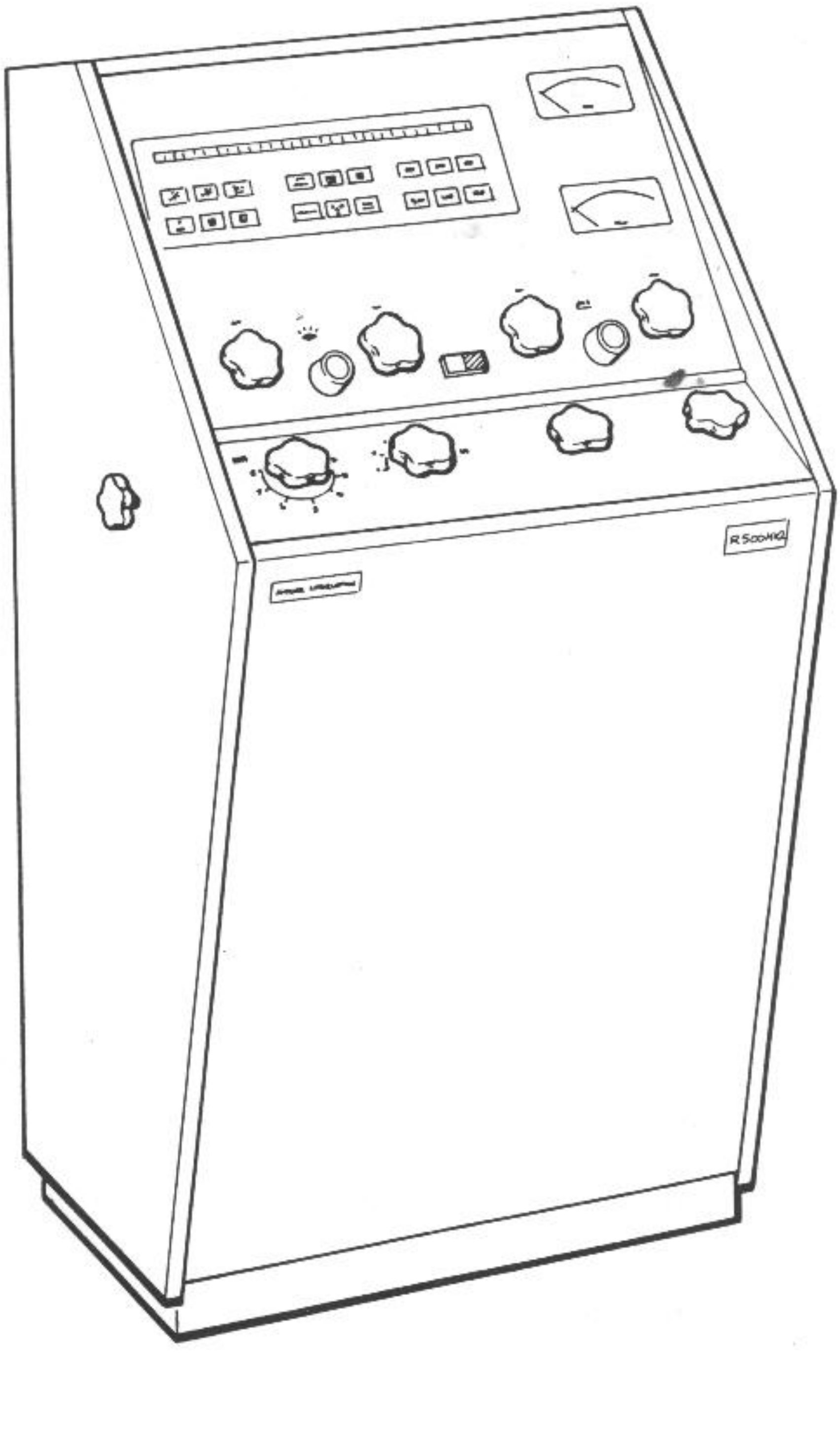

R500 SERIES 2 CONTROL CONSOLE

RADIATION HAZARDS & SAFETY PRECAUTIONS

It is dangerous for any person to operate this equipment without having appropriate training which will have included instruction in the means for using X-radiation without hazard to patient, user and surroundings.

The purpose of these instructions is to inform the user about the technical functioning of the equipment for the intended purpose(s); they do not cover any aspects of radiation protection or other aspects of safety relating to the application of the equipment.

The user must be aware of all regulations and requirements that may be applicable governing the installation and use of equipment producing ionising radiation for medical purposes.

ELECTRIC SHOCK HAZARD

Do not remove any high voltage cable connection to an X-ray tube. Note also that such a cable may retain an electric charge or be connected to other components retaining a charge after the equipment has been switched off.

Do not remove any covers or panels giving access to live parts. Any cover requiring the use of a tool for its removal can be assumed to be in this category.

EXPLOSION HAZARD

This equipment is not classified as anaesthetic-proof and may ignite flammable anaesthetics. Flammable agents used for skin cleaning or disinfection may also produce an explosion hazard.

HEALTH & SAFETY AT WORK ACT 1974 (UK installations only)

All equipment manufactured and supplied by this Company has been tested and examined to ensure as far as is reasonably practicable, that it is safe and without undue risk to health when properly used.

The conditions under which our equipment will operate safely and without undue risk to health are specified in our Operating Instructions and users should ensure that they fully understand the technical conditions regarding safe operating of the equipment and are conversant with and observe Regulations and Codes of Practice which relate to X-ray Equipment.

It is also the duty of the employer to ensure that his employees fully understand the Regulations and Operating Instructions.

CONTENTS

CONTENTS (Continued)

Always refer to the Supplement Section before commencing installation and/or service work.

ILLUSTRATIONS

GENERAL REQUIREMENTS

PRE-INSTALLATION INSTRUCTIONS

The following instructions are to be read in conjunction with the layout drawing prepared by **PICKER INTERNATIONAL LIMITED.**

GENERAL ELECTRICAL REQUIREMENTS

All electrical wiring and interconnection must be strictly in accordance with the recommendations contained in 'The regulations for the Electrical Equipment of Buildings' published by the Institute of Electrical Engineers or other appropriate national wiring regulations. Special care must be taken to ensure that all conduits are properly bonded and connected to earth.

The following table shows the sizes of cables to be used for interconnecting equipment.

Cross-Sectional Area mm	Metric Sizes		Imperial Sizes		Current Rating, A
	Stranded	Flexible	Stranded	Flexible	
1.0		32/0.20		40/.0076	10
1.25	3/.74		3/.02910		
1.5	nominal	30/0.25			15
2.0			3/.036	70/.0076	15
3.0			7/.029	110/.0076	20
2.5		50/0.30			20
4.0	7/0.85	56/0.30			25
4.5			7/036	162/.0076	25
5.3				105/.010	30
6.0	7/1.04				30
6.8			7/.044		36
10.0	7/1.35		7/.052		42
15.0	7/1.70		7/.064		53
20.0			19/.044		62
25.0	7/2.14		19/.052		73
35.0	19/1.53				90
40.0			19/.064		97
50.0	19/1.78				145
65.0			19/.083		160
70.0	19/2.14				185

The metric sizes quoted are nominal, some variations are made by suppliers.

Note: Solid conductors are **NOT** suitable. Stranded or flexible cables **MUST** be used.

All metal parts of items such as tables, tubestands and tracks must be securely earthed at the point indicated in the Pre-installation Schedule and layout drawings, then returned to the main earth point at the main isolator in the X-ray room. A stranded conductor of suitable cross-sectional area may be used or a copper strip of cross-section not less than 16mm x 2.5mm. A tail of 0.5 metre should be left for connection by the Installation Engineer. The resistance between any earthed metal part and the main earth point must not exceed 0.1ohm as specified in paragraph 7 of DHSS General Technical Clauses 1973. All leads must be enclosed in steel conduit or trunking.

Normally all connections to terminals will be made by **PICKER** Equipment Engineers.

GENERAL STRUCTURAL REQUIREMENTS

Each installation must be investigated by an Architect or Surveyor to determine the size of girders and other bearers required to support the weight of equipments installed.

PREPARATION OF CEILING

Ceiling tracks can be fixed directly to the ceiling but, normally, a board is required which must be of hardwood not less than 40mm thick. For width, length and positions, refer to layout drawing. Ceiling boards must be level and capable of supporting the moving load stated in the relevant pre-installation instruction and must be firmly bolted to the ceiling or other fixings. Access to the upper side of the board should be possible for the Installation Engineer to bolt the tracks in position.

CEILING MOUNTED TUBE SUPPORTS

The lateral movement of ceiling tracks must not be greater then 3mm; if necessary fit cross-members between girders or use some other method to prevent excessive lateral movement.

FLOOR TO CEILING MOUNTED TUBE SUPPORTS - MOBILE

The ceiling board and floor track must be plumb level to within a tolerance of 3mm in the position shown on the layout drawing.

FLOOR TO CEILING/WALL MOUNTED TUBE SUPPORTS & BUCKY STANDS

Provide and fit a hardwood fixing board to the ceiling or wall. The board should be a minimum size of 230mm x 230mm x 40mm. Fixings for the board must not coincide with the fixings on the extension tube plate or ceiling tracks. For the maximum loading on the extension tube plate fixings, refer to the pre-installation instructions.

CEILING SUPPORT FOR HT CABLES

A ceiling board 50mm wide is normally required to support the Capitol Track and fittings, together with the HT cables. For length and position refer to the layout drawing.

PREPARATION OF FLOOR

A level floor surface must be provided for all equipments. No part of the floor area concerned may be more than 3mm from the nominal floor level. The areas over which the equipments are to be fixed must be checked with the aid of a straight edge, and any high spots removed until the areas are within tolerance. If the floor cannot be improved or is too weak, bearers of the type as shown in the pre-installation instruction should be let into the floor. The upper surface of the bearers must be level in all directions and the bearing surface must not be lower than the highest point of the adjacent floor.

In rooms where a new concrete or composition floor is being laid, built in bearers may be considered.

FLOOR TRACKS

When a flush floor track is to be used a suitable channel must be made in the floor, or a channelled bearer provided. (See pre-installation schedules).

1 SPECIFICATION

1.1 Output

37.5 kW (IEC Rating) 2 pulse

Max mA - 500mA at 100kV on a line resistance of less than 0.3 ohm referred to 415V ac

Max kV - 125kV at 300mA

1.2 Power Supply

Nominal 415V, 380V and 220V, single phase, 50/60Hz

NOTE 1. There is reduced output performance with a 220V power supply.

2 The R500 Series 2 can be used on a 60Hz supply after factory modifications have been carried out. It is important, therefore, that the correct supply frequency is specified at the time of ordering.

Line-to-line resistance is not to exceed 0.33ohm at 415V, 0.3ohm at 380V and 0.15ohm at 220V.

1.3 Mains Voltage Compensation

Manual adjustment range available:

Nominal 415V	Adjustment range is 367-455V
Nominal 380V	Adjustment range is 332-420V
Nominal 220V	Adjustment range is 172-260V

1.4 kV Range

Radiography: Fine and coarse kilovoltage controls with adjustment between 45kVp to 125kVp in steps of approximately 1kV.

Fluoroscopy: 60-110kV, continuously adjustable.

1.5 mA Range

Broad Focus:	300mA at 125kV
	400mA at 125kV
	500mA at 100kV
Fine Focus:	50, 100, 200mA at 125kV
Fluoroscopy:	0.5 - 5mA, continuously adjustable

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Fine Focus:	50, 100, 200mA at 125kV
Fluoroscopy:	0.5 - 5mA, continuously adjustable

1.6 Timer Range

Radiography:	0.01 - 5 seconds 24 position rotary switch selector
Fluoroscopy:	0-10 minutes with buzzer alarm during last 5s prior to automatic termination at zero.

1.7 Repetition Rate

Up to 6 exposures per second

1.8 X-ray Tubes

Sockets are fitted for the connection of 4 double-focus X-ray tubes, the fourth tube being for mammography only. Automatic overload protection for a total of 6 different foci is provided.

1.9 Gecomat 2

If a Gecomat is incorporated, automatic kV compensation is applied at 60kV, 80kV and 100kV.

1.10 Displays

Figure 1 is a view of the control panel.

A Two meters are provided:

1 Voltmeter. This indicates the selected kV. During standby it indicates the kV preselected for radiography.

2 Combined voltmeter and mA meter. This has two scales: 0-10mA for fluoroscopy; 0-1000mA for radiography. During standby, a red mark at the centre of the scale indicates the correct line voltage. This is set by rotating the control at the left-hand side of the control console casing.

B The illuminated display panel indicates the following:

Pre-selected radiographic mA
Technique selected
Tube focus selected
Ready to expose
Tube overload
High speed stator selection (if applicable)
X-rays on
Exposure time

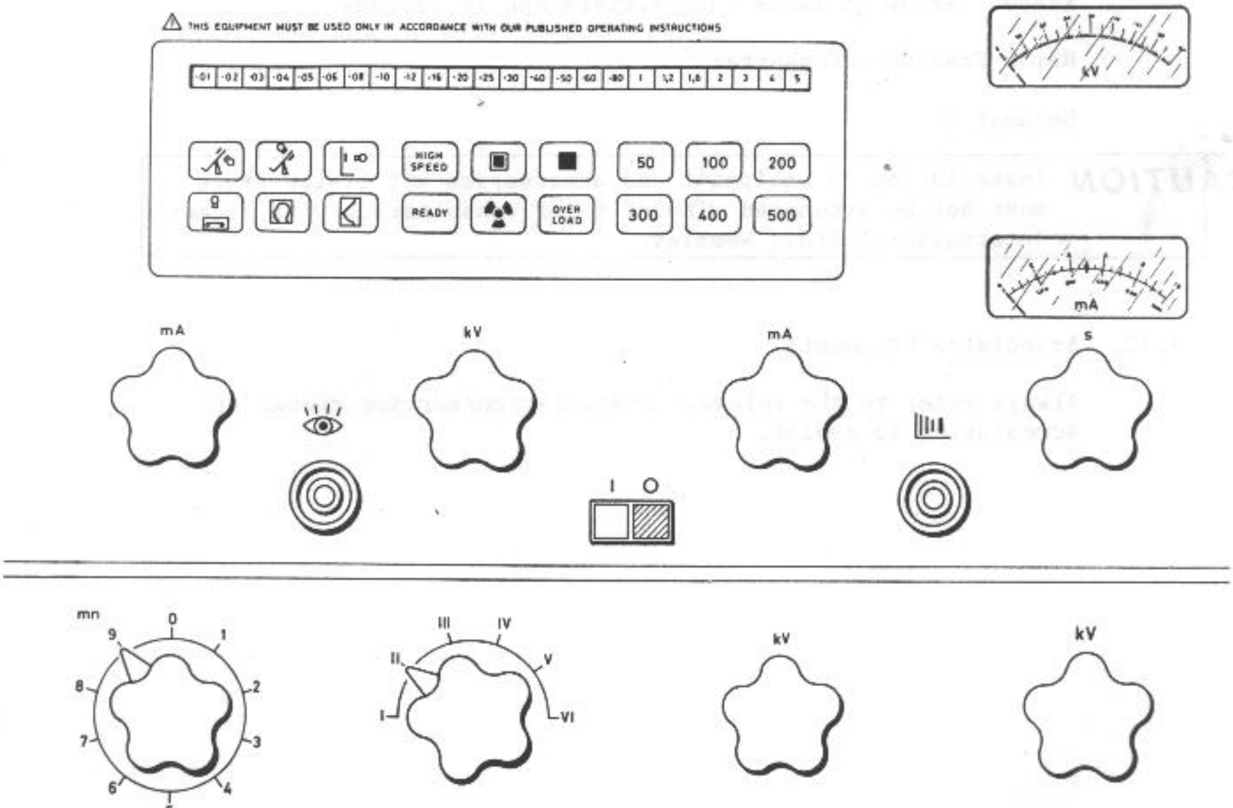

FIG.1 CONTROL CONSOLE-CONTROL PANEL

1.11 Interfacing

Facilities are provided for direct connection of the following equipment:

PICKER X-ray Tables and Chest Bucky Stands (modification is required for standard sectograph)

Apollo Ceiling Tubemount

K-S80 series of Image Intensifiers and TV Systems

HS150 Frequency Converter

Gecomat 2

CAUTION Installation of equipment and accessories not listed above must not be attempted without prior consultation with Picker International Ltd., Wembley.

1.12 Associated Documents

Always refer to the relevent installation/service manual of accessories to assist.

2 PRELIMINARY INSTALLATION WORK

2.1 Checking Pre-Installation Work

Ensure that the required pre-installation work has been completed in accordance with the pre-installations schedules and layout drawings provided.

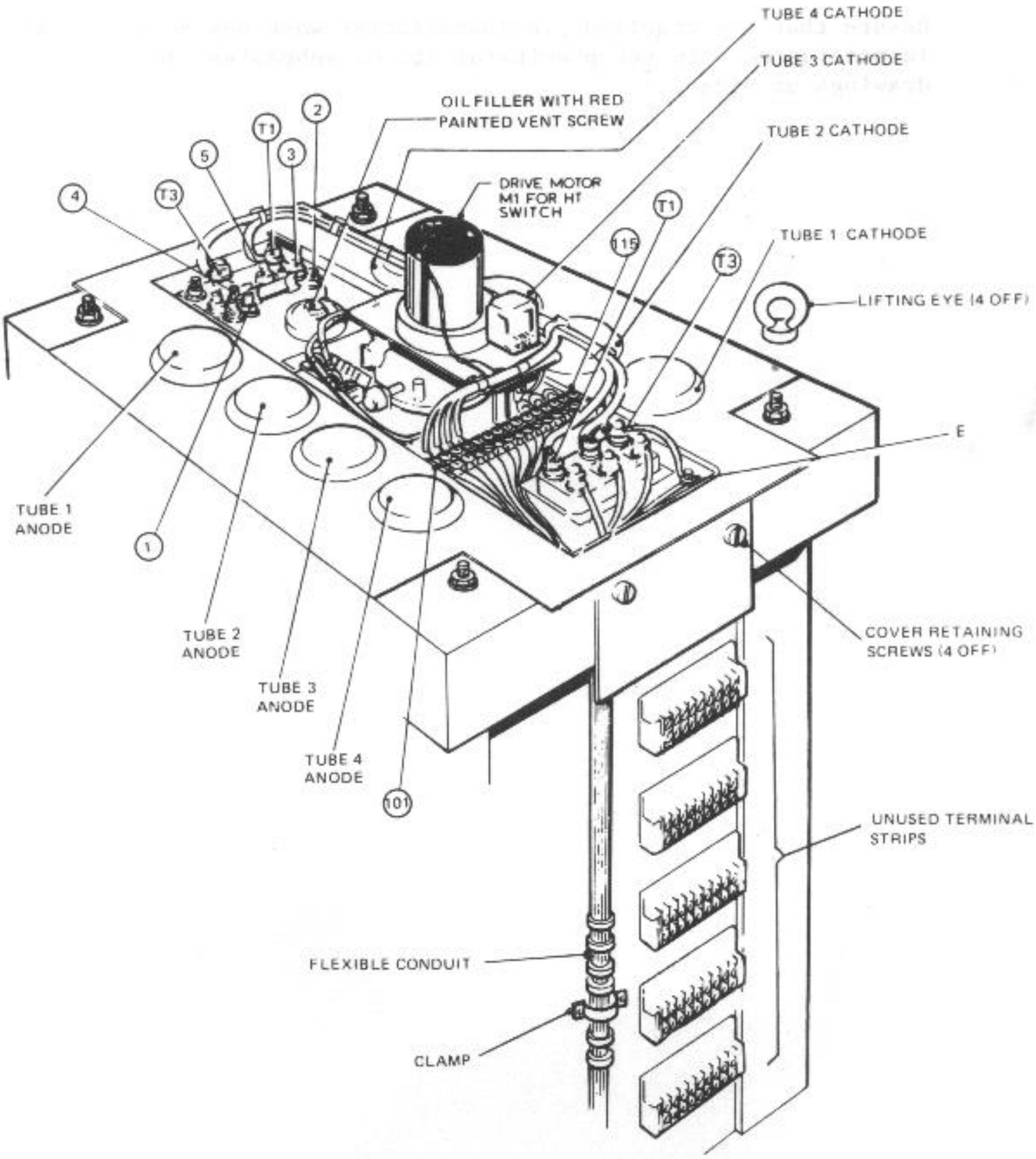

FIG.2 HT TRANSFORMER TOP AND CONNECTIONS

3 INVENTORY

Equipment is supplied as follows:

BOX 1 Containing R500 Series 2 Control Console

BOX 2 Containing R500 Series 2 HT Transformer

BOX 3 Containing the following items:

1 off Wall Junction Box prewired to 2 flexible wiring conduits for connection to the Control Console

1 off Wall Junction Box identical to the above for connection to the HT Transformer

1 off flexible wiring conduit to connect the Wall Junction Box to the HT Transformer

3.1 Kit Supplied with DHSS Orders

DHSS installations will be supplied with an additional kit Stock No.M1286-517 containing the following items:

4 off Exposure Counters	X610-905
25 off Terminals Crimp Spade 4 BA	6233-201
1 off Wall Box containing:	MC22049
Tube selected lights and Auxiliaries Panel	
Room lights transformer	

If any item is missing or damaged, inform Picker International and the carriers immediately.

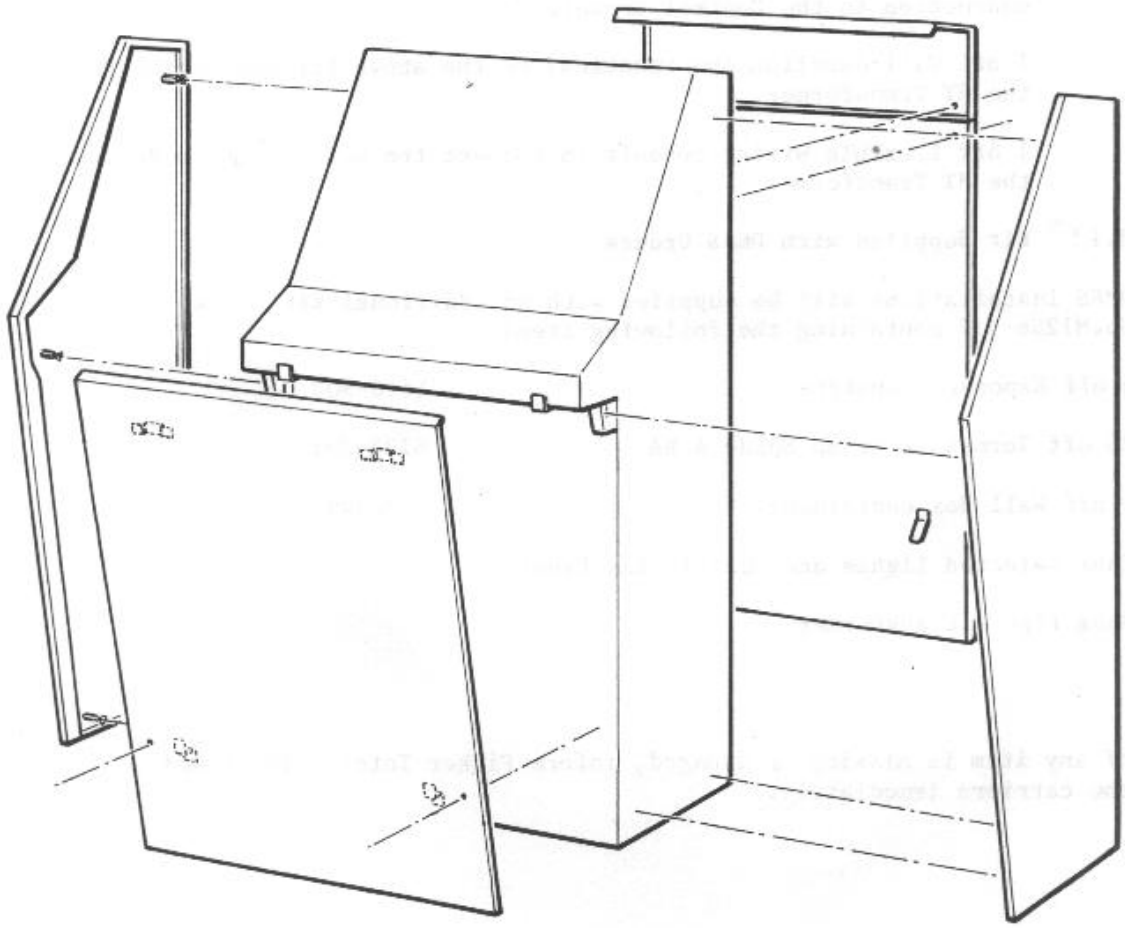

FIG.3 CONTROL CONSOLE - COVERS

4 INSTALLATION

4.1 Preliminaries

A Ensure that the required pre-installation work has been completed in accordance with the pre-installation schedules and layout drawings provided.

B Circuit diagrams for the R500 Series 2 are given in Appendix 2.

4.2 HT Transformer Oil Level

A Remove the HT transformer cover (see para. 4.3.2).

B Remove the oil-filler cover (see Fig. 2) from the HT transformer.

CAUTION: Complete the following steps as soon as possible to prevent contamination of the oil.

C Check that the oil level is between 25mm (1in) and 38mm (1½in.) from the oil filler top. Use a clean implement such as a screwdriver as a dipstick.

NOTE 1. The levels specified are at normal ambient temperature of 20°C.

2. Export units may have 23 litre (5 gallons) of oil despatched separately. Transfer the oil to the HT transformer using a funnel with a fine gauze to filter out any impurities. Add the oil slowly, directing it so that the minimum number of air bubbles are formed.

3. Only use DIALA grade B Shell or equivalent oil.

D If the oil level is low, add oil as detailed in **Note** 2 above.

E Refit the oil-filler cover having first removed the vent screw from it. (The vent screw is fitted to prevent oil spillage during transit.)

CAUTION: The vent screw must be removed when the HT transformer is in use.

F Refit the HT transformer cover.

4.3 Removing and Refitting Covers

4.3.1 Control Console

To gain access to the interior of the Control Console for installation connections and adjustments, it is necessary to remove the covers (see Figure 3). When work has been completed, the covers must be refitted.

4.3.2 HT Transformer

To gain access to the HT transformer terminals, it is necessary to remove the cover. To do this, the four cover securing screws must be unscrewed (see Figure 2). When work has been completed, the cover must be refitted.

4.4 Connecting the Control Console

A The two flexible conduits from the prewired wall box (see Figure 6) enter the Console through 2 holes in the base panel at the appropriate side.

B Cable clamps are used to secure the conduits to the left-hand side panel of the Console.

C The two conduits contain 120 light-duty conductors (5 of which are spare) and 8 heavy-duty ones.

D The light-duty conductors are formed into 8 branches. Each branch is terminated by a multi-way terminal strip, with the first and last wire on the strip being idented with numbers corresponding to those on the fixed terminal strip to which it is to be connected.

E There are 8 fixed terminal strips on the left-hand side panel of the Console (see Figure 4), the top strip being allocated for Gecomat connection.

F Connect the flexible conduit wiring strips to the corresponding fixed terminal strips and check that the flexible conduit terminal strip idents correspond to the numbers on the fixed terminal strips.

G The heavy-duty conductors are divided into three groups which are to be secured to the main terminal board on the Console as follows:

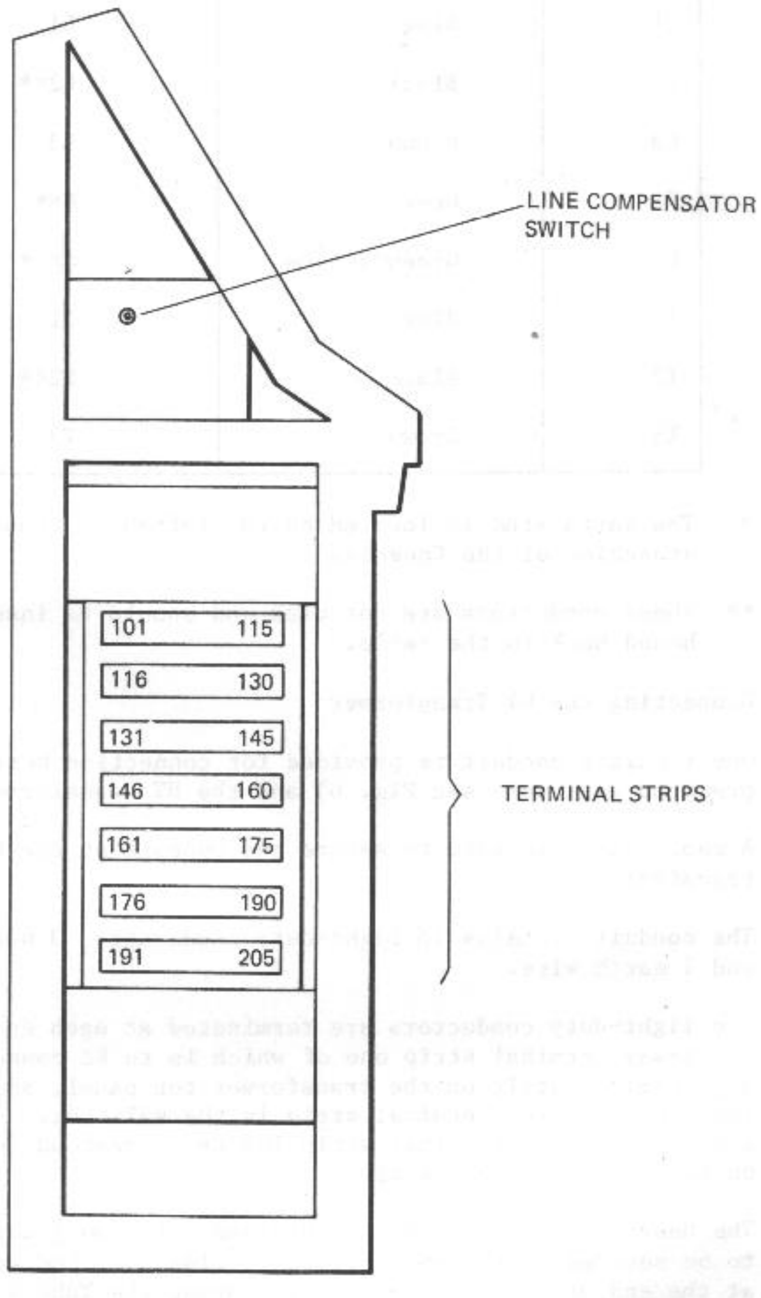

FIG. 4 CONTROL CONSOLE-TERMINAL STRIPS

Conductor		Terminal Connection
Ident	Colour	
L1	Blue	L1
L2	Black	L2**
L3	Brown	L3
N	Grey	N**
E	Green/Yellow	⏚ *
T1	Blue	T1
T2	Black	T2**
T3	Brown	T3

* The earth stud is located on the left-hand front stanchion of the Console.

** These conductors are not used and should be insulated and bound back to the cable.

4.5 **Connecting the HT Transformer**

A One flexible conduit is provided for connection between the prewired wall box (see Fig. 6) and the HT transformer (see Fig.2).

B A cable clamp is used to secure the conduit at the HT transformer.

C The conduit contains 15 light-duty conductors, 3 heavy-duty ones, and 1 earth wire.

D The light-duty conductors are terminated at each end by a multi-way terminal strip one of which is to be connected to the 15 way terminal strip on the transformer top panel, and the other to the corresponding terminal strip in the wall box. Check that the flexible conduit terminal strip idents correspond to the numbers on the fixed terminal strip.

E The heavy-duty conductors are divided into two groups which are to be secured to the appropriate terminals at the wall box and at the end of the HT transformer nearest the Tube 4 anode socket (see Fig. 2) as follows:

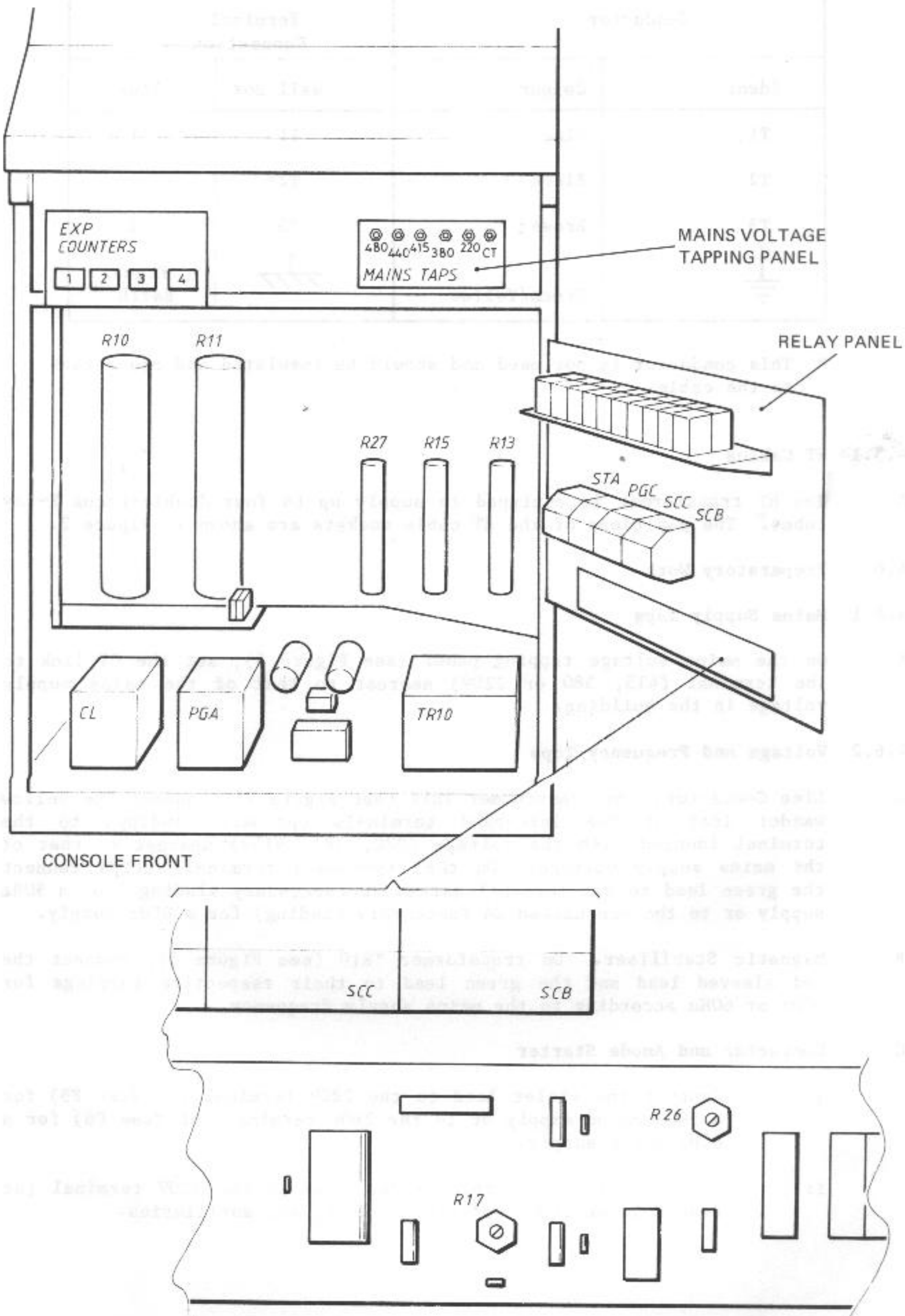

FIG.5 CONTROL CONSOLE-FRONT INTERNAL VIEW

Conductor		Terminal Connection	
Ident	Colour	Wall Box	Tank
T1	Blue	T1	1
T2	Black	T2*	
T3	Brown	T3	2
⏚	Green/Yellow	⏚	Frame Earth

* This conductor is not used and should be insulated and bound back to the cable.

4.5.1 HT Cables

A The HT transformer is equipped to supply up to four double-focus X-ray tubes. The positions of the HT cable sockets are shown in Figure 2.

4.6 Preparatory Work

4.6.1 Mains Supply Taps

A On the mains voltage tapping panel (see Figure 5), set the CT link to the terminal (415, 380 or 220V) nearest to that of the mains supply voltage in the building.

4.6.2 Voltage and Frequency Taps

A Line Contactor. On transformer TR17 (see Figure 7), connect the yellow wander lead at the left-hand terminals (primary winding) to the terminal idented with the voltage (220, 380, 415V) nearest to that of the mains supply voltage. On the right-hand terminal strips connect the green lead to the terminal marked 20 (secondary winding) for a 50Hz supply or to the one marked 24 (secondary winding) for a 60Hz supply.

B Magnetic Stabiliser. On transformer TR10 (see Figure 5), connect the red sleeved lead and the green lead to their respective tappings for 50Hz or 60Hz according to the mains supply frequency.

C **Contactor and Anode Starter**

i Connect the violet lead to the 220V terminal (at fuse F5) for a 50Hz mains supply or to the 260V terminal (at fuse F6) for a 60Hz mains supply.

ii Connect the single thick white lead to the 220V terminal (at fuse F5) for 240V operation of Bucky and ancillaries.

4.6.3 X-Ray Tube Over-Pressure Thermal Cut-Out Terminals

A On delivery these will be linked on the Console terminal strips (see Figure 4) as follows:

TUBE 1 110 to 117
TUBE 2 111 to 118
TUBE 3 112 to 119
TUBE 4 113 to 120

If over-pressure thermal cut-outs or X-ray table interlocks have to be fitted, the associated links must be removed. Terminals are available on the wall box to accommodate the wires from the tube thermal cut-outs. (See Appendix 1 for details of the interconnections.)

NOTE If tube or tubes are not installed, the corresponding link must be open (relay PL is open and Prep and Fluoro are disabled).

4.6.4 X-ray Tube Stator Connections

Stator wires should be connected to the wall box. The terminal numbers are as follows:

TUBE NUMBER	TERMINAL NUMBER	STATOR WIRE COLOUR
1	121	Brown (common)
	122	Blue (capacitive)
	123	Black (main)
	E	Green/Yellow
2	124	Brown (common)
	125	Blue (capacitive)
	126	Black (main)
	E	Green/Yellow
3	127	Brown (common)
	128	Blue (capacitive)
	129	Black (main)
	E	Green/Yellow
4	130	Brown (common)
	131	Blue (capacitive)
	132	Black (main)
	E	Green/Yellow

4.6.5 Bucky Connections

The standard Bucky connections are as follows:

133 - 220V Bucky 1 start
134 - 220V Bucky 2 start
135 - 220V Bucky 3 start
136 - 220V Bucky 4 start
137 - 220V Bucky 5 start
138 - 220V Bucky 6 start
141,142 - Common Bucky returns (220V)
146-148 - Common 0V timer start from Buckys

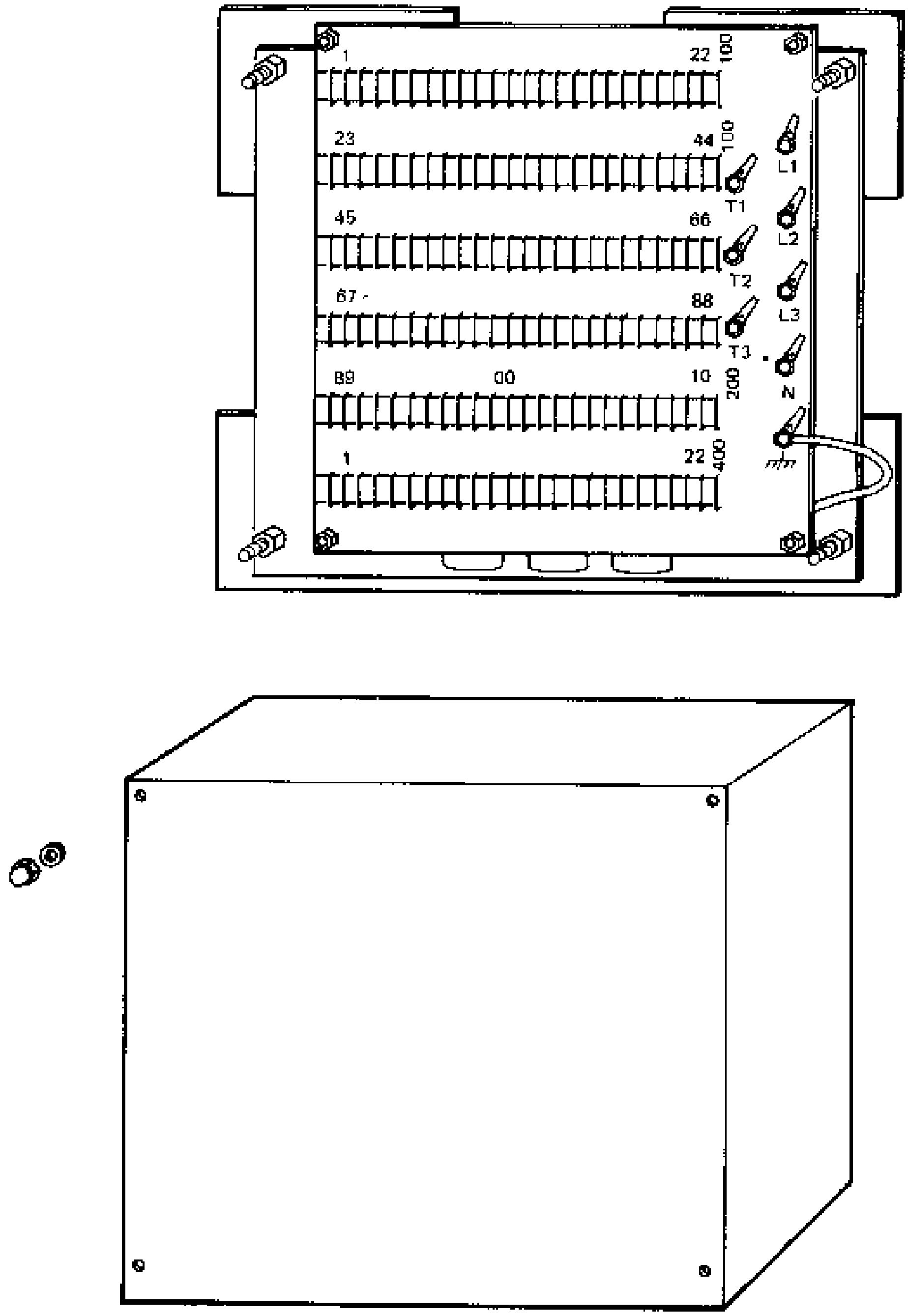

FIG.6 R500 SERIES 2 WALL BOX

For techniques that do not require buckies, link the associated bucky start terminals to terminal 147. This can be effected on the Console terminal strips.

The bucky wiring should be connected to the wall box terminals.

Typical interconnections are detailed below:

Technique	Tube	Bucky	R500 terminals	Bucky terminals
1	1	Not used	Link 133 to 148	Not used
2	2	Table	134	124
			148	125
			142	129
3	2	Versatilt	135	126
			148	125
			142	129
4	2	Other	136	Bucky start
			148	Exp start
			142	Bucky return
5	3	Other	137	Bucky start
			148	Exp start
			142	Bucky return
6	4	Mammo	138	Bucky start
			148	Exp start
			142	Bucky return

Note: There is no provision to switch a bucky in or out once a particular technique has been selected.

4.6.6 Tube Exposure Counters

A Screw the counter assemblies to the panel (see Fig. 5).

B Connect each pair of wires to the appropriate pair of terminals allocated to each tube (i.e. 1, 2, 3 and 4).

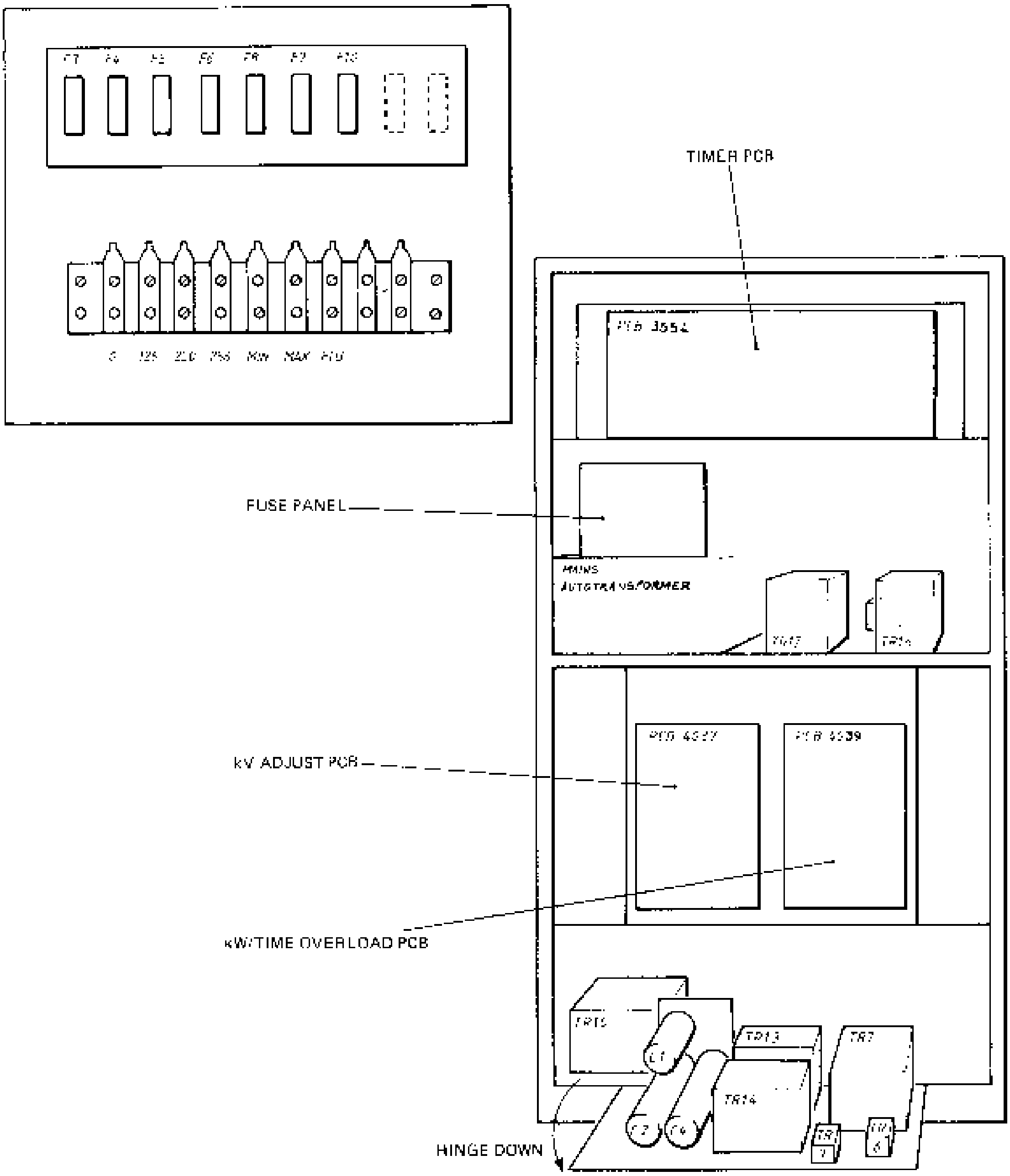

FIG.7 CONTROL CONSOLE-REAR INTERNAL VIEW

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4.7 R500 Series 2 Terminal Strip Connections

Figure 4 shows the locations of the terminal strips on the Console.

TERMINAL NUMBER	TERMINAL DESIGNATION	
101	HT tank -ve supply to metering	
102	HT tank +ve supply to metering	
103	X-ray tube filament transformer common	
104	X-ray tube filament transformer supply - broad focus	
105	X-ray tube filament transformer supply - fine focus	
106	Supply for tube 1 HT changeover circuit	
107	Supply for tube 2 HT changeover circuit	
108	Supply for tube 3 HT changeover circuit	
109	Supply for tube 4 HT changeover circuit	
110	From tube 1 thermal interlock switch	Verifies position of changeover switch after remote operation
111	From tube 2 thermal interlock switch	
112	From tube 3 thermal interlock switch	
113	From tube 4 thermal interlock switch	
114 -	Main 24V dc supply for HT changeover circuit	
115 +		
116	Spare terminal	
117	To tube 1 thermal interlock switch	Operates SPL relay if tube temperature is normal and correct tube is selected
118	To tube 2 thermal interlock switch	
119	To tube 3 thermal interlock switch	
120	To tube 4 thermal interlock switch	
121	Tube 1 common stator winding supply	
122	Tube 1 capacitive stator winding supply	
123	Tube 1 main stator winding supply	
124	Tube 2 common stator winding supply	
125	Tube 2 capacitive stator winding supply	
126	Tube 2 main stator winding supply	
127	Tube 3 common stator winding supply	
128	Tube 3 capacitive stator winding supply	
129	Tube 3 main stator winding supply	
130	Tube 4 common stator winding supply	
131	Tube 4 capacitive stator winding supply	
132	Tube 4 main stator winding supply	
133	OV Bucky 1 start	
134	OV Bucky 2 start	
135	OV Bucky 3 start	
136	OV Bucky 4 start	
137	OV Bucky 5 start	
138	OV Bucky 6 start	
139	Expose ready - spare N/O contact	
140		
141 } OV	220V ac supply for ancillaries	
142		
143 } 220V		
144		
145	Spare terminal	

TERMINAL NUMBER	TERMINAL DESIGNATION
146, 147, 148	Bucky feedback common
149	+24V technique 1
150	+24V technique 2
151	+24V technique 3
152	+24V technique 4
153	+24V technique 5
154	+24V technique 6
155	+24V enable to external exposure interlocks
156, 157	Fluoroscopy external footswitch
158	Remote radiography preparation command
159	Remote radiography expose command
160	Preparation enable circuit
161	Common (Anode speed selection circuit)
162	Normally closed (150Hz) contact (Anode speed selection circuit)
163	Normally open (50Hz) contact (Anode speed selection circuit)
164	Automatic exposure device circuit common for kV compensation
165	+ 15V dc
166	Minimum supply (from F9) external fluoroscopic
167	Maximum supply (from F8) kV variac connections
168	Slider internal fluoroscopy kV variac connection
169	Slider external fluoroscopy kV variac connection
170	Internal mA drive control input
171	Internal mA drive control output
172	Output from external fluoroscopy mA drive
173, 174	HS safety interlock
175	+ 24V enable from external exposure interlocks
176	Photo time in circuit
177	Photo time stop signal (stop exposure)
178, 179	Automatic exposure device circuit contacts (kV compensation)
180	Spare terminal
181	Spare technique switch common in
182	Spare technique switch out for Bucky 1 (signal contacts)
183	Spare technique switch out for Bucky 2 (signal contacts)
184	Spare technique switch out for Bucky 3 (signal contacts)
185	Spare technique switch out for Bucky 4 (signal contacts)
186	Spare technique switch out for Bucky 5 (signal contacts)
187	Spare technique switch out for Bucky 6 (signal contacts)
188, 189	Spare X-ray radiography contact (RTE-3)
190	Spare terminal
191	Common spare fluoroscopy contact
192	Normal closed spare fluoroscopy contact
193	Normally open spare fluoroscopy contact
194	Spare terminal

TERMINAL NUMBER	TERMINAL DESIGNATION
195, 196	Spare N/O radiography preparation contact
197, 198	Normally open spare fluoroscopy contact
199, 200	Normally open spare fluoroscopy contact
201	Common stator winding supply for 150Hz starter
202	Capacitive stator winding supply for 150Hz starter
203	Main stator winding supply for 150Hz starter
204 +, 205 -	mA meter (must be normally short circuited)

4.8 Common Interface Connections

Interfacing connections are detailed in Appendix 1.

C Turn the line compensator switch on the left-hand side of the Console until 220V is indicated on the test meter.

D Check that the pointer of the mA meter is coincident with the red datum mark. Adjust R17 (see Fig.5), if necessary, to achieve this.

E Switch OFF the R500.

F Disconnect the test voltmeter.

5.4 **Setting up the Tube Overload Circuits**

A Three types of X-ray tube can be deployed to make up the total complement of 4 tubes.

NOTE On delivery, the kW/Time Overload pcb (see Fig. 8) is set up as detailed below:

Tube Number	Tube Type	Tube Identification	Focal Size, mm	Rotor Drive Hz,	Maximum Voltage kV	Auxiliary Device (Working Station
1	X	Dynamax 50-69	0.6, 1.3	50	125	I
2	X	Dynamax 50-69	0.6, 1.3	50	125	II, III, IV
3	Y	Dynamax HD 40	1 - 2	50	125	V
4	Z	Dynamax HD 40 MO	0.8	50	40	VI

B On the kW/Time Overload pcb, the three types of tube are referred to as X, Y and Z.

C The tube selector switch must be programmed for the tube combination deployed. This is achieved by re-arranging the links on the kW/Time Overload pcb. Fig. 8 shows links A arranged for an application where tubes 1 and 2 are type X, tube 3 is type Y and tube 4 is type Z, three types of tube being used. Link B is shown arranged such that only tubes 1 and 2 are operated at high speed.

NOTE Technique 6 (tube 4) is exclusively reserved for mammography. If this facility is installed, the kW/Time Overload pcb will have been prewired to accommodate the ratings of a Dynamax HD 40 MO 0.8 mm tube with paralleled-filament.

D On delivery the tube focus combination is as follows :-

FINE FOCUS 50, 100 & 200mA

BROAD FOCUS 300, 400 & 500mA

These can be rearranged to suit individual tube requirements by following the example shown in Fig 10 page 28.

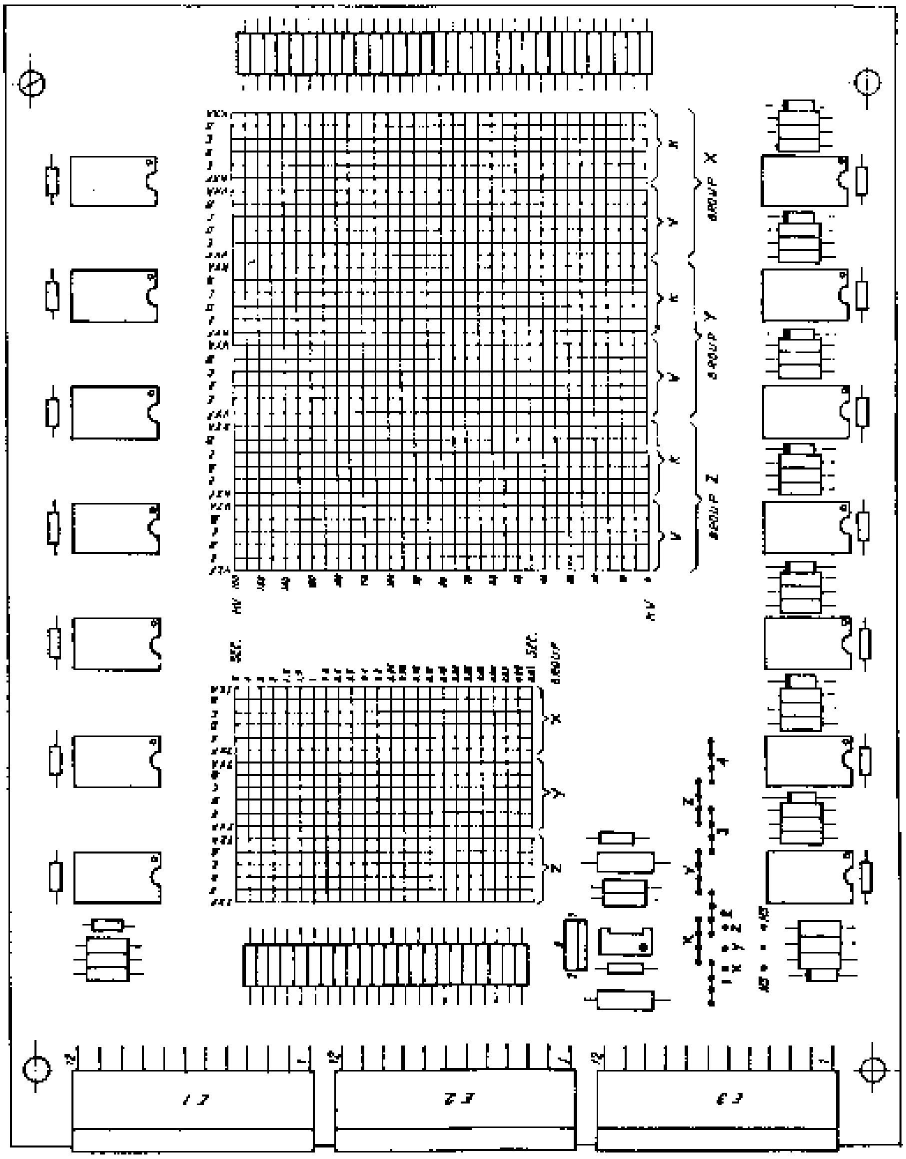


FIGURE 8   MAX LOAD PCB

E Ensure that the main supply to the R500 is OFF.

F Remove the front panel of the Console.

G Remove connectors E1, E2 and E3 from the kW/Time Overload pcb and plug them into the corresponding connectors on the test board (see Fig. 9).

5.4.1 Preliminary Work for Tube Type X

A Turn potentiometers P19 to P24 on the kV Adjust pcb (see Fig. 10) fully counter-clockwise.

B On the test board link terminal X in the GROUP CHOICE location to the tube number(s) to be displayed with Group X.

C Switch ON the R500.

D Rotate the control panel switch to select an auxiliary device associated with tube type X.

E If any of the auxiliary devices associated with the tube type X is fitted with a high-speed facility, link tube type X to HS at the TO HS CHOICE location on the test board. Then carry out the HS procedures detailed in para. 5.4.2, 5.4.3 and 5.4.4.

F If there are no high-speed facilities associated with tube type X proceed to para. 5.4.5.

NOTE A tolerance of ± 2 positions of the time-setting control is allowable on all the time settings given in the following procedures. The time settings available by adjustment of the time control switch are shown on Fig. 11.

5.4.2 Setting up Tube Type X Fine-Focus, High-Speed Overload Parameters

A Fine focus is automatically selected when one of the 50, 100 or 200 mA values is selected. The following details the setting-up procedures for the fine focus settings.

B 50 mA Setting

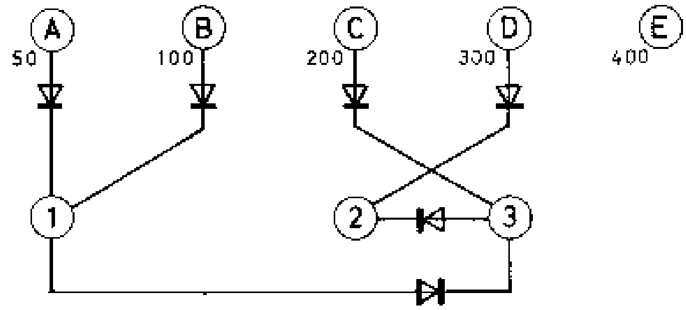
i Switch ON the R500 and select tube X and 50 mA.

ii Connect a 10V d.c. voltmeter across capacitor C25 on the kV Adjust pcb 4037. Rotate the radiography kV controls until the voltmeter indicates 7.5 V. Check that the indication on the kV readout is 150 ± 2 kV. If necessary, adjust P25 on pcb 4037 to give that indication. Disconnect the voltmeter.

NOTE On earlier models, check the number on kV Adjust PCB. If it is type 3591 the above C25 should read C14. For location refer to drawing No 3594 in Appendix 2.

TUBE FOCUS COMBINATION - EXAMPLE (See drawing No 3760)

TUBE 1 FINE	50 and 100mA ONLY
TUBE 2 FINE	50, 100, 200 & 300mA ONLY
TUBE 3 FINE	50, 100 & 200mA ONLY



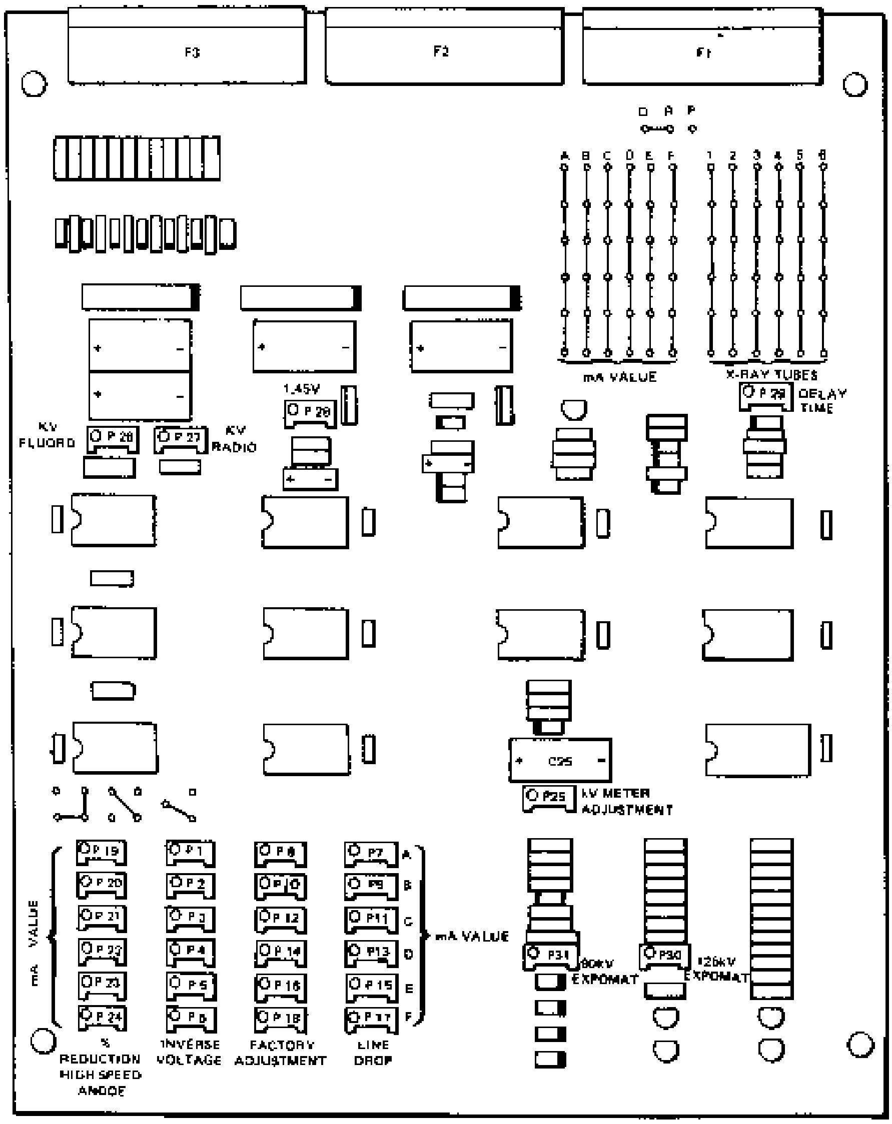


FIG 10. kV ADJUST PCB

iii Ascertain from the rating table supplied with tube type X the tube restriction at 50mA. (Fig. 11A is for a Dynamax Super 50-69 X-ray tube at high speed, 150 Hz, and fine focus, 0.6 mm, and it is used as an example to illustrate the setting up procedures.) There is no tube restriction in this case because 50 mA exposures are permitted within the full range of the 5s timer switch. The R500 generator ratings must limit the voltage to 125 kV (see Fig. 12):

mA Selected	R500 Series 2 maximum allowable voltage, kV
50	125
100	125
200	125
300	125
400	125
500	100

iv Select 50 mA.

v On the test board, link the following terminals:

TXA and 0.01s (the lowest time setting)

KXA and 125 kV

VXA and 125 kV

vi Turn the radiography kV controls until the OVERLOAD lamp illuminates. Check that the indication on the kV readout is 125 ± 2 kV. If it is not, move the ends of the KXA and VXA links attached to the 125 kV terminal to a higher voltage terminal (if the OVERLOAD lamp illuminated at less than 125 kV) or to a lower voltage terminal (if the OVERLOAD lamp illuminated at more than 125 kV).

vii Advance the time control to its maximum setting and check that the operation of the OVERLOAD lamp at 125 kV is not affected.

viii Mark the actual link positions on a copy of the matrix diagram for the overload board, e.g., if TXA link is at 0.01s, mark the point where the lines TXA and .01 intersect. If the KXA and VXA links are at 125 kV, mark the points where the KXA and 125, and the VXA and 125 lines meet. These are the points marked A on Fig. 8.

ix Remove the links fitted at step 5.4.2 B v.

C 100 mA Setting.

i Ascertain from the rating table, (Fig.11A), the tube restriction at 100 mA: It is possible to use the tube at 125 kV up to 5s, so the time and voltage settings should be the same as for the 50 mA setting.

ii Select 100 mA.

iii On the test board, link the following terminals:

TXB and 0.01s

KXB and 125 kV

VXB and 125 kV

iv Repeat steps B vi and vii for the 50 mA setting procedure.

v Mark the actual link position on the matrix diagram. The link positions are marked with a B on Fig. 8 assuming that the TXB link was at 0.01s and the KXB and VXB links were both at 125 kV.

vi Remove the links fitted at step 5.4.2 C iii.

D 200 mA Setting.

i Ascertain from the rating table (Fig. 11A) the tube restriction at 200 mA. This time, it is only possible to take 125 kV exposures up to 0.6s but not 0.8s which means that it will also be necessary to establish the maximum permitted kV at 5s. From Fig.11A 70 kV is permitted but not 80 kV. The maximum permitted time for an 80 kV exposure is therefore 4s and not 5s.

ii Select 200 mA.

iii On the test board, link the following terminals:

TXC and 0.8s

KXC and 125 kV

VXC and 80 kV

iv Set the radiography kV controls to give a readout of 80 kV.

kVp	Exposure Time, s												
	0.01	0.02	0.05	0.1	0.2	0.5	1	2	5	10	20	50	100
	Maximum Current, mA												
50	392	392	392	392	392	392	392	392	305	231	167	100	60
60	471	471	471	471	471	456	402	341	254	193	139	84	50
70	480	477	468	456	435	390	345	292	218	165	119	72	43
80	420	417	410	399	380	342	302	255	191	144	104	63	38
90	374	371	364	354	338	304	268	227	169	128	93	56	33
100	336	334	328	319	304	273	241	204	153	116	83	50	30
110	306	304	298	290	277	248	220	186	139	105	76	46	27
125	269	267	262	255	243	219	193	163	122	92	67	40	24
150	224	223	219	213	203	182	161	136	102	77	56	33	20

A FINE FOCUS (0.6 mm)

kVp	Exposure Time, s												
	0.01	0.02	0.05	0.1	0.2	0.5	1	2	5	10	20	50	100
	Maximum Current, mA												
50	750	750	750	750	750	750	750	750	593	412	273	120	60
60	924	924	924	924	924	924	924	739	494	343	228	100	50
70	1098	1098	1098	1098	1098	979	809	634	423	294	195	86	43
80	1204	1191	1154	1101	1017	856	708	554	370	258	171	75	38
90	1070	1058	1026	979	904	761	629	493	329	229	152	67	33
100	963	953	923	881	814	685	566	444	296	206	137	60	30
110	876	866	839	801	740	623	515	403	269	187	124	55	27
125	771	762	738	705	651	548	453	355	237	165	109	48	24
150	642	635	615	587	543	457	378	296	198	137	91	40	20

B BROAD FOCUS (1.3 mm)

NOTE These ratings are for a Dynamax Super 50-69 tube with a single-phase supply.

FIG.11 X-RAY TUBE RATINGS - HIGH SPEED (150 Hz)

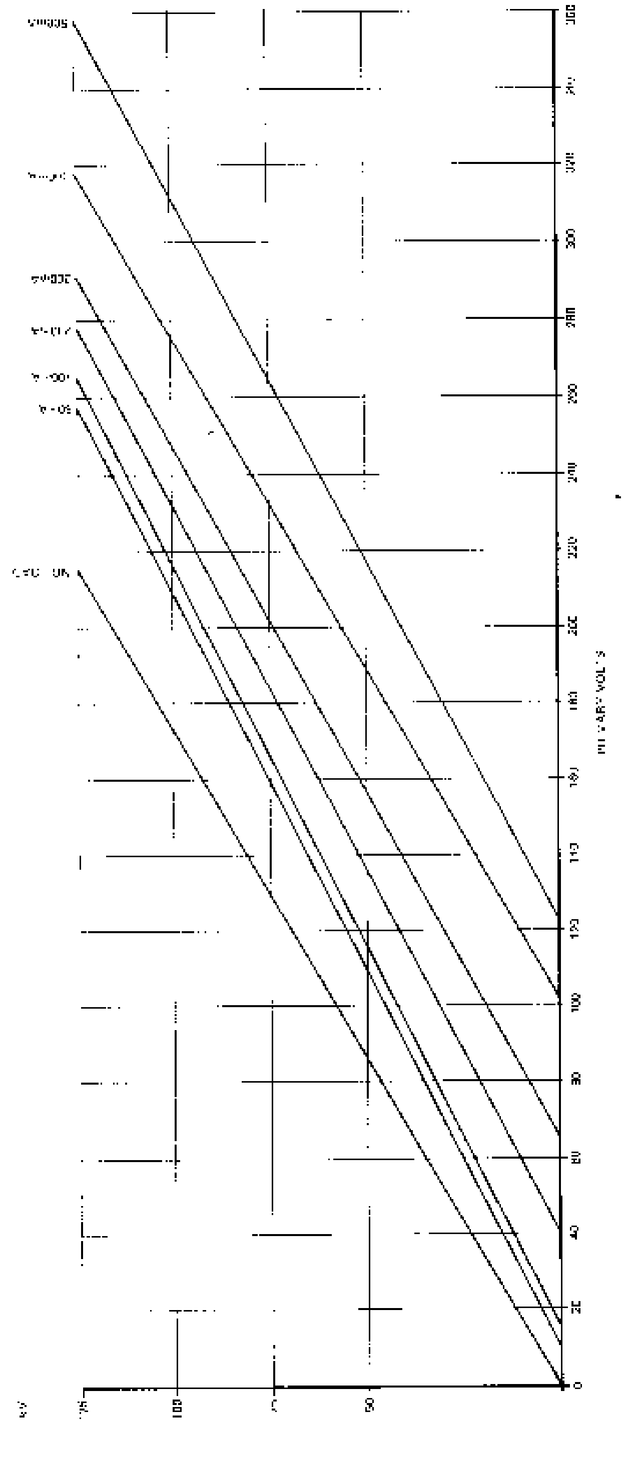


FIG.12 R500 SERIES 2 MAXIMUM RATING CHART

v Advance the time control to 4s (the next lowest time setting to 5s) and check that the OVERLOAD lamp is extinguished. Select 5s and check that the OVERLOAD lamp illuminates. If it does not, move the VXC link to progressively lower voltage terminals (75kV, 70kV, etc.) until the OVERLOAD lamp illuminates when the time setting is 5s.

vi Set the radiography kV controls to give a readout of 125kV.

vii Advance the time control and check that the OVERLOAD lamp illuminates at 0.8s. If it does not, move the KXC link to progressively lower voltage terminals until it does. If the OVERLOAD lamp illuminates at a time setting less than 0.6s, move the KXC link to progressively higher voltage terminals until the lamp illuminates at the 0.8s setting.

viii Repeat steps D iv and v to check that the OVERLOAD lamp illuminates at the setting combination of 80kV and 5s. If re-adjustment of the VXC link is necessary, then steps D vi and vii will have to be repeated until the settings are correct at both 125kV and 80kV.

ix Now check the settings at all other intermediate voltages. For example, at 110kV check that the OVERLOAD lamp illuminates at a time setting of 1.6s. If the tracking is poor around the high kV/short time zone on the tube rating chart, readjust matrix KXC. If the tracking is poor around the low kV/long time zone on the tube rating chart, readjust matrix VXC.

If there is still room for improvement in overload tracking around the high kV/short time zone, readjust matrix TXC followed by readjustment of matrix VXC to achieve an overall compromise.

NOTE Adjustment of the time link on the test board has a greater effect at high voltages than it does at low ones. The time link is moved in the same direction as the required time change, i.e., if the OVERLOAD lamp comes on at too high a time setting, the time link must be moved to a lower time value.

xi Mark the actual link positions on the matrix diagram as before.

xii Remove the links fitted at step 5.4.2 D iii.

5.4.3 Setting up Tube Type X Broad-Focus, High-Speed Overload Parameters

A Broad focus is automatically selected when one of the 300, 400 or 500mA pushbuttons is pressed.

B Figure 11B is the rating chart for the Dynamax Super 50-69 at high speed, 150Hz, and broad focus, 1.3mm. From this it can be seen that the time exposure blockages for 125 kV are 3s and 1.6s for the 300 and 400mA settings, respectively.

C The procedures for setting up the broad focus, high speed overload circuits are as detailed in para. 5.4.2 for the fine focus, high speed ones. However, it must be noted that at 500 mA the tube rating can exceed the 37.5 kW rating of the R500 Series 2.

Under these circumstances, the overload circuit must be adapted to restrict exposures to 100 kV max at 500 mA.

This means that at 500 mA the overload circuit must be made to follow the tube rating curve from 100 kV and not 125 kV. The KXF and TXF taps must therefore be set by trial and error to block 101 kV exposures on time switch settings below 1.6s.

Examples of final tapping points for a DX50-69 1.3mm H.S. Tube are shown below:

300 mA	KXD	135 kV
	TXD	2 s
	VXD	80 kV
400 mA	KXE	140 kV
	TXE	1.2s
	VXE	60 kV
500 mA	KXF	110 kV
	TXF	1.2s
	VXF	45 kV

5.4.4 Setting up Tube Type X Low Speed Overload Parameters

A Having set up the high speed overload parameters as detailed in para. 5.4.2 and 5.4.3, it is now necessary to set up the low speed overload parameters for each mA value for any tube which has an associated high-speed facility. This ensures that tubes will only be switched to the high-speed mode of control when the normal speed overload ratings are exceeded.

B Refer to the tube rating charts for low speed use, and adjust the potentiometer on the kV Adjust pcb 4037 (see Fig. 10) associated with each mA listed below clockwise until the HIGH SPEED lamp illuminates at or before the overload point calculated on every kV rating curve.

mA Selected	Potentiometer on pcb 4037
50	P19
100	P20
200	P21
300	P22
400	P23
500	P24

C Proceed to para. 5.4.6 for setting up the overload parameters for any other type of tube used. If only one type of tube is used, proceed to para. 5.4.7.

5.4.5 Tube Type X Without Associated High-Speed Facility

A Carry out the procedures detailed in para. 5.4.1, 5.4.2 and 5.4.3 for tube type X. In this case, the tube restrictions will be ascertained from the low-speed rating tables given in Fig. 13 instead of the high-speed rating tables given in Fig. 11.

B Proceed to para. 5.4.6 for setting up the overload parameters for any other type of tube used. If only one type of tube is used, proceed to para. 5.4.7.

5.4.6 Setting up Tubes Type Y and Z

A The procedures for setting up the overload parameters for tube type Y are identical to those already detailed for tube type X in para. 5.4.1 to 5.4.5.

B The procedure for setting up the overload circuits for tube type Z if this is a Dynamax HD 40 MO 0.8mm tube is as follows:

kVp	Exposure Time, s							
	0.1	0.2	0.5	1	2	3	4	5
	Maximum Current, mA							
25	250	250	250	250	250	248	232	216
30	300	300	293	260	226	205	193	180
40	280	255	220	195	170	155	145	135

SINGLE EXPOSURE RATINGS FOR HD 40 TUBE (1 ph, 50 Hz)

i On the test board link terminal Z to terminal 4 at the GROUP CHOICE location, and connect the other links as follows:

50 mA	TZA	0.01s	PERMANENTLY BLOCKED
	KZA	10 kV	
	VZA	10 kV	
100 mA	TZB	0.01s	
	KZB	40 kV	
	VZB	40 kV	
200 mA	TZC	0.4 s	
	KZC	45 kV	
	VZC	20 kV	
300 mA	TZD	0.16s	
	KZD	30 kV	
	VZD	20 kV	
400 mA	TZE	0.01s	PERMANENTLY BLOCKED
	KZE	10 kV	
	VZE	10 kV	
500 mA	TZF	0.01s	PERMANENTLY BLOCKED
	KZF	10 kV	
	VZF	10 kV	

ii Switch ON the R500 and check all the overload points as given in the table above "Single Exposure Ratings for HD40 Tube (1ph, 50 Hz)".

If the tracking is poor around the high kV/short time zone on the tube rating chart, readjust the matrix kZ. If the tracking is poor around the low kV/long time zone, readjust the matrix VZ.

If there is still room for improvement in overload tracking around the high kV/short time zone, readjust matrix TZ followed by readjustment of matrix VZ to obtain an overall compromise.

C When the overload parameters for all the tube types have been set up, proceed to para. 5.4.7.

5.4.7 Programming the Overload Board

A With the Overload Board removed from the R500, disconnect any links from the time and voltage matrixes that have not been marked on Fig. 8 during the overload circuit setting procedures. Solder in the remaining links as marked on Fig. 8.

CAUTION Ensure that matrix lines are not bridged during the soldering process.

B Solder in the links A and B as appropriate (see Fig. 8 and para. 5.4 C, for tube programming and high speed programming).

kVp	Exposure Time, s												
	0.01	0.02	0.05	0.1	0.2	0.5	1	2	5	10	20	50	100
	Maximum Current, mA												
50	391	391	389	385	377	357	332	298	241	193	146	93	60
60	326	326	324	320	314	297	277	248	201	161	122	77	50
70	279	279	278	275	269	255	237	213	172	138	104	66	43
80	244	244	243	240	235	223	208	186	150	120	91	58	38
90	217	217	216	214	209	198	185	165	134	107	81	51	33
100	196	196	194	192	188	178	166	149	120	96	73	46	30
110	178	178	177	175	171	162	151	135	109	88	66	42	27
125	156	156	156	154	151	143	133	119	96	77	48	37	24
150	130	130	130	128	126	119	111	99	80	64	49	31	20

A FINE FOCUS (0.6 mm)

kVp	Exposure Time, s												
	0.01	0.02	0.05	0.1	0.2	0.5	1	2	5	10	20	50	100
	Maximum Current, mA												
50	750	750	750	750	750	750	750	711	513	373	256	120	60
60	924	924	924	907	874	796	706	592	428	311	213	100	50
70	801	801	793	777	749	683	605	508	366	267	183	86	43
80	701	701	693	680	656	597	529	444	321	233	160	75	38
90	623	623	616	604	583	531	471	395	285	207	142	67	33
100	561	561	555	544	524	478	424	355	257	187	128	60	30
110	510	510	504	495	477	434	385	323	233	170	116	55	27
125	449	449	444	435	420	382	339	284	205	149	102	48	24
150	374	374	370	363	350	319	282	237	171	124	85	40	20

B BROAD FOCUS (1.3 mm)

NOTE These ratings are for a Dynamax Super 50-69 tube with a single-phase supply.

FIG. 13 X-RAY TUBE RATINGS - LOW SPEED (50 Hz)

5.5 kV Meter Calibration to HT Primary Voltage

5.5.1 Fluoroscopy

A Connect a 500V a.c., f.s.d., test meter across fuse 10 (see Fig. 7) and terminal 168 (on the terminal strips at the left-hand side of the Console).

B Temporarily link terminals 155 and 156.

C Switch ON the R500.

D Press the fluoroscopy pushbutton and set the fluoroscopy kV control (see Fig. 1) to give the following readings on the test meter:

Test Meter Reading, V	kV Meter Reading
111	50
167	75
223	100

E If the test meter reading at 50 kV differs by more than 1% from 111 V, or the one at 100 kV by more than 2% from 223V, adjust the fluoro kV control to give the correct reading on the test meter and then adjust potentiometer P26 on the kV Adjust pcb (see Fig.10) to obtain the associated kV meter reading on the console display.

F Remove the link fitted at B.

5.5.2 Radiography

A Connect a 1000V a.c., f.s.d. meter across fuses 11 and 12 on the Console.

B Ensure that potentiometers P7, P9, P11, P13, P15 and P17 on the kV. Adjust pcb 4037 are all turned to their extreme counter-clockwise positions.

C Switch ON the R500 and check the HT primary voltages for each mA and kV indicated in the Table below. (It does not matter which tube is selected).

mA	kV			
	50	75	100	125
	HT Primary Voltage, V			
50	111	160	210	260
100	116	166	217	267
200	136	185	232	280
300	158	203	249	294
400	190	233	276	320
500	218	266	313	360

D If the voltages at 50 kV are not within 2% adjust the appropriate mA compensation potentiometer on the kV Adjust pcb 4037 (see Fig.10).

50mA / 50kV	P1	IF THERE IS INSUFFICIENT ADJUSTMENT IN ANY OF THESE POTENTIOMETERS, MAKE FUTHER ADJUSTMENT WITH P28.
100mA / 50kV	P2	
200mA / 50kV	P3	
300mA / 50kV	P4	
400mA / 50kV	P5	
500mA / 50kV	P6	

E If the voltages at 125 kV are not within 1% adjust the appropriate mA compensation potentiometer on the kV Adjust pcb 4037:

50mA / 125kV	P8	IF THERE IS INSUFFICIENT ADJUSTMENT IN ANY OF THESE POTENTIOMETERS, MAKE FURTHER ADJUSTMENT WITH P27.
100mA / 125kV	P10	
200mA / 125kV	P12	
300mA / 125kV	P14	
400mA / 125kV	P16	
500mA / 125kV	P18	

NOTE If a particular mA potentiometer, e.g. the 50kV one, has to be adjusted the associated 125kV potentiometer must also be readjusted because they are interactive.

F Repeat steps D and E until the 125kV and 50kV values are correct.

5.6 Adjustment of Tube mA

A Connect the primary of the HT Transformer.

B To screen from the Console on all tubes, temporarily connect a suitable switch (to be used as the "fluoro test switch") across terminals 156 and 157 on the Console and link terminals 156 and 155.

C To set up the undertable tube mAs output from the Console, connect a temporary link across terminals 155 and 160 on J84 and use the Prep/Expose switch on the control facia. A Bucky link must also be connected across terminals 133 and 147.

5.6.1 Broad Focus Pre-Heat Adjustment for All Tubes

A Disconnect the broad and fine tube filament supply wires at terminals 104 and 105 on the HT transformer.

B Switch ON the R500 Series 2.

C Select tube 1 (undertable).

D Press the fluoroscopy kV pushbutton and set the flurorscopy kV control to indicate 70kV on the meter.

E Press the fluoro test switch and record the reading on the mA meter. This will be very small because it will only be recording the HT secondary capacitive current.

F Release the fluoro test switch.

G Switch OFF the R500 Series 2.

H Reconnect the broad focus wire to terminal 104 on the HT transformer.

J Switch ON the R500 Series 2.

K Press the fluoro test switch.

L Note the tube emission on the mA meter. This must be 0.1mA in excess of the reading recorded in paragraph 5.6.1 E.

If the pre-heat emission is incorrect, adjust the tapping band on resistor R15 (see Figure 5) until 0.1mA is added to the capacitive current recorded in paragraph 5.6.1 E.

WARNING **SWITCH OFF THE R500 Series 2 WHEN ADJUSTING R15**

5.6.2 **Fluoro mA Adjustment**

A Check that the R500 is OFF.

B Reconnect the fine focus wire to terminal 105 on the HT Transformer.

C Switch ON the R500.

D Select tube 1.

E Press the fluoro test switch and select 70kV.

F Increase the Fluoro mA. With the Fluoro mA control turned fully clockwise, the mA meter should indicate not more that 5mA.

If necessary, adjust the tapping band corresponding to tube 1 on resistance R13 (see Fig 5) until this value is obtained.

WARNING SWITCH OFF THE R500 WHEN ADJUSTING R13.

5.6.3 **Fine Focus Pre-heat Adjustments for Remaining Tubes**

A Switch ON the R500.

B Select the tube to be adjusted.

C Press the fluoro test switch and select 70kV.

D Increase the Fluoro mA. With the Fluoro mA control rotated fully clockwise, the mA meter should indicate not more than 5mA.

If necessary, adjust the R13 tapping band corresponding to the tube undergoing adjustment for 5mA maximum emission.

5.6.4 **Fluoro mA Capacity Compensation**

A Switch ON the R500.

B Select Tube 1.

C Switch ON the fluoro test switch and select 100kV and 5mA on the Fluoro Controls.

D Adjust R26 (see Fig.5) until the mA meter reading begins to decrease.

Continued adjustment in the same direction will cause the mA to decrease further until a point is reached when it will begin to rise again.

The correct adjustment is the minimum mA which can be obtained on the mA meter.

E Remove the fluoro test switch and the link across terminals 155 and 156.

5.6.5 Radiography Exposure Timer Check

A Read para. 5.6 (exposure links for technique 1).

B On the Timer pcb (see Fig. 7), connect the signal lead of a DM64 storage CRO or equivalent to the 6 pin Ansley edge connector A4 at pin 6 (unoccupied outlet) and clip the earth lead to chassis ground.

C Check that the coloured cursors on the mA adjustment rheostats R10 and R11 (see Fig.5) are at the bottom of their travel.

D Switch ON the R500 and select 50kV, 50mA and 0.01 seconds.

E Take a radiography exposure and check the trace as indicated on the CRO. This should have an amplitude of 15V and a width of 10 ms.

F Advance the Timer switch to 0.1 seconds and take another exposure. The CRO trace this time should measure 100 ms on the time base.

G Advance the Timer switch to 1 second and take another exposure. The CRO trace this time should measure 1 sec on the time base.

H If the Timer is inaccurate, refer to the setting-up procedure contained in the relevant service manual.

5.6.6 Radiography mA Adjustments, non Mammo

A The tube filament drive adjusting resistors are shown in Fig. 5.

R10 is used for tubes 1 and 2
R11 is used for tubes 3 and 4

Each has two sets of sliding cursors which are colour-coded for tube identification and also letter-coded for mA identification as in the table below:

	WHITE	RED	YELLOW	GREEN
A	TUBE 1 50mA	TUBE 2 50mA	TUBE 3 50mA	TUBE 4 NA
B	TUBE 1 100mA	TUBE 2 100mA	TUBE 3 100mA	TUBE 4 100mA
C	TUBE 1 200mA	TUBE 2 200mA	TUBE 3 200mA	TUBE 4 200mA
D	TUBE 1 300mA	TUBE 2 300mA	TUBE 3 300mA	TUBE 4 300mA
E	TUBE 1 400mA	TUBE 2 400mA	TUBE 3 400mA	TUBE 4 NA
F	TUBE 1 500mA	TUBE 2 500mA	TUBE 3 500mA	TUBE 4 NA

B Connect an mAs meter to the external mAs meter link and adjust all the tube mA values at 75kV by the sliding cursors tabulated above.

C If there is insufficient adjustment to set up the high mA values, return all sliding cursors to the bottom of their travel. Move the blue wander lead tap on TR10 (the stabilised filament drive transformer, see Fig.6) to the next highest voltage for fine focus. Move the orange wander lead tap to the next highest voltage for broad focus.

D Adjust all the tube mA values at 75kV by the sliding cursors tabulated above.

5.6.7 Space Charge Compensation

A Take a series of radiographic exposures at different kV settings on every position of the mA switch as tabulated below:

mA SELECTED	kV SETTINGS			
50	50	75	100	120
100	50	75	100	120
200	50	75	100	120
300	50	75	100	120
400	50	75	110	115
500	50	75	90	100

B Compare the mAs meter readings obtained within the kV range specified for each setting of the mA switch.

The overall variation should not exceed 5% of the nominal value measured at 75kV, e.g., for a nominal value of 20mAs a change of 2mAs is permissible within the kV range specified.

C Adjustment facilities are available on the secondary of the space charge compensation transformer TR7 (see Fig.7).

There are six wander lead taps idented as follows:

WANDER LEAD		CORRESPONDING mA
IDENT	COLOUR	
A	WHITE	50
B	RED	100
C	YELLOW	200
D	GREEN	300
E	BLUE	400
F	BLACK	500

If the indicated mA goes higher when the kV is increased, move the wander lead corresponding to the mA selected to a higher tap number and vice versa.

D If all tubes are of the same type, the space charge compensation for one should be adequate for the others.

In an installation with very different foci, such as 0.3 and 1mm and 1 and 2mm, not all the foci can be compensated within 5%. A compromise will have to be made.

5.6.8 Mammography mA Adjustments - Simultaneous Emission of both Tube Filaments (Parallel Operation)

A The tube filament drive adjusting resistors are shown in Figure 5.

R27 is used for adjusting the small focus.
R11 is used for adjusting the large focus.

Each has a set of three sliding cursors which are letter-coded for mA identification as in the table below:

	R27 SMALL	R11 LARGE
B	100 mA	100 mA
C	200 mA	200 mA
D	300 mA	300 mA

NOTE After calibration, each focus will deliver half the indicated mA.

B Connect a 100 volt fsd meter across terminals 104 and 105 on the HT tank. The object is to obtain meter readings as close to zero as possible during setting up. In this way both filaments will be balanced and thus capable of equal emission.

C Switch ON and select 35 kV and Technique 6.

D Take a series of radiographic exposures at 20 mAs starting at 100 mA. Adjust each rheostat R27 and R11 in turn to obtain the selected mAs on the mAs meter.

During final adjustment of each mA value closely observe the test volt meter during preparation, and fine tune R27 and R11 for minimum readings coincident with 20 mAs output during exposures.

5.7 FINAL CALIBRATION OF kV METER TO LINE RESISTANCE

A It is strongly recommended that an approved kV measuring device is used for these tests, such as a Voltix Shock Proof High Voltage Measuring Probe with suitable CRO, or a Winsconsin Penatrometer Cassette. If these are available, proceed as detailed in METHOD 1 (see paragraph 5.7.1).

B If an approved kV measuring device is not available, proceed as detailed in METHOD 2 (see paragraph 5.7.2), but note that this is not considered accurate, especially on the 400 and 500 mA bands of the R500 Series 2.

5.7.1 Method 1, with kV Measuring Device

A With the mA switch at 50 mA, set the kV meter to indicate 80 kV.

B Take a suitable exposure and note the reading recorded on the kV measuring device.

If this differs from the kV display indication, take more exposures with the kV coarse and fine controls reset accordingly until the kV measuring device records 80 kV peak.

C Adjust potentiometer P7 on the kV Adjust pcb 4037 (see Figure 10) until the kV display indicates 80 kV.

The kV display is now compensated to pre-select the actual kV which will be generated ON LOAD.

D Repeat this procedure for 100, 200, 300, 400 and 500 mA using potentiometers P9, P11, P13, P15 and P17 respectively on pcb 4037.

5.7.2 Method 2, Without kV Measuring Device

CAUTION: AVOID OVERHEATING X-RAY TUBES BY KEEPING EXPOSURE TIMES AS SHORT AS POSSIBLE WHEN OBSERVING ON-LOAD kV METER READINGS.

A With the mA switch at 50 mA, set the kV display to read 75 kV.

B Press the radiography Prepare/Expose switch and note the kV display indication ON LOAD.

C When the exposure is terminated, recalibrate the kV display to indicate the kV noted ON LOAD by adjusting potentiometer P7 on the kV Adjust pcb 4037 (see Figure 10).

The kV display is now compensated to pre-select the actual kV which will be generated ON LOAD.

D Repeat the procedure for 100, 200 and 300 mA using potentiometers P9, P11 and P13 respectively.

E At 400 and 500 mA it will be difficult to observe the ON LOAD kV display readings because of the exposure time limitations. kV compensation will therefore have to be estimated by multiplying the kV drop noted at 100 mA by a factor of 4 and 5 respectively.

These corrections can be applied by adjustment of potentiometer P15 (400 mA) and P17 (500 mA).

5.7.3 Fluoro kV with kV Measuring Device

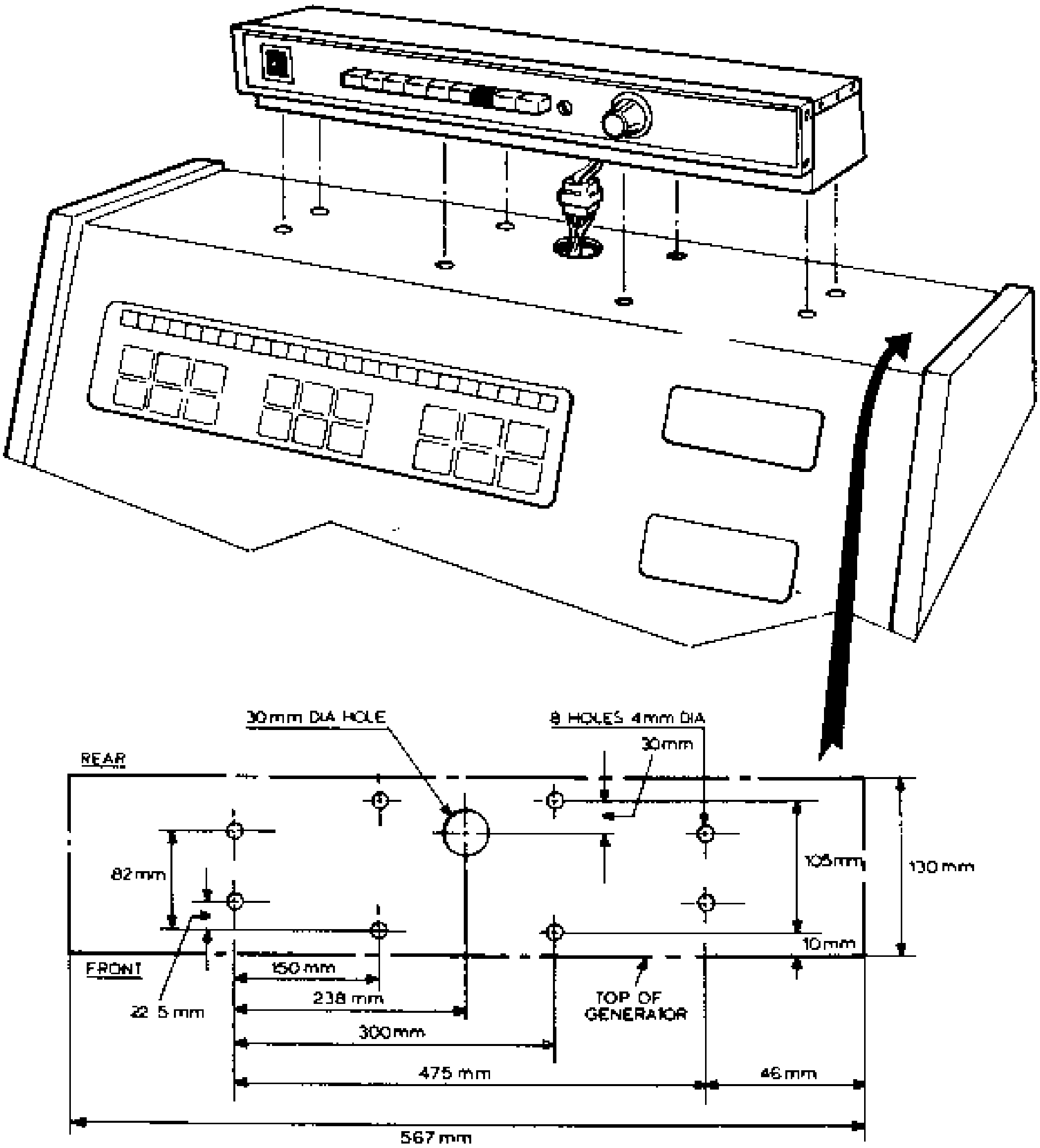
A Take a fluoro exposure at 1 mA and adjust kV controls to give a reading of 100 kV on the kV measuring device.

B If the fluoro kV display does not indicate 100 kV, adjust potentiometer P26 on the kV Adjust pcb 4037 until the fluoro kV display indicates 100 kV.

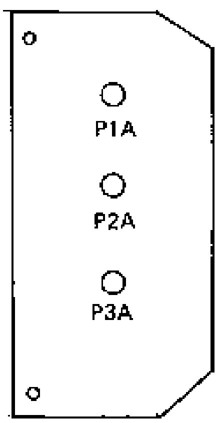
6 COMMISSIONING THE GECOMAT 2

The following pages detail commissioning the R500 Series 2 Generator with the Gecomat 2.

Refer also to Gecomat 2 Installation and Service Manual No 2249



INSCRIBING AND DRILLING DETAIL FOR THE GECOMAT CONTROL UNIT



GECOMAT IDENTIFICATION PANEL

FIG. 14 GECOMAT CONTROL UNIT - INSTALLATION INFORMATION

6.1 General

NOTE Further information is given in Inst. 2249 (Gecomat 2).

A Inscribe and drill holes for the Gecomat Control Unit (see Fig.14).

B If a bucky is to be used, the link between terminal 148 and the relevant terminals 133 to 137 on the R500 control console (see Fig.4) must be removed.

C Interface the Gecomat 2 to the R500 (see Fig.15 and Fig 17)

NOTE The terminals 401 to 420 on the front left-hand side of the R500 control console are not used for this interface.

D Fit the new identification panel (supplied with the Gecomat) (see Fig.14) into junction box 4.

NOTE Terminals T2 and P2A in the junction box are not used.

6.2 Automatic kV Compensation Controls

A Switch on the R500 and the Gecomat.

B Select 50kV.

C Observe that both relays K90 and K125 are closed on the R500 relay panel.

D Confirm that relay K90 opens when the kV controls are advanced to select 80kV. Adjustment can be effected by potentiometer P31 on the kV Adjust pcb (see Fig. 10).

E Confirm that relay K90 remains open and that relay K125 opens when the kV controls are advanced to select 100kV. Adjustment can be effected by potentiometer P30 on the kV Adjust pcb.

F On board U6 (see Fig. 16) in the Gecomat Electronics Module check that relays d609 and d608 open at 80kV and 100kV, respectively, and that they both stay open when the kV is advanced beyond 100kV to maximum.

If there is any discrepancy check the interface wiring.

6.3 Film Density Calibration, Tube 1

A Preliminaries.

i. This procedure is a guide for setting up the Gecomat in conjunction with cassettes fitted with par screens (medium speed). Screen 2 is therefore chosen for this calibration.

When adjustments are completed the base density jumpers on board U6 should be adjusted to give approx. -25% mAs on screen 1 and +25% mAs on screen 3.

If the X-ray department uses only fast tungstate or rare earth screens, screen 1 must be used for calibration and +25% mAs must be added between screen 1 and screen 2, and between screen 2 and screen 3 after calibration.

Ensure that sufficient phantom thickness is adopted to produce exposures in excess of the minimum switch time of the system. mAs checks will confirm this and the rule is to add more phantom if mAs drops below 8 mAs.

If a densitometer is not available, regard references to base density 1 as a level of density where bold black print on a white background is just about legible when the exposed film is used to mask the print in good daylight.

ii Prepare board U6 for the chamber/screen/density combination. For example, for a screening room with chest bucky, start with a jumper between screen 2, chamber 1 to density tap No 9, a jumper between screen 2, chamber 2 to density tap No.9 and a jumper between screen 2, chamber 3 to density tap No 9.

iii On board U7 jumper LINK 1 for automatic selection of centre cell when under table technique is selected.

iv Switch ON the R500, select tube 1, 70kV, 200mA and 1 second. Switch ON the Gecomat with centre cell and screen 2.

v On the X-ray table, load a full size cassette with no film inside. Ensure that grid is IN, cone OUT, shutters fully open and no phantom in the exposure area.

vi Take an exposure and check that termination is immediate with a very small value of mAs indicated on the actual mAs display.

If the exposure runs on to 1 second, check the interface wiring, chamber wiring and Gecomat for faults.

vii Repeat the above procedure for the overtable and chest chambers on each cell and ensure that in each case the overtable tube is carefully coned over the cell which is selected. Other cells must be blanked off with lead.

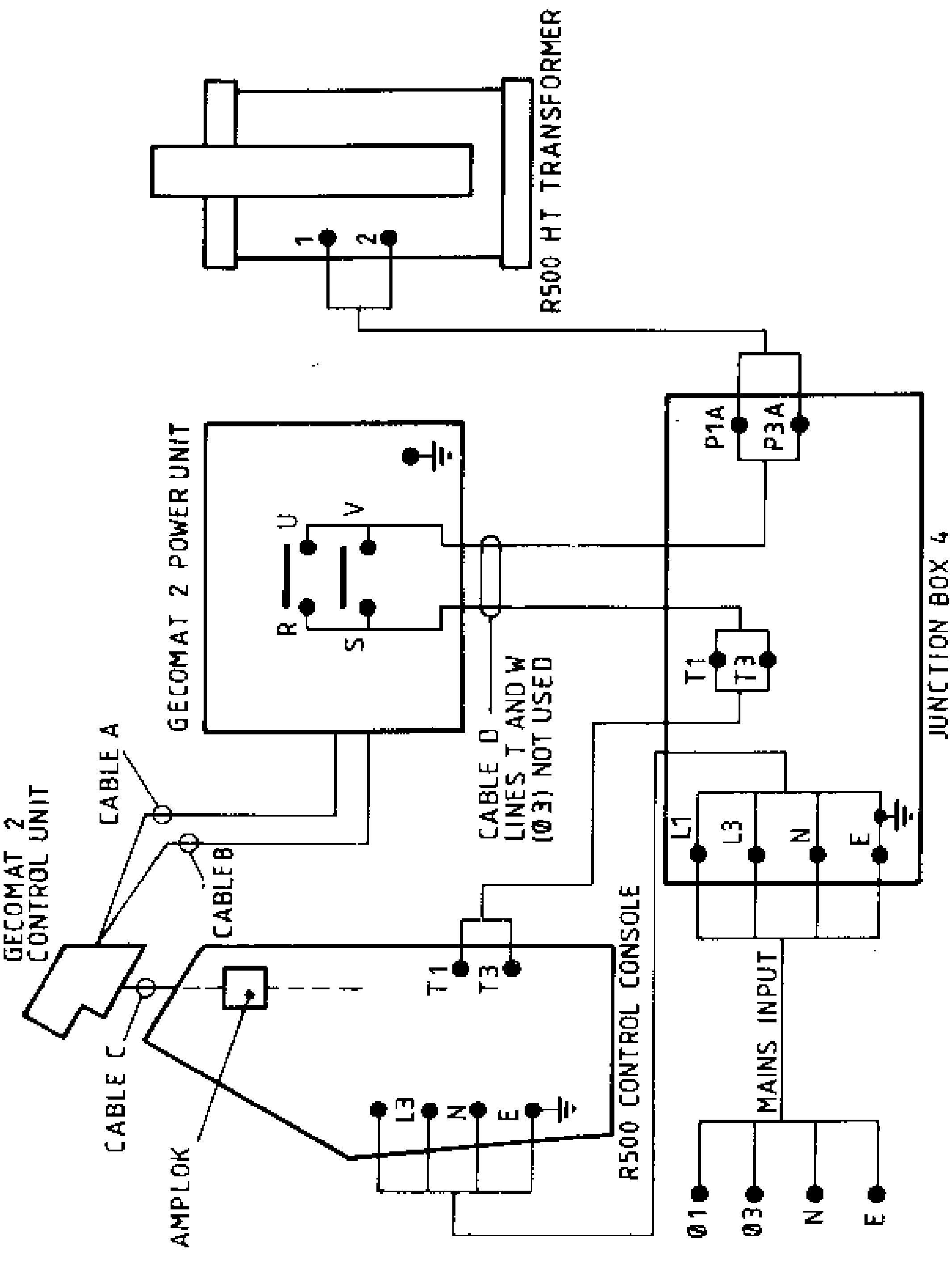


FIG.15 GECOMAT CONTROL UNIT - INTERCONNECTIONS

B Base Density Undertable Tube 1.

i Switch ON the R500, select tube 1, 60kV, 200mA and 1 second. Also switch ON the Gecomat.

ii On the table, insert a full size cassette loaded with film and switch the grid IN and cone OUT.

iii In the exposure area, place a phantom of approximately 10cm of hardboard. If hardboard is not available, a suitable phantom can be made out of a pile of books, a 3 gallon rectangular plastic container filled with water or soft metal blocks such as aluminium.

iv Cone the tube shutters down to the size of the centre cell and ensure that screen 2 is selected on the Gecomat and that the density control is turned to zero.

v Take an exposure and note the mAs readout after the exposure. If it is less than 8 mAs more phantom thickness is required.

Develop the film and ascertain whether it matches up to a density of 1.

vii If the film is under exposed, move the jumper from chamber 1, screen 2 to a higher density tap number. If the film is over exposed, move this tap to a lower density tap number.

Take a series of exposures adopting the above procedure until a film density of 1 is obtained.

C 80kV Density Compensation Tube 1.

i Change only the kV to 80kV and check that relay K90 in the R500 opens.

ii Take an exposure and check the developed film for density 1.

If it has become lighter, turn R623 in board U6 counter clockwise. If the film has gone darker turn R623 clockwise. Using this procedure take a series of exposures until film density 1 is obtained. Do not forget to add more phantom if actual mAs readout drops below 8 mAs.

D 100kV Density Compensation Tube 1.

i Change only the kV to 100kV and check that relay K125 in the R500 opens.

ii Take an exposure and check the developed film for density 1. Check also mAs for useful phantom thickness.

If the film has become lighter, turn R624 in board U6 counter clockwise. If the film has gone darker turn R624 clockwise. Using this procedure take a series of exposures until film density 1 is obtained.

iii Repeat para. 6.3B, C and D until the same film density is obtained at 60kV, 80kV, and 100kV.

NOTE It is quite normal for films to become blacker between these steps especially when fast screens are used.

E Cone Density Compensation for Serial Radiography TUBE 1.

On the board U6, connect a jumper between screen 2, chamber 1 (T) and the next lowest density tap number to the tap previously used for the base density.

This setting is generally acceptable in combating the effects of dye or barium, but may have to be changed by one more step pending user comment.

NOTE The taps are not used for overtable techniques.

F Screen 1 and Screen 3 Density Adjustments TUBE 1

i Screen 1 should generally give shorter exposures (Approx 25% less mAs).
Screen 3 should generally give longer exposures (Approx 25% more mAs).

ii The remaining jumpers on Board U6 for chamber 1 should therefore be positioned as follows until user preference is ascertained.

Screen 1	Two density taps numerically DOWN from screen 2
Screen 1 (T)	Two density taps numerically DOWN from screen 2 (T)
Screen 3	Two density taps numerically UP from screen 2
Screen 3 (T)	Two density taps numerically UP from screen 2

6.4 Film Density Calibration, Tube 2

A Overtable Bucky.

i On the board U6, reposition the jumper connecting chamber 2 on screen 2 matrix to the same density as tube 1.

ii Using this tap as a starting point, proceed to set up the overtable bucky chamber using the same procedure already applied to the undertable tube (see para. 6.3).

NOTE The table cone switch taps T on each screen matrix are not used and it is also not necessary to check 80kV and 100kV compensation again.

B Chest Bucky

i On the board U6, reposition the remaining jumper to connect chamber 3 on screen 2 matrix to the same density tap as the overtable bucky.

ii Using this tap as a starting point proceed to set up the chest stand bucky chamber using the same procedures already applied to undertable and overtable buckies.

NOTE The table cone switch taps T on each screen matrix are not used and it is also not necessary to check 80kV and 100kV compensation again.

C Finally, insert the jumpers for chambers 2 and 3 between screen 1 and 3 matrices to the density taps suggested in para. 6.3 F, e.g., two down for screen 1 and two up for screen 3.

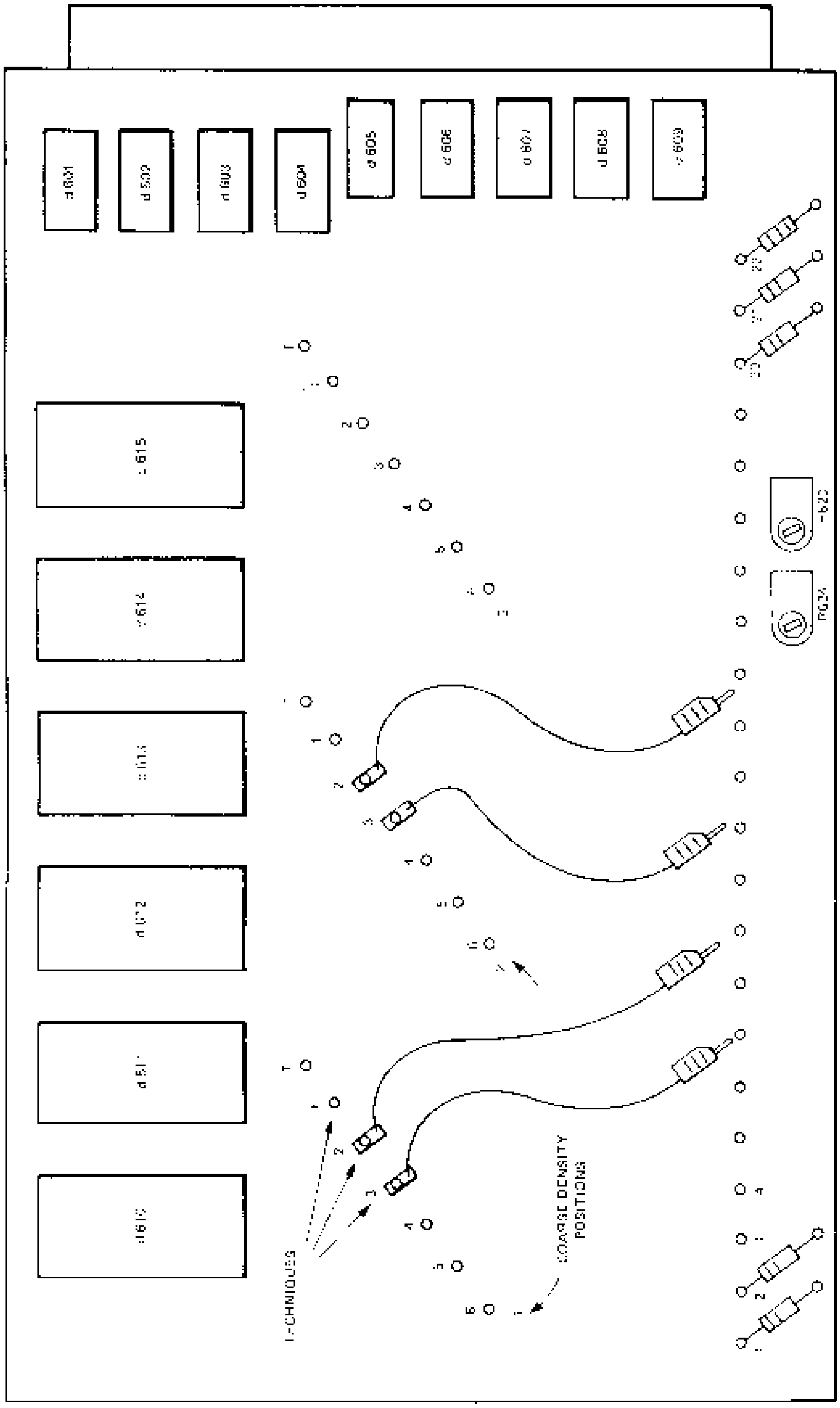
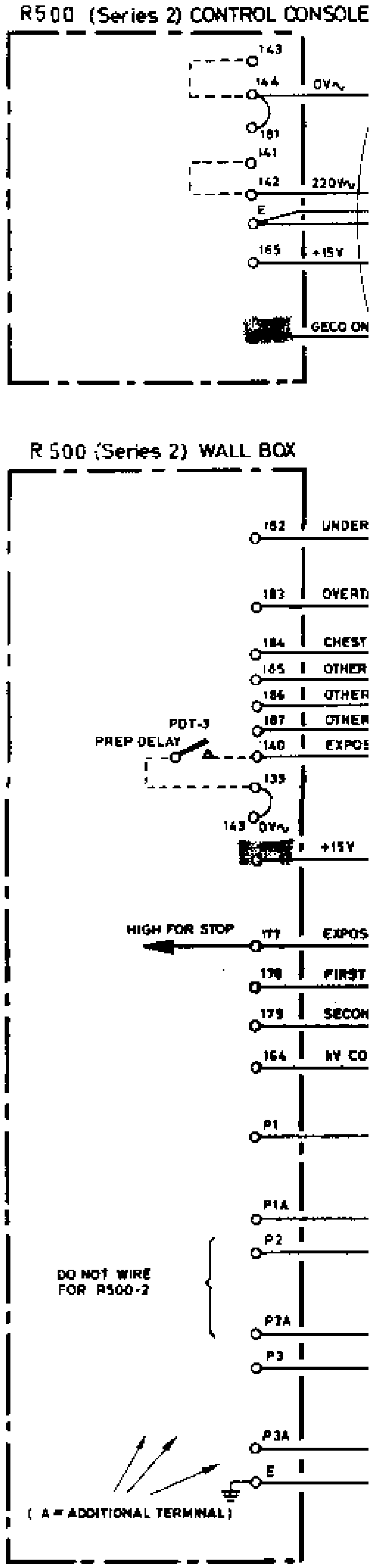


FIG.16 GECOMAT ELECTRONICS MODULE-BOARD L6

——— DENOTES INTERFACE WIRING

- - - - DENOTES EXISTING WIRING



NOTE 1 In the Gecomat Control run in a new wire from NO contact 7 of RL1/3 and use a spare terminal to connect this wire to terminal 176 in the R500 via Amplok cable C (brown wire).

NOTE 2 The blue and brown wires from terminals 10 & 11 in Geco Control which run through cable A to the electronics unit must be disconnected and insulated with tape.

NOTE 3 In the Geco Control terminals 10 & 11 must be jumpered as shown in the interface diagram.

NOTE 4 Disconnect kV Comp pushbuttons to Geco Electronic Unit. †

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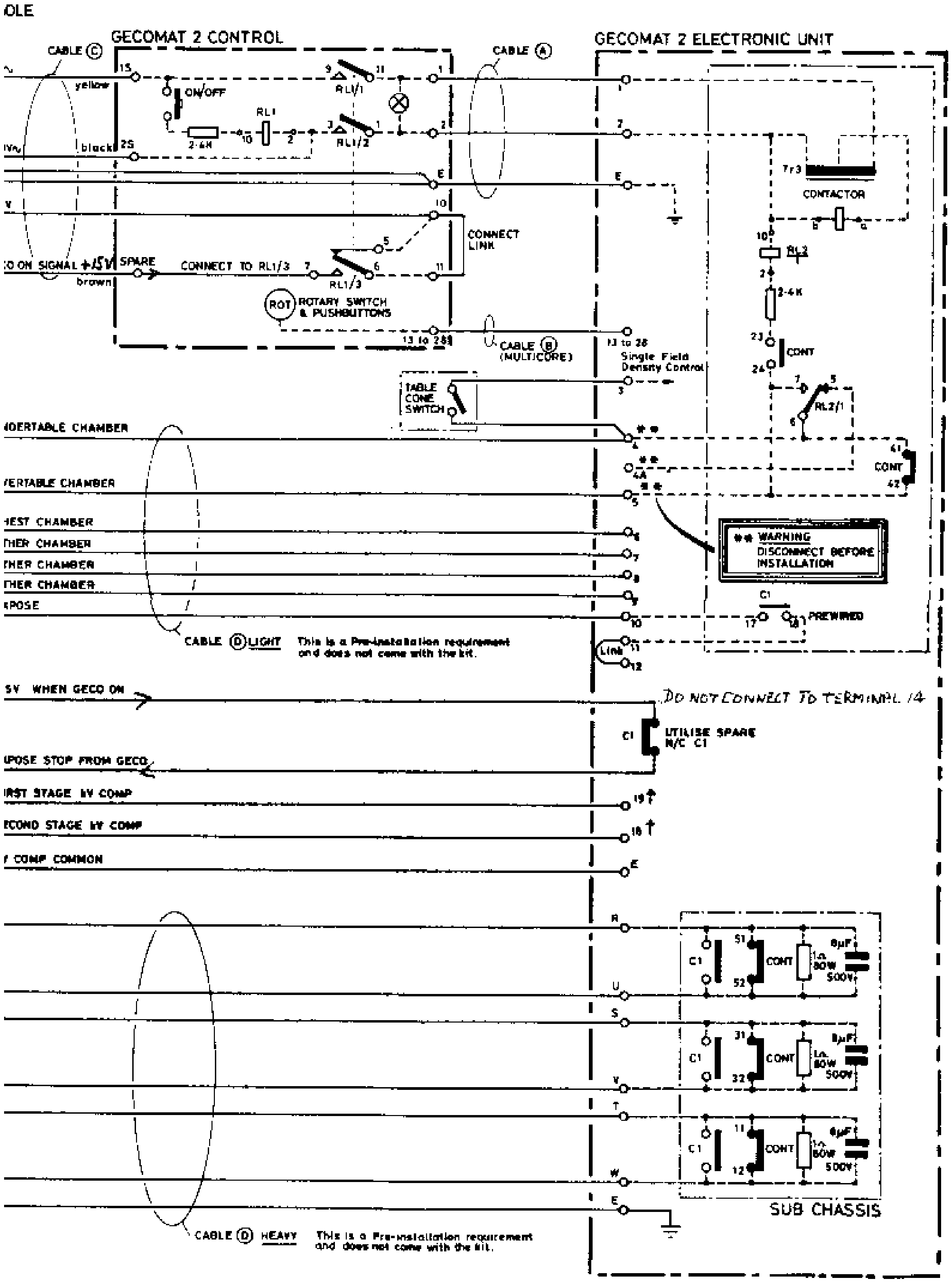

FIG 17. R500 (Series 2) to GECOMAT 2

7 FINAL TESTS AND HANDING OVER

7.1 Final Tests

A Remove all temporary connecting links.

B Check all modes of control for correct functioning.

C Take a stepwedge film for record purposes and recheck that the correct mAs is indicated for each exposure.

D Remove all test equipment, and ensure that any links removed for test purposes are refitted.

E If exposure counters are fitted, record their readings.

F Replace all Control Console, Wall Box and HT Transformer covers.

7.2 Handing Over

A Demonstrate the equipment to the user and ensure that they know how to use it.

B Ensure that the user has a copy of the Operator's Manual INST. 2449.

8 RELAY, CONTACTOR AND MICROSWITCH FUNCTIONS

8.1 Relays

DESIGNATION	DRAWING REFERENCE		FUNCTION
RM 24V coil (HT CHANGEOVER) (Mounted on HT tank)	3760B	F6	Closed to rotate HT switch cam plate c/clockwise during tube selection. Open to rotate HT switch cam plate clockwise during tube selection.
RM/1	3760B	F5/6	Changes drive sense of switch motor M1.
RM/2	3760B	F6	Hold on for RM during c/clockwise rotation after I-16 has opened.
SPL 12V coil (TUBE THERMAL O/L)	3760B	F9	Closed when tube is selected and tube thermal switch is closed at safe.
SPL/1	3760B	F10	Blocks fluoro, prep and expose enabling circuits if tube is overheated or HT switch is not homed to the correct tube.
SPL/2	3763B	H2	Disconnects the lamps in the tube/technique push-buttons if the tube is overheated or HT switch is not homed to the correct tube.
SPL/3		F7	Not used
OAD 24V coil (OVERLOAD)	3760B	F21	Closed if not tube overload
OAD/1	3760B	F10	Blocks the line to the fluoro, prep and expose control circuits if the pre-set kW/time overload factors are exceeded.
OAD/2	3763/B	H4/5	Switches OFF the ready lamp and switches ON the overload lamp if the pre-set kW/time overload factors are exceeded.
OAD/3	3760B	F13	Not used.

8 RELAY, CONTACTOR AND MICROSWITCH FUNCTIONS

8.1 Relays

DESIGNATION	DRAWING REFERENCE	FUNCTION
RM 24V coil (HT CHANGEOVER) (Mounted on HT tank)	3760B F6	Closed to rotate HT switch cam plate c/clockwise during tube selection. Open to rotate HT switch cam plate clockwise during tube selection.
RM/1	3760B F5/6	Changes drive sense of switch motor M1.
RM/2	3760B F6	Hold on for RM during c/clockwise rotation after I-16 has opened.
SPL 12V coil (TUBE THERMAL O/L)	3760B F9	Closed when tube is selected and tube thermal switch is closed at safe.
SPL/1	3760B F10	Blocks fluoro, prep and expose enabling circuits if tube is overheated or HT switch is not homed to the correct tube.
SPL/2	3763B H2	Disconnects the lamps in the tube/technique push-buttons if the tube is overheated or HT switch is not homed to the correct tube.
SPL/3	F7	Not used
OAD 24V coil (OVERLOAD)	3760B F21	Closed if not tube overload
OAD/1	3760B F10	Blocks the line to the fluoro, prep and expose control circuits if the pre-set kW/time overload factors are exceeded.
OAD/2	3763/B H4/5	Switches OFF the ready lamp and switches ON the overload lamp if the pre-set kW/time overload factors are exceeded.
OAD/3	3760B F13	Not used.

DESIGNATION	DRAWING REFERENCE	FUNCTION
CF 24V coil (FOCUS SELECT)	3760B F24	Closed when small focus is selected. This normally occurs at 50mA, 100mA and 200mA.
CF/1	3763B H4	Connects small focus indicator lamp when energised. Connects large focus indicator lamp when de-energised.
CF/2	3758B D5	Supplies secondary of space charge compensation transformer TR7 with 110V on small focus and 140V on large focus.
CF/3	3758B D15	Selects small focus filament transformer when ON and large focus filament transformer when OFF.
RPM 24V coil (HIGH SPEED SELECT)	3760B F22	Closed when high speed not requested.
RPM/1	3763B H11	Connects high speed indicator lamp when de-energised.
RPM/2	3762C I7	Connects 161 to 163 for normal speed start and 161 to 162 for high speed start. These terminals for interface to the MCU.
RPM/3	3760B F13/14	Not used.
K90 24V coil (GECO 90kV)	3760B F19/20	Closed below 80kV.
K90/1	3762C I9	Disconnects 164 from 178 for GECOMAT interface to activate the low kV compensation.
K90/2	3760B F11	Not used.
K90/3	3760B F11	Not used.

DESIGNATION	DRAWING REFERENCE	FUNCTION
K125 24V coil (GECO 125kV)	3760B F20	Closed below 100kV.
K125/1	3762C I8	Disconnects 164 from 179 for GECOMAT interface to activate the High kV compensation.
K125/2	3760B F12	Not used.
K125/3	3760B F12	Not used.
SCA 24V coil (FLUORO ORDER)	3760B F14	Closes when fluoro is ordered from footswitch provided technique 1 is selected and the fluoro timer is reset with no radiography prep command present.
SCA/1	3761B G6	Energises fluoro contactor SCB when ON.
SCA/2	3762C I5	Spare Interface contacts with 191 normally closed to 192 and 191 making to 193 during fluoro.
SCA/3	3756E B8	Change 10mA mA meter scale from line indication to fluoro mA indication.
PGE 24V coil (PREP ORDER)	3760B F15	Closes when radiography prep is ordered, provided that the tube overload, tube thermal, tube selected lights and tube selection circuits are enabled safe.
PGE/1	3761B G7	Blocks fluoro SCC contactor for 0.8s after prep and expose.
PGE/2	3760B F5	Not used.
PGE/3	3760B F5	Not used.

DESIGNATION	DRAWING REFERENCE	FUNCTION
PGB 24V coil (FALSE mAs DETECTOR)	3760B F16	Closes when prep is commanded only if EEE is not indicated on the mAs display.
PGB/1	3761B G10	Blocks PGA, PGC and MA during prep if a false mAs is selected. If mAs is normal it also freezes the Line Automatic Driver prior to expose and also prepares the exposure counter to operate when exposure starts.
PGB/2	3760B F14	Blocks fluoro SCA relay and fluoro display during rad prep and expose.
PGB/3	3756E B8	Change mA meter scales from 10 to 1000mA (from fluoroscopy to radiography).
PDT 24V coil (PREP DELAY)	3760B F23	Closes 0.8s after prep is commanded.
PDT/1	3761B G12	Enables the radiography timer at the end of the prep boost delay time, provided that the stator detector circuits are closed, the tube filament is intact, no fluoro is commanded and the operators expose button is pressed.
PDT/2	3762C I10	Spare NO contact connected to 139 and 140 for interface purposes.
PDT/3	3757E B8	Change mA meter input from line indication to mA radiography.

DESIGNATION	DRAWING REFERENCE	FUNCTION
SF 6V coil (FILAMENT SECURITY)	3758B D14	Closes during radiography prep and expose if current is present in the tube filament.
SF/1	3761B G13	Blocks the radiography exposure timer if the tube filament is open circuited.
SF/2	3758B D14	Not used.
SF/3	3758B D14	Not used.
AMP 1.5 A Coil (STATOR MAIN)	3761B G18	Closes to indicate that current is present in the stator main winding during preparation run up.
AMP/1	3761B G12	Blocks STA contactor if stator main winding is open during prep.
AMP/2	3761B G13	Blocks exposure timer start line if AMP does not open after the end of the prep boost period.
AMP/3	3761B G17/18	Delays changeover from 220V stator start to 40V stator run to minimise arcing on STA-3 contact.
VCC 220V coil (STATOR CAPACITOR)	3761B G18	Closes if voltage is present across stator phase shifting C3 and C4 during stator run up.
VCC/1	3761B G12	Blocks the exposure timer start line if the stator phase shift capacitor is short circuited or if the capacitive winding goes open circuit.
VCC/2	3761B G14	Not used.
VCC/3	3761B G14	Not used.

DESIGNATION	DRAWING REFERENCE	FUNCTION
ZCC 110V coil (STATOR 90° WINDING)	3761B G19	Closes to detect voltage across the stator capacitive winding during prep boost.
ZCC/1	3761B G12	Blocks the exposure timer start line if the stator capacitive winding is short circuited.
ZCC/2	3761B G14/15	Not used.
ZCC/3	3761B G14/15	Not used.
RAY 24V coil (EXPOSE ORDER)	3760B F17	Closes when radiography exposures are commanded by the operators control button provided that the correct technique is selected and that the tube overload, tube thermal, tube selected lights and tube selection circuits are enabled safe.
RAY/1	3761B G13	Closes one of the interlocks in the exposure command line to the radiography exposure timer.
RAY/2	3756E B8	Open circuits the external mAs meter link when a radiography exposure is commanded.
RAY/3	3760B F10	Not used.

DESIGNATION	DRAWING REFERENCE	FUNCTION
RTE 24V coil (EXPOSE ON)	3760B F18	Closes after radiography timer commands an exposure via XL/1.
RTE/1	3761B G11	Completes common return for exposure counters via PGB/1 prep and SCC/6 fluoro.
RTE/2	3763B H5/6	Connects +5V to radiography X-rays ON lamp for a period long enough to give adequate visual indication on short exposures.
RTE/3	3762C I3	Spare NO contact connected to 188 and 189 for interface purposes. NOTE: This remains closed for a short period after each exposure due to the slugging action of XL.
MA 220V coil (MAMMO PREP)	3761B G11	Closes on prep when Tube 4 is selected.
MA/1	3760B F26	Completes circuit for relays MB, MC and MD during prep if IQN 6 and TUBE 4 are selected.
MA/2	3761B G12	Not used.
MA/3	3761B G12	Not used.
MB 24V coil (MAMMO 100mA)	3760B F25/26	Closes on prep when TQN 6, TUBE 4 and 100mA are selected.
MB/1	3758B D12/13	Connects supply to 100mA tapping band on R11 for adjusting small focus on Mammo.
MB/2	3758B D13	Connects supply to 100mA tapping band of R27 for adjusting large focus on Mammo.
MB/3	3760B F18	Not used.

DESIGNATION	DRAWING REFERENCE	FUNCTION
MC 24V coil (MAMMO 200mA)	3760B F26	Closes on prep when TQN 6, TUBE 4 and 200mA is selected.
MC/1	3758B D13	Connects supply to 200mA tapping band of R11 for adjusting small focus on Mammo.
MC/2	3758B D13	Connects supply to 200mA tapping band of R27 for adjusting large focus on Mammo.
MC/3	3760B F20	Not used.
MD 24V coil (MAMMO 300mA)	3760B F26	Closes on prep when TQN 6, TUBE 4 and 300mA is selected.
MD/1	3758/B D12/13	Connects supply to 300 mA tapping band of R11 for adjusting small focus on Mammo.
MD/2	3758B D13	Connects supply to 300mA tapping band of R27 for adjusting large focus on mammo.
MD/3	3760B F22	Not used.
BK 24V coil (TIMER) (PCB 3371 N3554)	3554 3759A E10	Closes if there is excess primary current in the HT tank during exposure or if there is X-rays outside exposure.
BK/1	3767A P2 3554	Removes supply from line contactor C1 to isolate the R500 from the room supply.
XL 24V coil (TIMER) (PCB 3371 N3554)	3554	Closes during radiography exposures and is held ON after termination for short period to permit adequate switching time during the shortest exposure durations.
XL/1	3554 3760B F18	Energises relay RTE during radiography exposures.

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8.2 Contactors

DESIGNATION	DRAWING REFERENCE	FUNCTION
CL 24V 60Hz coil (LINE CONTACTOR)	3767A P2	Closes when ON switch I-15 is pressed via OFF switch I-16 and breaker relay contact BK/1.
CL/1 n/c	3767A P2	Not used.
CL/2	3767A P2	Hold on for CL after I-15 is released.
CL/3	3767A P3 3755B A2	Connects L1 to red phase Line Compensator Switch Pole.
CL/4	3767A P2	Not used.
CL/5	3767A P3 3755B A2	Connects L3 to blue phase Line change voltage link.
CL/6 n/o	3767A P2	Not used.
CL/7 n/c	3767A P2	Not used.
PGA 220V (SCR ISOLATOR)	3761B G9	Closes end of prep boost except if a HS MCU is fitted. In this case it closes during prep.
PGA/1	3761B G10	Not used.
PGA/2	3761B G10	Not used.
PGA/3	3755B A7	Connects TR1A Auto to SCRs.
PGA/4	3761B G10	Not used.
PGA/5	3755B A7	Completes HT primary circuit to TR1A Auto.
PGA/6	3761B G10	Not used.
PGA/7 n/c	3761B G10	Not used.

DESIGNATION	DRAWING REFERENCE	FUNCTION
SCB 220V coil (FLUORO ROTATION)	3761B G6	Closes on fluoro order from SCA/1
SCB/1	3761B G11/12	Supplies 220v to stator drive transformer TR16.
SCB/2	3761B G11/12	Shorts prep delay contact PDT/1 to energise stator changeover STA contactor immediately all stator interlocks are made.
SCB/3	3761B G6/7	Enables fluoro contactor SCC after STA is energised.
SCB/4 n/o	3761B G6/7	Not used.
SCB/5 n/o	3761B G6/7	Not used.
SCB/6 n/c	3761B G10	Disables exposure counter, line volts and PGA & PGC contactors.
SCB/7 n/c	3761B G6/7	Not used.
SCB/8 n/c	3761B G6/7	Not used.
SCB/9 n/c	3761B G6/7	Not used.
SCB/10 n/c	3761B G6/7	Not used.

DESIGNATION	DRAWING REFERENCE	FUNCTION
SCC 220V coil (FLUORO CONTACTOR)	3761B G7	Closes when SCB/3 and STA/5 make provided prep is not commanded.
SCC/1	3757A C6	Connects output of fluoro kV variac to T3 on HT primary.
SCC/2	3757A C6	Connects return from T1 on HT primary to main auto via F10.
SCC/3	3763B H5	Supplies 5V to fluoro X-rays ON lamp.
SCC/4	3762C I1	197 makes to 198 for external interface purposes.
SCC/5 n/o	3761B G8	Not used.
SCC/6	3761B G8	Not used.
SCC/7 n/c	3763B H7	Reduces light to kV meter and mA meter during fluoro exposure.
SCC/8	3762C I2	199 to 200 opens during fluoro for external interfacing purposes.
SCC/9 n/c	3761B G8	Not used.
SCC/10 n/c	3761B G8	Not used.

DESIGNATION	DRAWING REFERENCE	FUNCTION
PGC 220V coil (PREP BOOST)	3761B G10	Closes on prep order from PCB/1 via SCC/6.
PGC/1	3761B G12	Supplies 220V to stator drive transformer TR16A.
PGC/2	3761B G9/10	Enables SCR isolating contactor via STA/5 (end of prep delay) or immediately if the HS link is fitted.
PGC/3	3758B D14/15	Connects filament boost supply to selected focus and enables RL SF.
PGC/4	3762B 13	195 makes to 196 for external interfacing purposes.
PGC/5	3765C M4/5 4037	Applies +15V to kV Adjust PCB 4037 to freeze the overload, HS select, and GECOMAT kV comp circuits during exposure.
PGC/6	3758B D17/18	Disconnects the standby filament supply from R13/14 to small focus.
PGC/7	3758B D17/18	Disconnects the standby filament supply from R15 to large focus.
PGC/8 n/c) PGC/9 n/c) PGC/10 n/c)	3761B G11	Not used

DESIGNATION	DRAWING REFERENCE	FUNCTION
STA 220V coil (RAPID START)	3761B G12	Closes after prep delay time via PGC/1 and PDT/1 in RAD or immediately via SCB/1 and SCB/2 in FLUORO provided all stator interlocks are closed.
STA/1	3761B G12/13	Shorts out stator interlocks during expose.
STA/2	3761B G13	Shorts out external MCU interlocks in HS mode only via AMP/2
STA/3	3761B G17	Connects 50V to stators at end of rapid start period after AMP relay de-energisation period.
STA/4	3761B G18	Short circuits AMP relay at end of prep boost period.
STA/5	3761B G7	Enables fluoro contactor SCC when stator is running following a fluoro command.
STA/6	3761B G17	Removes the 220V stator when the prep boost period is over.
STA/7	3761B G19/20	Disconnects ZCC during expose to eliminate relay buzz on line drop.
STA/8 n/c) STA/9 n/c) STA/10 n/c)	3761B G13	Not used.

8.3 **Microswitches, Rotary Switches and Pushbutton Switches**

DESIGNATION	DRAWING REFERENCE	FUNCTION
Microswitches		
I1	3760B F4	TUBE 1 selector stop.
I2	3760B F4	TUBE 2 selector stop.
I3	3760B F4	TUBE 3 selector stop.
I4	3760B F4	TUBE 4 selector stop.
I5	3760B F6	De-energises relay RM for clockwise rotation of tube selector drive.
I6	3760B F6	Energises relay RM for c/clockwise rotation of tube selector drive.
I7 Not used.		
I8 Not used.		
I9 Not used.		
I10 Not used.		
Rotary Switches		
D1	3755B	Line compensation.
D2	3755B	kV major selector.
D3	3755B	kV minor selector.
D6A	3763B	Time selector.
D6B	3764A	
D6C	3765C	

DESIGNATION	DRAWING REFERENCE	FUNCTION
Pushbutton Switches		
I15	3767A P2/3	Mains ON pushbutton.
I16	3767A P2	Mains OFF pushbutton.
I11	3760B F13	Fluoro kV display push-button.
I12 Not fitted on UK models.		
I13	3760B F15/16	Radiography prep pushbutton.
I14	3760B F16/17	Radiography expose push-button.

9.1 Main Auto Transformer Line Connections

Refer to Drawings 3755B, 3767A & 3761B

A. This is a single phase transformer which can be manually adjusted to operate on power supplies as follows :-

180 - 268 volts
340 - 428 volts
375 - 463 volts

NOTE

It is not recommended to use the 180 - 268 volt supply because the line resistance to an X-ray department is invariably too high for unrestricted power output.

B. Fixed taps are provided at 220V, 380V and 415V for coarse adjustment to the prevailing mains supply.

C. A line compensation switch D1A is provided for fine adjustment as follows :-

i) 6 x 8 volt steps to increase the output voltage by 48 volts
ii) 5 x 8 volt steps to decrease the output voltage by 40 volts

D. Line compensator switch D1 is a break before make switch. For this reason R1 is connected between D1 switch poles and a low voltage tap on the Auto Transformer to prevent circuit tripping when the switch is rotated in between studs. This resistor also serves as an inductive bypass to diminish contact flash over during tap selection.

E. The power supply is normally provided from L3 and L1 and is connected to the Auto Transformer via contacts CL5 and CL3 of the line contactor.

F. The Neutral supply line is not required for the generator and neither should it be used for interfacing ancillaries.

G. Contact CL2 provides a hold on circuit for the Contactor coil after the Mains ON/push button I15 has been released. (See drawing 3767A.)

H. The coil circuit is broken when either the mains OFF push button I16 is depressed or the contact BK1 opens as a result of excessive current in the HT Transformer. BK1 also opens if there is X-rays outside exposure. The coil is connected across two phases namely L1 and L3 and is tapped at 220V 380V 415V and 440V. The tap is reset on installation to the prevailing mains supply. In the factory it is set to 380 volts.

J. The main auxiliary lines from the Auto Transformer are connected to terminals 143/144 via Fuse 3 and 141/142 via Fuse 5 (Drawing 3761B).

The potential of these lines should be 220 volts when the Automatic Line Compensator Switch is correctly set.

K. On 50Hz supplies, the violet common return for all 220v relays and contactors is connected to Fuse 5 (See Drawing 3761B).

The 220 volt ac relay circuits are supplied from terminal 143 and Fuse 5 but they will only function correctly if the 220 volt supply is delivered at 50Hz.

On 60Hz supplies the impedance of the relays will increase which means that the applied voltage will have to be increased by a proportionate amount.

In this case the violet common return is reconnected to Fuse 6 which raises the voltage to the relays and contactors from 220v to 260v.

9.1.1 Power Output Supply

The drive for the HT transformer TR5 is preselected by the kV coarse and fine switches D2 and D3 respectively.

D2 can select kV in approximately 10 kV steps which can be subdivided by D3 into approximately 1 kV steps.

The advantage of coarse/fine kV selection systems is economic in that the tapped windings on the fine selection transformer are recycled after every coarse kV step. In this way the number of taps which would otherwise have to be taken out from the windings is drastically reduced.

The kV selection circuit is routed to terminals T3 and T1 on the transformer tank via the heavy duty primary winding of TR2.

This current transformer provides the excess current and X-rays before and after exposure detection signals.

Also in series with the exposure power lines are contacts 3 and 5 of SCR isolating contactor PGA.

PGA closes at the end of prep boost and thyristors A and B are enabled following an expose command in the sequence outlined in paragraph 9.5.1 expose timer explanation.

It should be noted that the power diode W10 in conjunction with series resistor R6 provides a current path to the HT primary at the end of prep boost BEFORE an exposure is commanded in order to magnetically condition the transformer core.

CAUTION

AS SUCH IT IS IMPORTANT TO REMEMBER THAT LETHAL VOLTAGES ARE PRESENT IN THE HT CABLES WHEN THE GENERATOR IS HELD IN THE PREPARATION MODE OF CONTROL.

9.2 Tube Filament Circuit

Drawing 3758B, 3760B, 3761B and 3763B.

9.2.1 The tube filament stabiliser transformer TR10 is specially wound with a capacitative loaded secondary which provides a degree of stability in the outputs from the secondary windings.

9.2.2 The primary is fed with 220 volts from lines 143 and 141 and is protected by fuses 3 and 5.

9.2.3 The main secondary winding is tapped at 0 volts, 80, 110, 120, 130, 140, 150, 160 and 170 volts.

The 80 volt tap is employed for the tube pre-heat and/or fluoroscopy broad and fine filament circuits.

Broad focus filament transformer TR12 is supplied via pre-heat rheostat R15, contactor PG7 and terminal 104. The return is to the 0 volt tap on TR10 via line 103.

Fine focus filament transformer TR11 is supplied via technique selector switch wafer D5D, max-heat rheostat R13, Fluoro mA Control R14, terminals 171-172, PG6 and terminal 105. The return to the 0 volt tap is via line 103.

9.2.4 During the Radiography Mode of Control the 140 volt and 110 volt taps are used to supply the tube filament broad and fine transformers respectively which of course is dependent on the focus selected. Normally Fine on 50, 100 and 200mA and Broad on 300, 400 and 500mA.

In both cases, the tube filament transformers TR12 and TR11 are fed via the secondary of space charge compensation transformer TR7 which injects an anti-phase voltage proportional to kV into the filament circuit.

This voltage provides maximum filament boost when the coarse kV selector is at position 1 and decreases as the switch is rotated to position 12. (All buck system.)

9.2.5 When broad focus is selected, relay CR is dormant.

Contact CF2 Connects the broad filament radiography supply source to the 140 volt tap on TR10.
Contact CF1 Connects the broad focus indicator light L9 on Drawing 3763B to the 10 volt supply on TR14.
Contact CF3 Selects broad focus filament transformer TR12.

TR12 primary is therefore fed from the 140 volt tap on TR10 via CF2, TR7 secondary, mA switch wafer D49, technique selector switch wafer D5C, mA selector switch wafer D4B (positions 4, 5 or 6), Radiography mA adjusting rheostat R10, Filament Security RL SF, Contact PGC-3 and Contact CF3 to terminal 104. The return to the 0 volt tap on TR10 is via line 103. PGC6 and PGC7 disconnect standby filament drive during prepare and expose.

9.2.6 When fine focus is selected, RL CF is energised from the 24 volt line feeding the diode matrix in kV Adjust PCB 4037 via mA switch D4H and on through to technique switch wafer D5L (Tubes 1, 2 or 3) (see page 28). The other end of RL CF is connected to 0 volts dc.

Contact CF2 Connects the fine filament supply source to the 110 volt tap on TR10.

Contact CF1 Connects the fine focus indicator light L10 to the 10 volt supply on TR14.

Contact CF3 Selects fine focus filament transformer TR11.

9.2.7 Mammography is selected when the technique selector switch is turned to tube 4. In this position the Mammo relay MA will be energised during Prepare via PGB-1 and technique switch D5-0 (see Drawing 3761B).

Contact MA1 closes which allows either relay MB, MC or MD on Drawing 3760B to be selected via mA switch wafer D4H and the diode matrix in kV Adjust PCB 4037. Normally these relays correspond to 100, 200 & 300 mA respectively.

With the mA switch at 100 mA, the contacts of RL, MB will be closed. These connect the mA adjusting rheostats R11 and R27 in parallel and if they are correctly set as per the reference in page 44 paragraph 5.6.8, each broad and fine filament should emit at 50 mA.

The procedure for 200 and 300 mA is the same during which relay MC and MD contacts will close respectively to parallel the 200 and 300 mA portions of R11 and R27.

9.3 kV Calibration Circuits

See Drawings 4039, 4037, 3757A, 3764A, 3760B, 3755B, 3761B, 3762C, 3763B & 3765C

9.3.1 Introduction

A The kV meter is scaled to read 160kV FSD when +7.5 volts is applied to its terminals.

It is connected to F3 pin 8 on kV Adjust PCB 4037 (see drawing 4037) terminal 114, 0 volts dc (see Drawing 3760B coordinates F13).

Pin 8 from the above edge connector is therefore the output from the kV Adjust PCB and it contains a voltage analogue proportional to kV in both the fluoro and radiography modes of control.

B. The purpose of the kV Adjust PCB is to forecast the voltage drop on load within the internal generator circuitry and also the on load voltage drop in the external supply for any given mA. The resultant kV drop to be expected is thus subtracted from the kV display which will then be corrected by the user prior to an exposure: eg. on a properly calibrated PCB, the corrected kV analogue and hence display will naturally decrease with each increase in selected mA, thus when the user increases the kV to the desired value, the correct kV compensation for the mA value selected will be applied to offset the losses encountered on load.

C. The kV analogue voltage is also used within PCB 4037 to control the following functions :-

i kV signal to kW/time overload circuit
ii kV signal to switch tubes from normal speed to high speed operation
iii 90 kV signal for Gecomat compensation
iv 125 kV signal for Gecomat compensation

D. Also on the same PCB there is a diode matrix which is used to preset the tube focal spot combination desired for each mA switch position. Normally it is factory set to give 50, 100 and 200 mA on small focus and 300, 500 and 700 mA on large focus. It is however possible with large tubes to employ small focus in excess of 200 mA if a high speed MCU is deployed (see page 28).

E. The preparation delay circuit for tube filament boost and stator rapid start is also incorporated on this PCB and is adjustable by P29 which forms part of the CR network R52 and C33 for the 556 timer IC-4.

9.3.2 Derivation of kV Analogue Signal - Fluoro

On Drawing 3757A the fluoro supply lines to the primary of the HT tank at the live side of fluoro contactor SCC-1 and SCC-2 are also connected to the primary of fluoro signal step down transformer TR9-P.

The secondary of TR9 is shown on Drawing 3764A and connects direct to edge connector F2 pins 3 and 1.

Edge connector F2 is repeated on Drawing 4037 bottom left and the input to pins 3 and 1 is half wave rectified by D4. The resultant waveform is smoothed and scaled by C17 and P26 respectively.

The output from P26 is taken to pin 1 of analogue switch IC-9. This is a CD4066 Quad Bi-Lateral Switch and it requires a high on pin 13 to make pins 1 and 2 conductive. When ON the circuit in series with pins 1 and 2 can conduct in both directions.

IC9 pins 1 and 2 completes the path to the dual fluoro/radiography kV meter only when the kV meter push button is pressed during standby or during the periods when fluoroscopic exposures are commanded.

Pin 13 of IC-9 therefore goes high during either of the above sequences because pin 6 of NAND Gate IC-7 will be switched high following a high on edge connector F3 pin 7.

From Drawing 3760B coordinates F13 it can be seen that F3-7 can only be high when either I-11 (kV display pushbutton) or the external fluoro foot-switch connected to terminals 156 and 157 is pressed.

The high from IC-7 pin 6 also switches ON a second analogue switch namely IC-9 pin 12. This inserts a dummy load resistor R22 across the output of the radiography kV display circuit when IC-9 pins 11 and 10 switch ON.

The third analogue switch IC9 pin 5 is switched OFF with a low from IC-7 pin 3 which disconnects the kV meter from the radiography calibration circuits.

The scaling potentiometer P26 is adjusted to produce a display of 100kV when the fluoro kV control is set to supply 223 volts to the HT primary circuit from terminal 168 and fuse 10 (see Drawing 3763B).

9.3.3 Derivation of kV Analogue Signal - Radiography
(See simplified schematic Figure 9.1)

On the left hand side of Drawing 4037, three control voltage sources are applied to the PCB and each has a specific function as follows :-

A) Radiography kV Analogue

This is derived from step-down transformer TR6 shown in Drawings 3755B and 3764A.

The primary is connected to fuses 11 and 12 which are in turn connected to the L1 and L3 output phases from the radiography coarse and fine selectors. This voltage is directly related to the HT primary voltage and hence kV.

The secondary of TR6 is connected to edge connector F2 pins 5 and 4 where it becomes full wave rectified and smoothed by W3 and C16.

A potential dividing network comprising P27 and R5 scales the smoothed output voltage to an OFF LOAD voltage analogue proportional to 125kV.

P27 is therefore the NO LOAD top end adjustment potentiometer.

B) Radiography kV Range

This is derived from transformer TR13.

The primary is connected across the 220 volt line on Drawing 3761B.

The secondary on Drawing 3764A provides a constant 10 volts to edge connector F2 pins 7 and 6, after which it becomes full wave rectified and smoothed by W2 and C14 respectively.

The smoothed output is applied to the input of a LM317T voltage regulator T2.

The output at pin 2 is used to provide an OFF LOAD voltage proportional to 50kV.

This voltage can be adjusted by P28. When it is all in circuit, the output is high. When it is all out the output is zero.

P28 is therefore the NO LOAD bottom end adjustment potentiometer and it is normally factory set to develop 1.4 volts across C15.

C) Radiography kV Inverse Volts

Again this is derived from TR13 which on Drawing 3764A has another secondary winding S3 which generates a constant 20 volts into edge connector F2 pins 9 and 8.

Rectifiers W1 and C12 respectively provide full wave rectification and smoothing of the inverse voltage supply source and the resultant dc voltage is applied to input pin 3 of a LM317T voltage regulator T1.

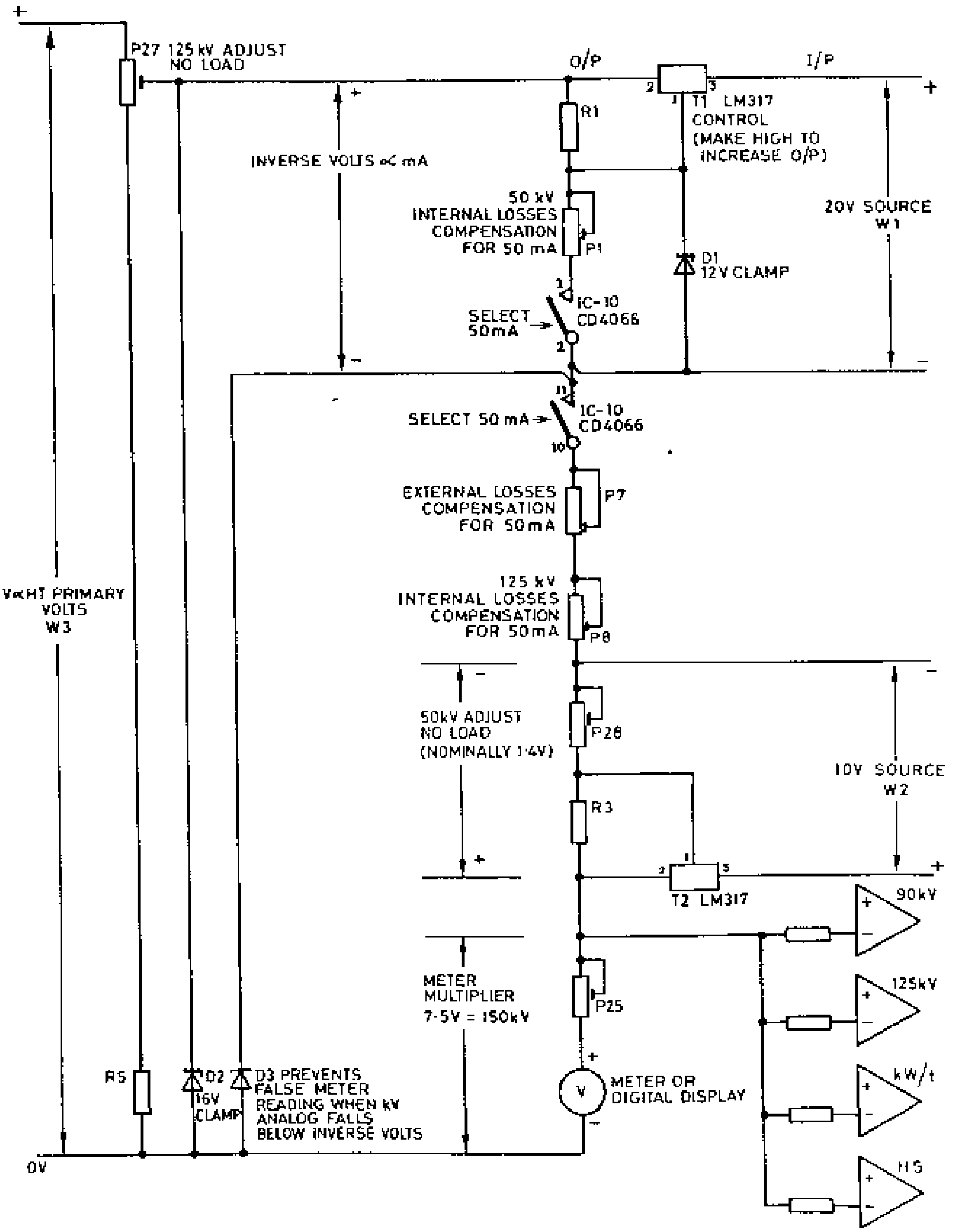


Figure 9.1 SIMPLIFIED CIRCUIT OF kV CALIBRATION FOR 50 mA

The output of T1 can be controlled by any of the following potentiometers one at a time :-

- i P1 when 50mA is selected
- ii P2 when 100mA is selected
- iii P3 when 200mA is selected
- iv P4 when 300mA is selected
- v P5 when 400mA is selected
- vi P6 when 500mA is selected

If 50mA is selected, P1 is factory set to output a small voltage from voltage regulator T1 which is in series opposition to the kV meter drive signal.

This reduces the kV meter reading by the amount which would be lost during an exposure on account of the internal voltage drops inherent in the generator circuitry at 50kV.

The complementary 50mA potentiometer P8 is factory set to modify the bucking voltage at 125kV.

Thus with both potentiometers correctly set, the actual internal losses will be indicated on the kV meter and corrected prior to an actual exposure.

With each increase in selected mA the internal losses become greater which calls for more opposition volts to be outputted from T1.

Thus at 500mA the 50kV related output from T1 would be factory set by P6 to inject a much higher opposition voltage in series with the kV display than 50, 100, 200, 300 and 400mA which calls for a much greater correction of the coarse and fine kV controls prior to an exposure.

The 125kV inverse voltage correction is this case will be P18 which is the 500mA high kV complementary potentiometer for P6.

9.3.4 kV Analogue Circuit Description

The potentiometers discussed so far are summarised as follows :-

P26	Fluoro kV calibration
P27	125kV adjust NO LOAD
P28	50kV adjust NO LOAD
P8	125kV adjust for 50mA ON LOAD INTERNAL LOSSES
P10	125kV adjust for 100mA ON LOAD INTERNAL LOSSES
P12	125kV adjust for 200mA ON LOAD INTERNAL LOSSES
P14	125kV adjust for 300mA ON LOAD INTERNAL LOSSES
P16	125kV adjust for 400mA ON LOAD INTERNAL LOSSES
P18	125kV adjust for 500mA ON LOAD INTERNAL LOSSES
P1	50kV adjust for 50mA ON LOAD INTERNAL LOSSES
P2	50kV adjust for 100mA ON LOAD INTERNAL LOSSES
P3	50kV adjust for 200mA ON LOAD INTERNAL LOSSES
P4	50kV adjust for 300mA ON LOAD INTERNAL LOSSES
P5	50kV adjust for 400mA ON LOAD INTERNAL LOSSES
P6	50kV adjust for 500mA ON LOAD INTERNAL LOSSES

Those not discussed are engineers' adjustments to compensate for line losses encountered on site. They are as follows :-

P7	Adjust for 50mA ON LOAD EXTERNAL LOSSES
P9	Adjust for 100mA ON LOAD EXTERNAL LOSSES
P11	Adjust for 200mA ON LOAD EXTERNAL LOSSES
P13	Adjust for 300mA ON LOAD EXTERNAL LOSSES
P15	Adjust for 400mA ON LOAD EXTERNAL LOSSES
P17	Adjust for 500mA ON LOAD EXTERNAL LOSSES

The simplified schematic on Figure 9.1 illustrates the radiography kV display calibration circuit with a 50mA selection.

Analogue switches IC10 pins 13, 1 and 2 and IC10 pins 12, 11 and 10 are therefore biased ON to insert P1, P7 and P8 in circuit.

The +ve bias signal for IC10 pins 13 and 12 comes from the +15V line via mA switch D4-I on Drawing 3765C and enters pcb 4037 at edge connector F3 pin 1.

With IC-10 pins 1 to 2 & IC-10 pins 11 to 10 conductive, the +ve kV analogue signal is delivered to the +ve input of the kV meter via the following route :-

No load adjustment	P27	(125kV)
Internal losses adjustment	R1	(50kV at 50mA)
	P1	Subtraction volts set by P1
50mA analogue switch	IC-10	pins 1 and 2
50mA analogue switch	IC-10	pins 11 and 10
External losses adjustment	P7	(50mA)
Internal losses adjustment	P8	(125kV at 50mA)
No load adjustment	P28	(50kV)
	R3	
kV meter multiplier	P25	

The -ve output from the kV display is returned direct to 0 volts dc (terminal 114).

If 100mA is selected, then the above route will change as follows :-

No load adjustment	P27	(125kV)
Internal losses adjustment	R1	(50kV at 100mA)
	P2	Subtraction volts set by P2
100mA analogue switch	IC-10	pins 3 and 4
100mA analogue switch	IC-10	pins 9 and 8
External losses adjustment	P9	(100mA)
Internal losses adjustment	P10	(125kV at 100mA)
No load adjustment	P28	(50kV)
	R3	
kV meter multiplier	P25	

The -ve output from the kV display is returned to 0 volts dc (terminal 114).

Note that the current entering the top end of P28 does not actually flow through P28 and R3. The 10 volt step-up supply carries this current and it is outputted from pin 2 of T2 at the voltage level preset by P28.

For the 200, 300, 400 and 500 mA switch positions the current is routed via the associated analogue switches and scaling potentiometers shown on Drawing 4037 using the same reasoning as described for 50mA and 100mA.

Diode D2 provides clamping at 16 volts should the kV analogue signal be driven in excess of this voltage level.

Diode D1 clamps the control voltage for inverse voltage regulator T6 to a maximum of 12 volts.

Diode D3 prevents false readings on the kV meter if the kV voltage analogue value becomes less than the inverse voltage level from T1. If this was allowed to happen, the output of T1 would predominate at very low kV settings and send a reverse current through the kV meter which would try to reverse, eg. the meter reading would follow a decrease in set kV until the kV analogue signal equals the inverse volts signal. Any further decrease in set kV would then cause the kV meter to reverse.

9.3.5 Application of the kV Analogue to the kW/Time Tube Overload Circuit

Correct adjustment of the kV calibration circuits should produce +7.5 volts at the high potential end of multiplier P25 when 150kV is selected. This voltage is also applied to the inverting input of OP AMP IC-8 pin 4 via R30.

The non-inverting input, pin 5, is connected to time switch D6-B pole via edge connector F2 pin 12 (see Drawing 3764A).

Time switch D6-B pole outputs a voltage analogue proportional to mA and time. It is calibrated to the characteristics of the X-ray tube deployed. (See kW/time tube overload circuit.)

The above voltage must always be higher than the kV analogue voltage when the tube overload factors, namely time, mA and kV, are within the ratings of the tube.

This will make the output of OP AMP IC-8 pin 2 high and also pin 13 of the 4042 Quad Latch IC-11. Pin 13 is the D3 input and it will only be low when the tube overload parameters are exceeded.

The Q3 output on pin 11 follows the D3 input only when a high clock signal is present on pin 5. When the clock signal is low, eg. during prep with no fluoro, the D3 input is disabled and Q3 remains in its latched state.

During standby and fluoro mode of control, the clock signal is therefore high and this will latch the Q3 output to the high on the D3 input. D3 and Q3 will of course be low if the tube overload factors are exceeded.

With no tube overload, pin 11 of IC-11 is therefore high and it causes transistor T5 to switch on. The collector/emitter current subsequently energises relay OAD on Drawing 3760B (coordinates F21).

When OAD relay energises, the ready lamp on Drawing 3763B (coordinates H3) illuminates and the fluoro and radiography exposure control circuits are cleared.

In its de-energised stàte, the tube overload lamp is lit (on Drawing 3763B) and the fluoro and radiography exposure control circuits on Drawing 3760B (coordinates F10) are blocked.

The clock signal for IC-11 pin 5 goes low when prep is commanded. As already stated, a low clock signal disables the 4042C Quad Latch when prep is commanded with no fluoro. This is necessary during radiography exposures because a lot of noise is generated which can enter the data inputs. The Q outputs must therefore be isolated from the data inputs during prep and expose in order to prevent hiccuping from the circuits they control.

The Quad Latches are however enabled during fluoro exposures because it is frequently necessary for the user to change radiography kV in preparation for the next radiograph. In this situation, the overload sensing circuits must therefore remain active.

The +15 volt prep signal comes from Drawing 3765C (coordinates M5) when contactor PGC-5 closes and it enters Drawing 4037 at edge connector F2 pin 10 (centre lower right).

F2 pin 10 connects to pin 9 of NAND gate IC-7 and the output at pin 8 only goes low if both pins 9 and 10 are high. Pin 10 remains high until fluoro is commanded via a high on edge connector F3 pin 7, thus if F3-7 is low and F2-10 is high, the output of IC-7 pin 8 will be low to disable IC-11 at pin 5.

When fluoro is commanded, edge connector F3 pin 7 goes high which applies a low to IC-7 pin 10 via inverter IC-7 pins 12, 13 and 11. The clock input at pin 5 of IC-11 therefore remains high during fluoro to enable the Quad Latch.

9.3.6 <u>Application of the kV Analogue to the High Speed Select Circuit</u>
See Figure 9.2.

On the Maximum Load PCB (Drawing 4039), links have to be inserted for tubes destined for high speed operation. These solder links are shown bottom centre left on the drawing.

The maximum complement of tubes for the R500 is four, from which three can be of different types, namely group X, group Y or group Z.

If tube 2 is the high speed tube, then it can be allocated to either group X or group Y. (Group Z is normally allocated for the mammo tube.)

Assuming that group X is allocated for tube 2, it will be necessary to solder links between sockets HS, X and 2.

It is arranged on the R500 for technique switch positions 2, 3 and 4 to select tube 2 and these are shown on Drawing 3765C (coordinates M8) wired to D5-N.

+15 volts will therefore be applied to edge connector E3 pin 8 on the Max Load PCB when any of the above techniques are selected causing the HS link on Drawing 4039 and edge connector E2-1 to become high. This high is passed to the kV Adjust PCB (Drawing 4037) and makes pin 6 of analogue switch IC-9 high via edge connector F1 pin 6 and R48 (lower right of centre on drg 4037).

With IC-9 enabled, the output pin of OP AMP IC-8 is connected to D4 input pin 14 of IC-11.

Pin 14 of the above Quad Latch will be high during the periods when Tube 2, kV, mA and time factors are within the permissible normal speed ratings and this high is transferred to the Q4 output at pin 1 of IC-11 and subsequently T6 base junction via R45.

The collector/emitter current in T6 energises relay RPM on Drawing 3760B (coordinates F22). Contact RPM/1 on Drawing 3763B (coordinates H11) blocks the HS select indicator and contact RPM/2 on Drawing 3762C (coordinates I7) deselects the HS stator circuits in the MCU for normal speed control.

Potentiometers P19 through P24 on Drawing 4037 are the normal speed overload adjustments (HS selects) for 50, 100, 200, 300, 400 and 500mA respectively. Only one is switched ON at a time by their respective analogue switches as follows :-

50mA	IC-1	pins 13, 1 and 2
100mA	IC-1	pins 5, 3 and 4
200mA	IC-1	pins 6, 8 and 9
300mA	IC-1	pins 12, 10 and 11
400mA	IC-1	pins 13, 1 and 2
500mA	IC-5	pins 5, 3 and 4

Assuming that 50mA is selected as in Figure 9.2, IC-1 pin 13 will be driven high from edge connector F3 pin 1 (top left of centre on Drawing 4037).

F3-1 is connected back to +15 volts via 50mA selector D4-I.

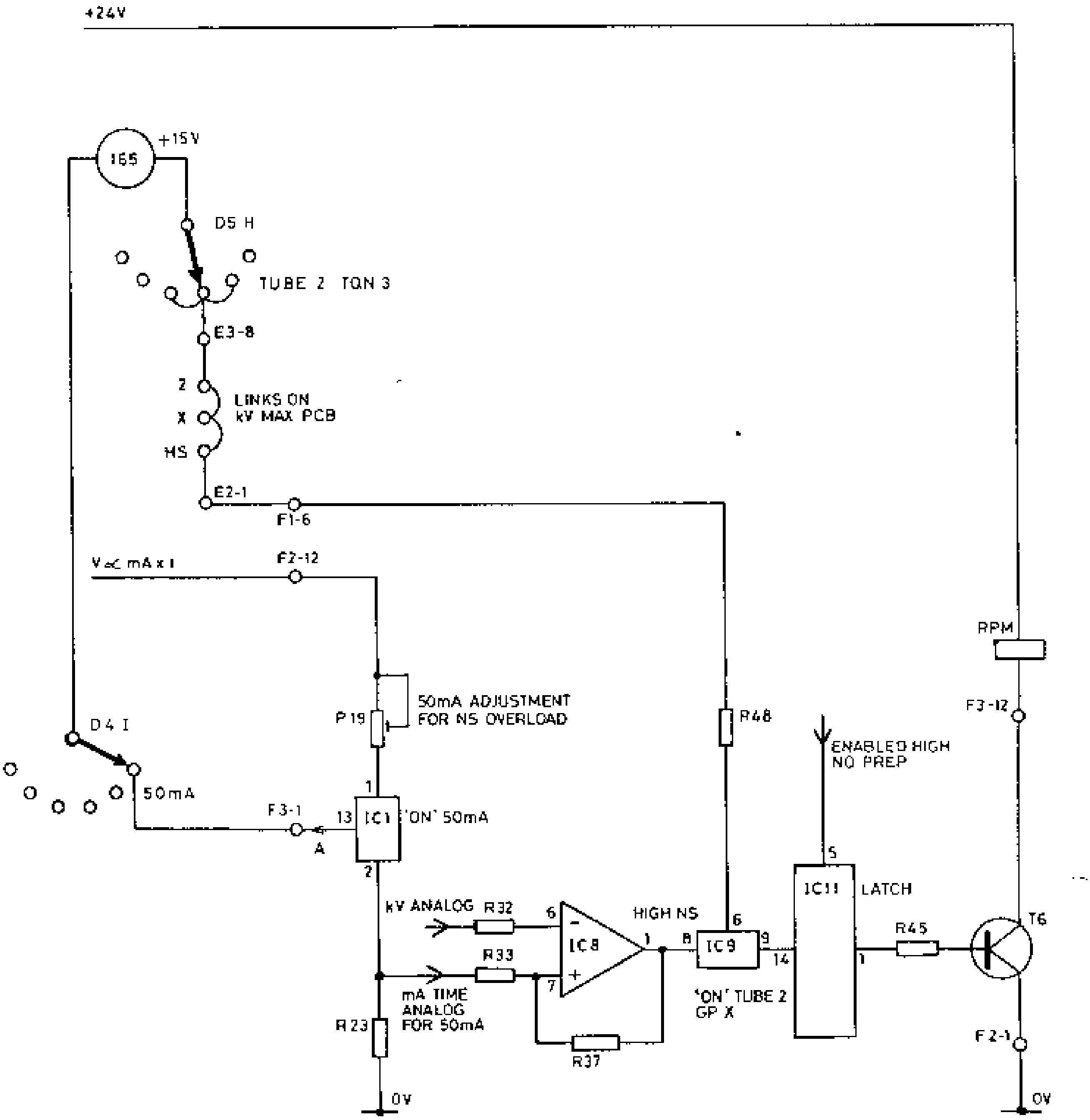


Figure 9.2 HIGH SPEED STATOR SELECT

With IC-1 pins 1 and 2 now conductive, P19 in conjunction with R23 is connected to the mA/time voltage analogue to form a potential divider which is adjusted to satisfy the 50mA normal speed overload characteristics of the high speed tube. This assumes of course that the high speed overload factors were correctly adjusted in the first place.

The output from the top end of R23 is passed to the non-inverting input of OP AMP IC-8 at pin 7. During adjustment, pin 7 is taken progressively lower in value by gradually increasing the resistance of P19 until the kV analogue volts at the inverting input exceeds the mA/time analogue volts on the non-inverting input.

At this point, pin 1' goes low to switch OFF transistor T6 via Quad Latch IC-II.

Relay RPM reverts to its de-energised state to illuminate the high speed indicator (RPM/1, coordinates H11 on Drawing 3763B) and prepares the MCU for high speed stator control (RPM/2, coordinates I7 on Drawing 3762C).

9.3.7. Application of the kV Analogue to the Gecomat kV Compensation Circuits

A) General

The standard Gecomat is equipped with kV compensation push buttons to provide density correction at 90kV and 125kV.

These are normally selected manually by the operator on the Gecomat Control Panel. On the R500 there is however no requirement to use these buttons which can be disconnected in favour of automatic selection facilities within the generator.

As this is a 125kV Generator, maximum benefit is derived by automatically selecting the 90kV compensation at 80kV and the 125kV compensation at 100kV. They can of course be altered to any other values to suit individual user preference.

B) 90kV Compensation

This is factory set to 80kV by adjustment of P31 on Drawing 4037.

When the selected kV is below 80kV, the non-inverting input at pin 11 of OP AMP IC-8 exceeds the inverting input at pin 10.

Pin 13 output is therefore high which switches transistor T3 ON via Quad Latch IC-11 pins 4 to 2 and R42.

Relay K90 on Drawing 3760B (coordinates F19) becomes energised with T6 collector/emitter current and contact K90/1 on Drawing 3762C closes to energise relay d609 in the Gecomat Electronics Module.

When contact d609 closes, it short circuits the 90kV adjustment potentiometer R623 on the Gecomat U6 PCB.

With P31 correctly set, the voltage on the inverting input on IC-8 pin 10 will exceed the voltage at the non-inverting input of IC-8 pin 11 if the selected kV exceeds 80kV.

This will result in a low output from IC-8 pin 13 which in turn unlatches IC-11 pins 4 and 2 to switch OFF T3.

Relay K90 in the R500 opens.
Relay d609 in the Gecomat opens.
R623 in the Gecomat is inserted in circuit to reduce film blackening to the same level as the 60kV base density.

C) <u>125kV Compensation</u>

This is factory set to 100kV by adjustment of P30 on Drawing 4037.

When the selected kV is below 100kV, the non-inverting input at pin 9 of OP AMP IC-8 exceeds the inverting input at pin 8.

Pin 14 output is therefore high which switches ON transistor T4 via Quad Latch IC-11 pins 7 to 10 and R43.

Relay K125 on Drawing 3760B (coordinates F20) becomes energised with T4 collector/emitter current and contact K125/1 on Drawing 3762C closes to energise d608 in the Gecomat Electronics Module.

When contact d608 closes, it short circuits the 125kV adjustment potentiometer R624 in the Gecomat U6 PCB.

With P30 correctly set, the voltage on the inverting input of IC-8 pin 8 will exceed the voltage at the non-inverting input of IC-8 pin 9 if the selected kV exceeds 100kV.

This will result in a low output from IC-8 Pin 14 which in turn unlatches IC-11 pins 7 and 10 to switch OFF T4.

Relay K125 in the R703 opens.
Relay d608 in the Gecomat opens.
R624 in the Gecomat is inserted in circuit to reduce film blackening to the same level as the 60kV base density.

9.4 The kW/Time Overload Circuit

See Drawings 4037, 4039 and 4040

9.4.1 General

Figure 9.3 is a simplified schematic depicting the kW/time Overload circuit when 50mA is selected for tube type X.

The two comparators IC-8 form the heart of the circuit.

IC-8 pins 4,5 and 2 is used to switch OFF relay OAD via transistor T5 if the tube overload parameters are exceeded.

IC-8 pins 6,7 and 1 is used to switch OFF relay RPM via transistor T6 if the normal speed overload parameters of a high speed tube are exceeded. This in turn sets the MCU to accept high speed stator commands when the generator is switched to radiography preparation.

The two comparators work on the principle that a voltage analogue directly proportional to selected kV applied to the inverting inputs is compared with a signal which includes a kV analogue PLUS a voltage analogue proportional to selected mA and time. This signal is applied to the non-inverting inputs and it is calibrated to switch OFF relays RPM and OAD if the mA and time increments exceed the rating of the tube for any selected kV.

In the case of a high speed tube, relay RPM would open first to switch the system into high speed mode when the normal speed rating is exceeded and finally relay OAD will open when the high speed rating is exceeded.

If a normal speed only tube is deployed, relay RPM will be permanently closed for normal speed operation and the circuit will be calibrated to open relay OAD when the normal speed tube rating is exceeded. In this case, IC-9 pin 6 will be permanently low which open circuits pins 8 to 9. Pull-up resistor R41 however ensures that T6 is held ON via Quad Latch IC-11 pins 14 and 1 and R45.

The Quad Latch IC-11 latches the outputs to the state of the inputs only when pin 5 clock signal is held high. During radiography preparation, the clock signal is taken low to isolate the latch inputs from undesirable voltage transients during exposures. The outputs therefore remain latched at their pre-preparation states.

9.4.2 The Calibration Networks

A resistance chain comprising R3 to R34 is connected to the output of Voltage Regulator T1 (left side of Drawing 4039). It has 33 tapping points which are connected to a solder pin matrix displayed on Drawing 4040. The correct kV analogue is chosen and solder pinned on this matrix during calibration.

With a constant 8 volts applied to the above resistance chain, it is possible to obtain 32 different analogue voltages in 0.25 volt steps. Each step equates to approximately 5kV.

Another resistance chain comprising R53 to R74 (right of Drawing 4039) has 23 taps connected to each position of the timer switch and also the time matrix displayed on Drawing 4040. NOTE that the 0.003, 0.006, 0.01, and 0.02 taps are at the same potential.

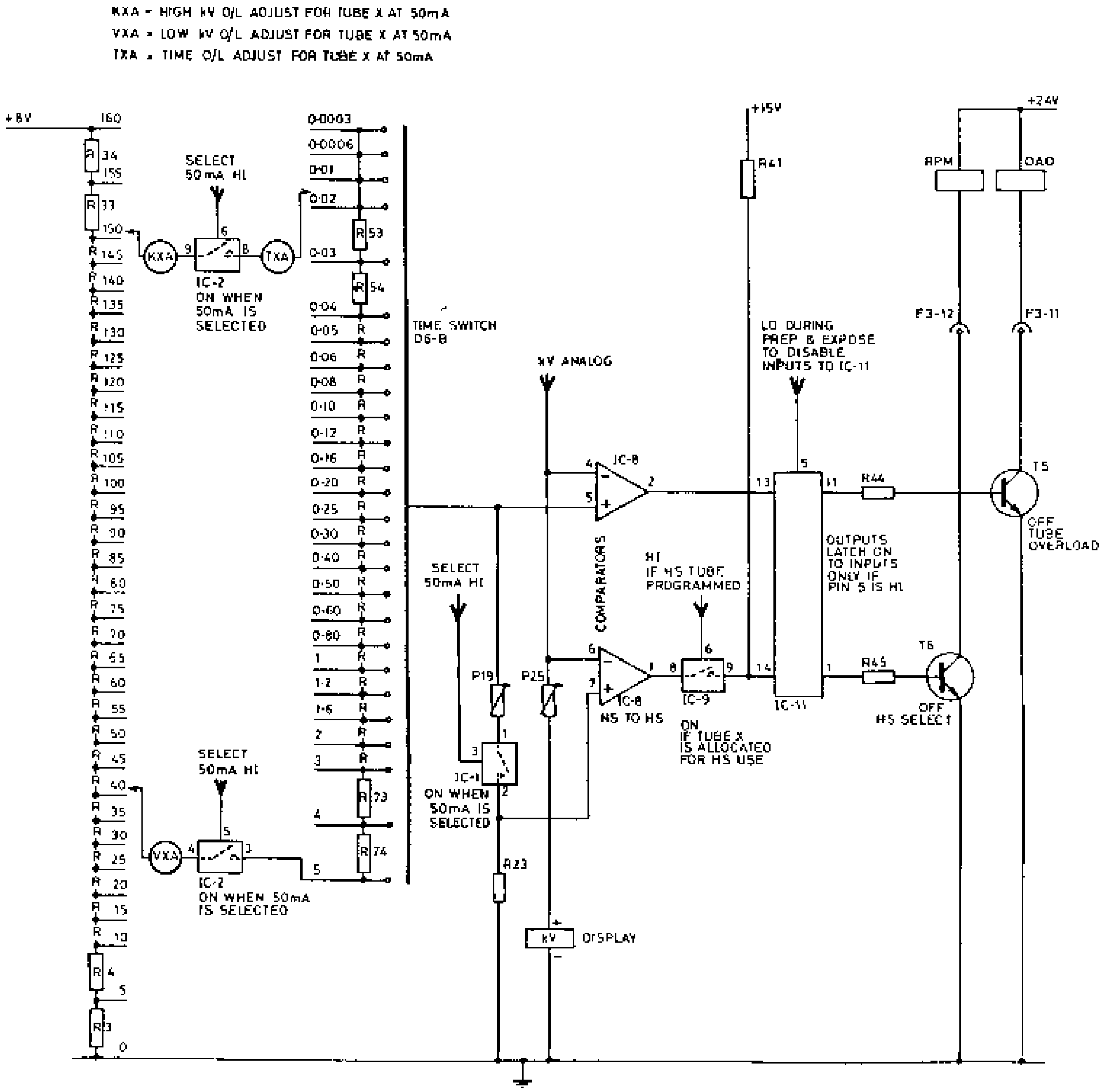


Figure 9.3 SIMPLIFIED SCHEMATIC kW/TIME OVERLOAD

WHEN 50 mA IS SELECTED

mA	TIME		
	GROUP X	GROUP Y	GROUP Z
50	TXA	TYA	TZA
100	TXB	TYB	TZB
200	TXC	TYC	TZC
300	TXD	TYD	TZD
400	TXE	TYE	TZE
500	TXF	TYF	TZF

mA	HIGH KV SHORT TIME ZONE ADJUSTMENT		
50	KXA	KYA	KZA
100	KXB	KYB	KZB
200	KXC	KYC	KZC
300	KXD	KYD	KZD
400	KXE	KYE	KZE
500	KXF	KYF	KZF

mA	LOW kV 5 SECOND POINT ADJUSTMENT		
	GROUP X	GROUP Y	GROUP Z
50	VXA	VYA	VZA
100	VXB	VYB	VZB
200	VXC	VYC	VZC
300	VXD	VYD	VZD
400	VXE	VYE	VZE
500	VXF	VYF	VZF

TABLE OF MATRIX SOLDER PIN CONNECTIONS.

9.4.2.1 High Speed Overload Calibration

If for example a particular high speed tube rating chart indicates that 125kV exposures are permitted up to 0.2 secs at 50mA, the KXA tap on Figure 9.3 should be matrixed to 125kV on the kV divider chain and the TXA tap should be matrixed to 0.2 secs on the time divider chain.

This is the starting point and the next step is to establish the overload kV associated with 5 secs. If in our example this happens to be 70kV, the VXA tap should be matrixed with 70kV on the kV divider chain.

In theory this should apply the analogue voltage output from the 125kV tap to the 0.2 second tap via the 50mA analogue switch IC-2 pins 9 to 8 and the 5 second tap will complete the circuit back to the 70kV tap via the 50mA analogue switch IC-2 pins 3 to 4.

If the time switch is rotated from 0.01 secs to 5 secs, the output from the switch will remain reasonably constant up to 0.2 secs. From thereon, the output will progressively decrease.

The above output is applied to the non-inverting input pin 5 of IC-8, thus with 125kV selected, the voltage at pin 5 should drop below the voltage at pin 4 only when 0.25 seconds and above are selected.

This causes IC-8 pin 2 to swing -ve and so switch OFF transistor T5 and ultimately relay OAD via Quad Latch IC-11 and R44.

At 5 seconds, the non-inverting input of IC-8 will be very low with respect to the inverting input causing relay OAD to remain de-energised.

If the kV however is reduced to below 70kV, then the inverting input should swing to a value less +ve than the non-inverting input. This will cause the output to swing +ve and so switch ON transistor T5 and hence relay OAD to clear the overload. The full range of the time switch is therefore only available at 69kV and below.

In practice, a certain amount of trial and error is involved before correct tube overload tracking can be achieved because we are attempting to match a basically linear circuit to parameters which are non-linear. The kV and time values allocated to the matrices must therefore be regarded as approximate.

Once the initial matrix points have been pegged, eg. in our example

KXA	125kV
TXA	0.2 secs
VXA	70kV

the following rules should be adopted:-

A. Select 50mA and 70kV.

B. Advance time switch to 5 secs.

C. a) If overload does not switch ON, move VXA to a lower kV tap.
b) If overload occurs at 4 secs or less, move VXA to a higher kV tap.

D. Turn back timer switch to 0.01 secs, select 125kV and then advance the timer to 0.25 secs.

E. a) If overload occurs early before 0.25 secs, move KXA to a higher kV tap.
b) If overload occurs late after 0.25 secs, move KXA to a lower kV tap.

F. Repeat steps A, B and C followed by steps D, E and F until the 70kV and 125kV overload parameters are correct.

G. Check the in-between kV values at 110, 100, 90 and 80kV.

H. If tracking is poor at 110kV and 100kV, compromise with a readjustment of KXA and then re-check 70kV at 5 secs. If necessary readjust VXA.

J. If tracking is poor at 90kV and 80kV, compromise with a readjustment of VXA and then re-check 125kV at 0.25 secs. If necessary readjust KXA.

K. If there is still room for improvement at 110kV and 100kV, readjust TXA and VXA for best compromise overall.

A special calibration board is available at Regional level for trial and error adjustments before final soldering of the matrix pins on the R500 MAX LOAD PCB.

9.4.2.2 Max kV Calibration

For X-ray tubes that are capable of delivering 125kV exposures right up to 5 secs, the only adjustment that is required on the overload PCB is to limit the generator output to 125kV max. The R500 is a 125kV generator and must not be permitted to operate above this figure. At 500mA it is further restricted to 100kV in order to keep it inside the overall 35.5 kW power output rating.

In our 50mA example on Figure 9.3, TXA must therefore be pinned to 0.01 secs and KXA and VXA should both be initially pinned to the 125kV tap.

If exposure blocking occurs at 125kV or less, KXA and VXA must be moved upwards to a higher kV tap.

If exposure blocking occurs at 127kV or more, KXA and VXA must be moved downwards to a lower kV tap.

When correctly set, the output from time switch D6-B should make the non-inverting input to IC-8 pin 5 less +ve than the inverting input to pin 4 when the kV is increased from 125kV to 126kV.

This in turn activates the overload circuit by de-energising relay OAD via T5, R44 and Quad Latch IC-11 pins 11/13.

9.4.2.3 Max Load Calibration

At 500mA, the generator is limited to 100kV. This must be taken into account when consulting tube rating charts for the maximum allowable kV, eg. if a particular tube is capable of 125kV exposures at 500mA, then it must be forbidden by setting the KXE and TXE matrices to track the tube overload parameters from 100kV down (not 125kV down).

9.4.2.4 Normal Speed Overload Calibration

As regards normal speed overload adjustments, these are finalised by adjustment of P19 through P24. They are shown on Drawing 4037 and cater for 50mA to 700mA adjustment in that order.

In our 50mA example on Figure 9.3, P19 is set to enable the high speed motor control unit when the normal speed tube overload parameters are exceeded.

Increasing the resistance of P19 causes the non-inverting input of IC-8 pin 7 to decrease. With correct normal speed overload mA, kV and time factors selected on the generator, P19 resistance is increased to the point where IC-8 pin 7 volts just becomes less than IC-8 pin 6 volts. This causes the output from pin 1 to swing -ve and so switch OFF transistor T6 and ultimately relay RPM via HS Select Analogue switch IC-9 pins 8/9, Quad Latch IC-11 pins 14/1 and R46.

With relay RPM de-energised, the MCU is raised to the ready state for high speed stator running following a radiography preparation command.

A detailed description is contained in Paragraph 9.3.6.

NOTE If a normal speed only tube is deployed, P19 to P24 should be turned fully counter clockwise and matrixes K, T and V must be set up to the parameters contained in the normal speed tube rating charts.

9.5 The Timer

See Drawing 3554, Drawing 3755B and Drawing 3761B.

9.5.1 General

A binary count-up timer dependent on clock pulses derived from the mains frequency is employed to control the exposure duration (see IC-1, IC-2, IC-3 of Drawing 3554.

The clock pulse generator (IC-5 of Drawing 3554) shapes the 10 mS wide pulses into a series of square pulses 100 uS wide at a rate of 1 every 10 mS. As these are derived from mains frequency, they can only count in multiples of 10 mS for a 50 Hz supply. (See Figure 9.4 A, B, C.)

A synchro phasing circuit (W2, Z2, IC-4 pins 5 & 6 of Drawing 3554) generates half wave rectified pulses 10 mS wide once every 20 mS which in conjunction with the timer clock pulses and an exposure command signal sets a flip flop (IC-8 pins 1, 2 & 14 of Drawing 3554) to initiate exposures approximately 1.5 mS after the +ve going line phase commences an excursion into the -ve region. This is known as the phasing-in period prior to the actual expose start. (See Figure 9.4F.)

The 1.5 mS delay time is made up as follows. The pulse generator transformer TR1 (Drawing 3554) is connected to the line auto transformer to produce a waveform which is in phase with the main power supply as shown on Figure 9.4 A. The resultant clock pulses (Figure 9.4 B, C, D, E & G) occur approximately 1.5 mS after the zero crossover of the -ve going waveform. In this way an exposure start hold-off circuit is activated as shown in Figure 9.4 H, J & K, to start exposures only when the line phase is approaching zero crossover just before the next +ve going excursion.

An adjustable monostable (expose start delay IC-7 pins 6 & 5 on Drawing 3554) is arranged to hold off the actual exposure start until the line phase has climbed almost into the positive region. The actual expose start usually occurs approximately 1 mS before zero crossover in order to produce adequate HT waveforms on the shortest time switch setting as seen in Figure 9.5, eg 10 mS.

The firing order of the two SCRs shown in Drawing 3755B is as follows:

10 mS (L3 +ve) to L1 via SCRA & TR5 & switching circuits

20 mS (L3 +ve) to L1 via SCRA & TR5 & switching circuits

then (L1 +ve) to L3 via TR5 & SCRB & switching circuits

During the exposure, the decade count up timer IC1 (units), IC3 (tens), IC2 (hundreds) counts up the clock pulses in multiples of 10 mS as shown in the Table on page 9.34. If, for example, the set exposure time is 0.12 seconds, termination will commence when Q1 of IC1 and Q0 of IC3 both go high.

This in turn switches OFF transistors T5 and T8 to produce a high on the base of transistor T3. With T3 now ON, the STOP monostable IC7 receives a negative trigger pulse via buffer IC4 pins 1 and 2, inverter IC-10 pins 4, 5 and 6 and capacitor C15.

The output at pin 9 of monostable IC7 goes high for the period preset by P2 which has an adjustable range of up to 12 mS.

When correctly set, the output from pin 9 of IC7 should go low just before zero crossover on the correct terminating phase. This will complement the high on pin 9 of IC6 with a high on pin 10 to change pin 8 to a low.

This will disable expose start gate IC11 with a low on pin 5 which in turn will inhibit gate pulses to all SCRs. The SCR which is conducting will therefore extinguish at the zero crossover point of the phase associated with the stop command.

9.5.2 Exposure Synchro Phasing Stage

The primary of TR1 is connected to the 220V ac lines 143 and 141 (see Drawing 3761B bottom left).

From the above drawing it can be seen that lines 143 and 141 are connected to auto transformer TR1 via fuses 5 and 3 respectively on Drawing 3755B.

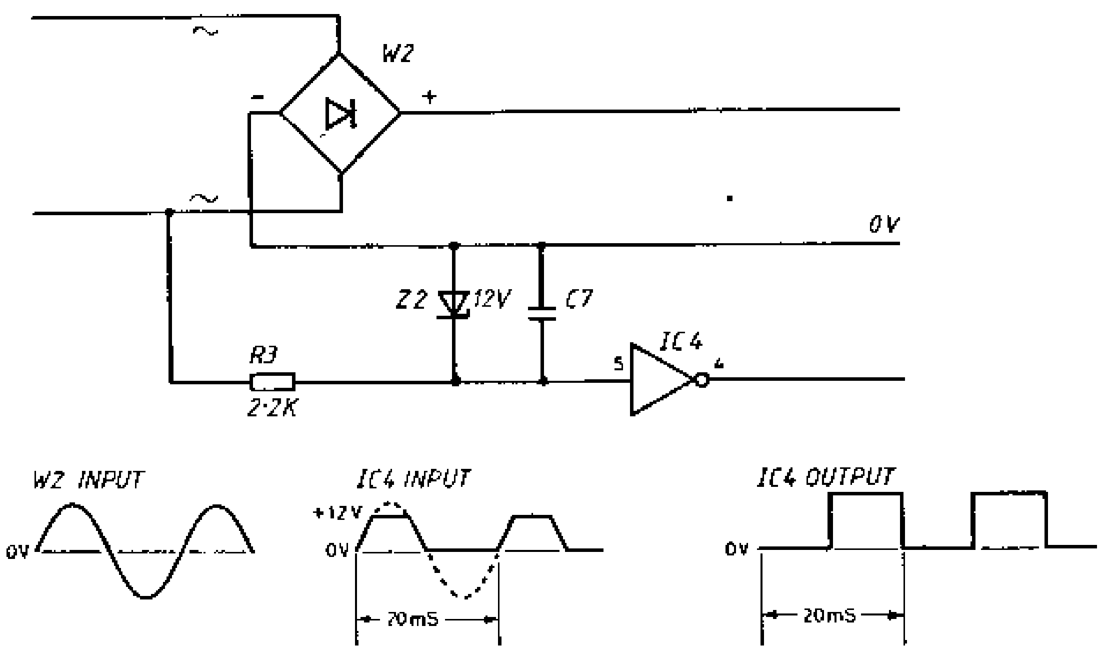
The secondary of TR1 supplies full wave bridge rectifier W2 which provides unsmoothed dc pulses for the clock pulse generator and exposure synchro phasing stage.

The Exposure Synchro Phasing Stage is connected across one half of the full wave rectifier W2 and it comprises the following circuit elements:-

R3, Z2, C7, part of hex inverter IC4 pins 5 and 6, C64 and the J input of JK flip flop IC8 pin 14.

Half wave rectified pulses of positive going amplitude are therefore applied to pin 5 of IC4 every time the bottom ac input to W2 goes +ve with respect to the top ac input (see Figure 9.6).

Zener diode Z2 clips the sinusoidal rising waveform at 12 volts to partially tidy and square it up prior to final shaping by IC4. The output from pin 6 of IC4 is therefore a series of perfectly square shaped inverted pulses 10 mS wide appearing at the rate of one every 20 mS as shown in Figure 9.4 F.



W2
+
-
0V
Z2
12V
C7
IC4
R3
2·2K
5
4
W2 INPUT
0V
IC4 INPUT
+12V
0V
20mS
IC4 OUTPUT
0V
20mS

It should also be noted from Figure 9.4 A & F that the pulses only change from 0 volts to +15 volts every time the line phase begins an excursion into the negative region. If an exposure command signal is present, the first +ve rising pulse which reaches pin 14 of JK flip flop IC8 will enable it to latch on a clock pulse at pin 1 almost immediately after. This will trigger the 556 monostable IC7 with a low on pin 6 via C12. When the monostable time of approximately 6 mS has elapsed, the output from pin 5 should drop low to start the exposure just before the line phase passes zero crossover during its climb into the +ve region.

In conclusion, the purpose of the Synchro Phasing Stage is to detect line phase after it swings negative and to enable the Start Delay Stage to commence exposure just before line phase swings +ve again. Eg, exposures must always start when L3 is +ve with respect to L1.

9.5.3 Clock Pulse Generator

Full wave rectifier W2 is also used to generate clock pulses synchronised to the frequency of the hospital power supply.

The clock pulses are used to clock the Decade Count-Up Timer CD4029, integrated circuits IC1 (units), IC3 (tens) and IC2 (hundreds).

A 12V Zener diode Z1 in conjunction with R1 is used to partially tidy and square up the full wave rectified output pulses from W2 (see Figure 9.4 B).

From Figure 9.4 C it can be seen that these pulses are inverted and perfectly square at pin 4 of IC4.

Figure 9.4 D shows the above waveform after differentiation by C9, and the 0 volt seeking pulses are used to trigger a 556 monostable IC5 to produce a series of narrow 100 mS pulses once every 10 mS as shown in Figure 9.4 E.

The above clock pulses are conveyed to the Exposure Timer start gate IC11 pin 13. Pin 2 is reset high when the decade timer is cleared following an exposure command. Pin 1 goes high when the decade timer is cleared following an exposure command. Pin 1 goes high only when the Q output of JK flip flop IC8 is set high following an expose command when red phase has passed zero crossover into the -ve region. When IC11 gate is enabled, the inverted clock pulses from pin 12 clock the decade counters on the rising edge of the 100 mS wide pulses. The Decade Timer clock pulses will be similar to those shown in Figure 9.4 G.

9.5.4 Expose Start and Expose Start Delay

Transformer TR2 on the bottom left of Drawing 3554 receives 220V ac expose start commands from the Bucky circuits in Drawing 3761B. During EXPOSE, the 22V ac output from TR2 is full wave rectified by W3 and smoothed by R10, C5 and C6. A zener diode Z3 is included to clip the waveform at 5.1 volts and so facilitate smoothing with smaller sized capacitors.

With 5.1 volts across R11 and R97, transistor T2 switches ON to make pin 13 of IC4 low. The high from pin 12 of IC4 travels along the bottom of Drawing 3554 to pin 11 of another inverter on IC4 to clear the three decade count up ICs 1, 3 and 2.

Coming back to the bottom of Drawing 3554, the high on IC4 also continues right across to the far right of the drawing where it enables the RS latch comprising IC9 pins 1, 2 and 3 and IC9 pins 4, 5 and 6.

The latch is in the Circuit Breaker Stage which detects excessive primary HT current during expose and also X-rays before or after the set exposure time when the expose button is pressed.

Looking back to the left of Drawing 3554 the low exposure command signal from IC4 pin 12 is also applied to pin 4 of NAND Gate IC6. This enables the clock pulses from the Clock Pulse Generator Stage to clear and trigger the JK flip flop IC8. Data on pin 14 J input immediately get transferred to the Q output (pin 12) and so the Q and bar Q outputs become high and low respectively.

The high Q output enables the exposure timer start gate IC11 at pin 1 when pin 13 is raised high by a timer clock pulse. Pin 2 was set high following the expose start clear pulse to the decade timers IC1, IC3 and IC2 at each of their respective pin 1 PE inputs. This restored the Q3, Q2, Q1 and Q0 outputs on each chip all LOW and transistor T3 was switched OFF to clear the timer start gate IC11 pin 2 high via IC4 pins 1 and 2 and IC10 pins 4, 5 and 6. IC11 pin 12 therefore outputs clock pulses to IC1 pin 15 and it starts counting. On the count 10, a one is carried forward from pin 7 into IC3 pin 15 and so the cycle repeats itself with a carry from IC1 every tenth count until IC3 becomes filled. On the hundredth count a one is carried from pin 7 into pin 15 of IC2 and so the sequence continues. IC2 will never become full because the maximum time selectable by the timer switch is 5 seconds. This in binary will be 0101 0000 0000 which equals 500 counts at the rate of one count every 10 mS = 5000 mS.

The low Q output from JK flip flop IC8 triggers monostable IC7 via capacitor C12. P1 is adjusted to start the exposure just before zero crossover on a rising +ve phase (see Figure 9.4 K and Figure 9.5). Potentiometer P1 has an adjustable range of up to 6.6 mS and when correctly adjusted the start of the kV waveform should resemble the correct example shown in the 50 mA waveforms in Figure 9.7.

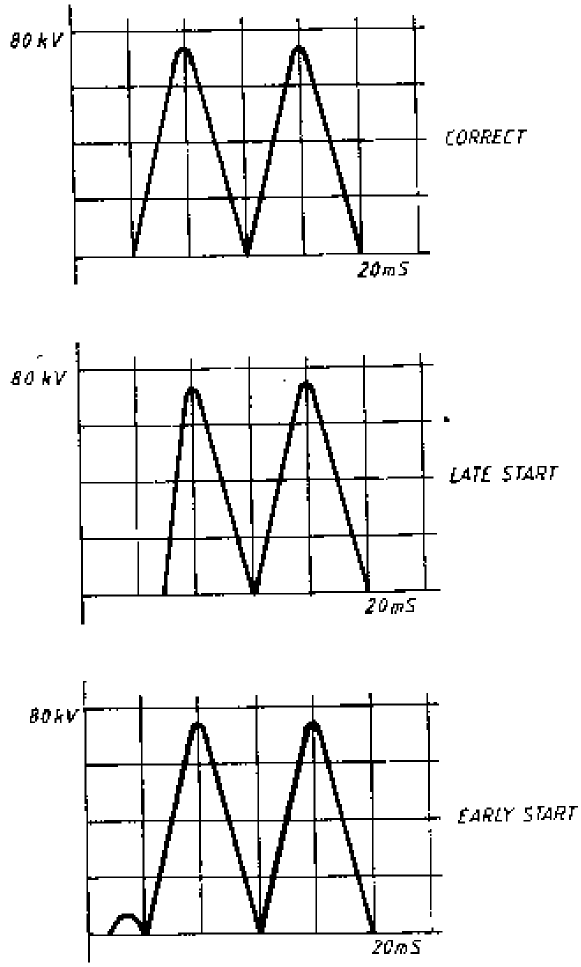


Figure 9.7 CORRECT AND INCORRECT EXAMPLES OF EXPOSURE START kV WAVEFORM

The output of monostable IC7 therefore pulls pin 5 low at the end of the delay period to enable the expose start gate IC11 pin 3 high via inverter IC10 pins 1, 2 and 3. Pins 4 and 5 are already high on account of the high Q output from IC8 and the high timer clear output from IC6 pin 8 resulting from the low on IC4 pin 2.

The low output from IC11 pin 6 is now inverted by IC10 pins 12, 13 and 11 to start the SCR driver oscillator via the Gecomat Gating Circuitry comprising IC10 pins 10, 9 and 8 and IC9 pins 12, 13 and 11.

Normally edge connector A4 pins 1 and 2 are low when the Gecomat is switched OFF which makes pin 9 of IC10 high. IC10 pin 8 is therefore enabled low on receipt of a high exposure GO signal from IC10 pin 11.

The low from IC10 pin 8 is passed along the top of Drawing 3554 to the SCR driver oscillator circuitry and the SCR gating circuits are also enabled with a high from IC14 pin 6. This high is also taken out to edge connector A4 pin 6 which is useful for checking the exposure timer with the aid of a CRO. It should be noted that the measured time at this point is usually between 1 and 2 mS longer than the indicated time because of the phasing in time lag to switch ON the red phase start SCR.

9.5.5 SCR Driver Oscillator and Gating Circuitry

The Driver Oscillator is a group of three inverter buffers comprising IC15 pins 3 and 4, IC15 pins 5 and 6, and IC15 pins 13 and 12 close loop coupled with R36 and C19 acting as the 2 kHz RC network and R35 as +ve feedback drive for the oscillator input at IC15 pin 3.

During standby the oscillator is disabled with a low from buffer IC15 pin 2 which forward biases D67 and maintains a steady low at the oscillator input (IC15 pin 3).

To start an exposure pin 1 of IC15 goes low and the resultant high on pin 2 reverse biases D67.

The bottom end of C19 is charged positive with respect to 0V and it is now free to lift the oscillator input high at IC15 pin 3 which in turn causes pin 12 of IC15 to swing low causing C19 to discharge through R36. This process brings about a high on IC15 pin 6 which charges up C19 with +ve at the top and -ve on the bottom.

The -ve charge applied to IC15 pin 3 via R35 now makes IC15 pin 6 low and IC15 pin 12 high thus C19 is forced to discharge and become recharged once more with the bottom plate +ve and top plate -ve. This cycle of events continues at 2 kHz for as long as an exposure command signal is present on IC15 pin 1.

The oscillator output drives buffer IC15 pins 11 and 10 after which the pulses are integrated before transmission to IC12 pin 5 gate via buffer IC1 pins 9 and 8.

With IC12 gate enabled with a high on pin 4, 2 kHz pulses are transmitted from IC12 pin 6 to pin 1 of buffer IC14. Output pin 2 of IC14 pulses transistor T19 ON and OFF and the resultant oscillating current in TR3 primary generates an alternating voltage in each secondary having a magnitude of between 1.5 and 2 volts to drive the SCR gates.

The first SCR to fire is always SCRA in Drawing 3755B.

9.5.6 Exposure Decade Count Up Timer

The Q3, Q2, Q1 and Q0 outputs of the three CD4029 integrated circuits IC1 (units), IC3 (tens) and IC2 (hundreds) are connected to the emitters of transistors T4 to T27 respectively.

A decoder matrix of diodes connects the bases of these transistors to the time switch.

Normally the Q3, Q2, Q1 and Q0 outputs of the three timers are low thus the transistors which are selected by the time switch matrix will be ON and their collectors will forward bias their associated diodes. If any of these diodes (D4 to D27) are forward biased then transistor T3 will be switched OFF, to clear the exposure start and timer start gates.

The truth table for the decade timer is shown below, thus if 0.12 mS is selected by the timer switch, transistors T5 (Q1 of IC1) and T8 (Q0 of IC3) will be switched on via the diode matrix decoder.

When the exposure commences, clock pulses will be applied to IC1 and it will count up binary fashion as shown on the table.

On the second count, Q1 of IC1 will go high to switch OFF transistor T5 but transistor T8 is still ON to hold the base of T3 low via D13. It will also be seen that T5 goes OFF three times because Q1 of IC1 goes high at 0.02 seconds, 0.03 seconds and 0.06 seconds.

At 0.12 seconds, however, both transistors T5 and T8 switch OFF because Q1 of IC1 and Q0 of IC3 are both high together.

Diodes D7 and D13 in consequence both stop conducting, causing the base of transistor T3 to go high.

With T3 now ON, pin 2 of IC4 goes high to produce a low on IC10 pin 6. This low triggers pin 8 of the stop monostable IC7 via C15 to make the output at pin 9 high for the time period preset by P2 which is approximately 6 mS.

During this 6 mS, the exposure stop command maintains a high on IC6 pin 9, but the low on pin 10 only lasts for the duration of the monostable delay.

When the monostable resets, the correct exposure terminating phase should just be approaching zero crossover.

When this occurs the output pin 9 of monostable IC7 will return to a low causing IC6 pin 10 to go high.

The resultant low from IC6 pin 8 will disable the expose start gate IC11 with a low on pin 5. This disables the SCR drive oscillator and gate pulses to all SCRs cease. The conducting SCRs therefore extinguish at the first zero crossover point following cessation of gate pulses.

	IC2 HUNDREDS (x 10 for mSecs)				IC3 TENS (x 10 for mSecs)				IC1 UNITS (x 10 for mSecs)			
SECS	800 Q3	400 Q2	200 Q1	100 Q0	80 Q3	40 Q2	20 Q1	10 Q0	8 Q3	4 Q2	2 Q1	1 Q0
.01	0	0	0	0	0	0	0	0	0	0	0	1
.02	0	0	0	0	0	0	0	0	0	0	1	0
.03	0	0	0	0	0	0	0	0	0	0	1	1
.04	0	0	0	0	0	0	0	0	0	1	0	0
.05	0	0	0	0	0	0	0	0	0	1	0	1
.06	0	0	0	0	0	0	0	0	0	1	1	0
.08	0	0	0	0	0	0	0	0	1	0	0	0
.1	0	0	0	0	0	0	0	1	0	0	0	0
.12	0	0	0	0	0	0	0	1	0	0	1	0
.16	0	0	0	0	0	0	0	1	0	1	1	0
.2	0	0	0	0	0	0	1	0	0	0	0	0
.25	0	0	0	0	0	0	1	0	0	1	0	1
.3	0	0	0	0	0	0	1	1	0	0	0	0
.4	0	0	0	0	0	1	0	0	0	0	0	0
.5	0	0	0	0	0	1	0	1	0	0	0	0
.6	0	0	0	0	0	1	1	0	0	0	0	0
.8	0	0	0	0	1	0	0	0	0	0	0	0
1.0	0	0	0	1	0	0	0	0	0	0	0	0
1.2	0	0	0	1	0	0	1	0	0	0	0	0
1.6	0	0	0	1	0	1	1	0	0	0	0	0
2.0	0	0	1	0	0	0	0	0	0	0	0	0
3.0	0	0	1	1	0	0	0	0	0	0	0	0
4.0	0	1	0	0	0	0	0	0	0	0	0	0
5.0	0	1	0	1	0	0	0	0	0	0	0	0

TRUTH TABLE FOR DECADE COUNT UP TIMER

In conclusion it should be observed from Figure 9.4 A & E that the decade timer can output a stop command only when line phase is approaching a peak in the -ve direction or approaching a peak in the +ve direction.

The stop monostable is adjusted to delay this stop command until the correct exposure terminating phase is very close to zero crossover.

A perusal of the 20 mS example in Figure 9.5 should make it clear that if the stop monostable delay time is adjusted too long, the exposure would terminate 10 mS too late because SCRA would fire again when line phase changed from -ve to +ve on the third half cycle.

Potentiometer P2 is therefore the fine adjustment for exposure times and in our 20 mS example there should be 2 peaks in the kV waveform.

9.6 The Electronic Circuit Breaker

Drawing Nos. 3755B, 3759A, 3554 and 3767A

9.6.1 Derivation of the Fault Detection Signal

On drawing 3755B, there is a heavy duty current transformer TR2 in series with the T1 line supplying the HT transformer.

The secondary winding for the above current transformer is displayed on drawing 3759A and the output is full wave rectified by W24 in the Timer PCB to provide a dc voltage proportional to HT drive current.

This signal is used to activate an electronic sensing ciruit mounted on the exposure time pcb. (see drawing 3554)

When this circuit is activated, it energises the circuit breaker BK which in turn disables the main line contactor CL to isolate the generator from its power supply. (see drawing 3767A)

The electronic circuit breaker is activated whenever any of the following abnormalities occur:-

A. Tube overcurrent

i	If a 50mA exposure exceeds 80mA	60% excess
ii	If a 100mA exposure exceeds 150mA	50% excess
iii	If a 200mA exposure exceeds 280mA	40% excess
iv	If a 300mA exposure exceeds 400mA	33% excess
v	If a 400mA exposure exceeds 500mA	25% excess
vi	If a 500mA exposure exceeds 600mA	20% excess

B Excessive HT primary current

Any other overload which would cause excessive HT drive current during radiography mode of control, eg. faulty primary switching circuits, faulty HT tank, faulty HT cables or faulty X-ray tube.

C X-rays outside exposure

The expose push button must be pressed to detect this fault and it will occur either during the phasing in period prior to the start of a radiographic exposure or immediately after the timer has terminated the exposure. (Shorted SCRs is the usual symptom.)

During standby, this fault should not happen because Prep contactor PGA isolates the SCRs from the drive circuits.

9.6.2 The Fault Detection Signal Attenuation Network

For overload sensing purposes, the signal from rectifier W24 in Drawing 3759A must be attenuated whenever the selected mA is increased, otherwise the preset 50mA tube overload signal would activate the circuit breaker if 100mA or more is selected.

The correct level of attenuation is therefore preset by each of the following multipliers :-

50mA selected - R43 with P3 preset for 80mA maximum
100mA selected - R44 with P4 preset for 150mA maximum
200mA selected - R45 with P5 preset for 280mA maximum
300mA selected - R46 with P6 preset for 400mA maximum
400mA selected - R47 with P7 preset for 500mA maximum
500mA selected - R48 with P8 preset for 600mA maximum

In practice, the above potentiometers are factory set to produce the following voltage levels across Zener Z7 during normal exposures.

50mA	P3 set for 7.6V	across Z7
100mA	P4 set for 6.6V	across Z7
200mA	P5 set for 7.2V	across Z7
300mA	P6 set for 8.0V	across Z7
400mA	P7 set for 8.4V	across Z7
500mA	P8 set for 9.0V	across Z7

With the above potentiometers set as shown, the circuit breaker should trip off line when the selected mA value is raised to its associated overload value. Zener Z7 protects the integrated circuit from voltage levels in excess of +12 volts.

9.6.3 Integrated Circuit Description

The top pair of operational amplifiers IC13 (centre of drawing 3554) are assigned to detect excess current during radiographic exposures.

The bottom pair of operational amplifiers on IC13 are assigned to detect X-rays outside exposure.

Note... that on early versions of drawing 3759A these Op Amps are incorrectly designated IC15. In all cases drawing 3554 should be considered as the master. Please therefore amend drawing 3759A accordingly.

The potential dividing chain R52, R51 provides a reference voltage of approx 10 volts to inverting pin 8 on IC13.

The output from pin 14 of IC13 can therefore only change state when the overload signal voltage developed across Z7 exceeds +10 volts.

Normally this signal is in the region of 6 to 9 volts and in this state, the output from IC13 pin 4 is maintained low at 0 volts dc.

Another potential dividing chain R49, R50 provides a reference of approx +2.3 volts to inverting input pin 10 on IC13.

As it does not require much tube emmission mA to lift the signal level across Z7 in excess of +2.3 volts, IC13 pin 11 should always be more +ve than pin 10 when X-rays are being generated in radiography mode. In this state IC13 pin 13 should always output a high +15 volts.

9.6.3.1 Normal Operation

The HT drive signal voltage developed across Z7 during a normal radiograph will be somewhere between 6 and 9 volts.

This is not sufficient to have any affect on the top left Op Amp IC13 pins 8, 9 and 14 and so the output through R55 to pin 4 on the top right Op Amp IC13 will remain low to maintain the output from pin 2 high.

The lower left Op Amp on IC13 pins 11, 10 & 13 will however change state following the commencement of a radiograph because the HT drive signal rises in excess of the 2.3 volt reference voltage at IC13 pin 10. The output from IC13 pin 13 will therefore lift pin 12 on NAND gate IC12 high.

Pin 13 on IC12 was however taken low by the timer start signal C X-ray and so output pin 11 stays high and in consequence has no affect on the bottom right Op Amp in IC13 pins 7, 6 and 1.

The other section of NAND gate IC12 which follows also remains unaffected with a high on both input pins 1 & 2 to maintain a low output from pin 3. This low is passed to pin 10 on one of the NAND gates in IC9 to hold its output pin 8 high.

IC9 pins 5, 4 & 6 together with IC9 pins 2, 1 & 3 forms an RS flip flop with pins $\overline{5}$ and 1 acting as the R and S inputs and pin 6 and 3 acting as the Q and $\overline{Q}$ outputs respectively.

The truth table for an RS flip flop is reproduced below

R	S	Q	$\overline{Q}$
L	L	NOT ALLOWED	
L	L	H	L
H	L	L	H
H	H	NO CHANGE	

TRUTH TABLE FOR AN RS FLIP FLOP

Prior to the exposure, the C GR signal was low and the state of the R and S inputs was high and low respectively. From the truth table, this should make the Q output from pin 6 low to hold transistor T18 and relay BK OFF.

The C GR signal is the actual expose start request and is derived from the Bucky start circuit. This signal goes high when a radiograph is requested and lifts the S input to IC9 pin 1 high. It can thus be readily concluded from the truth table that if the S input is lifted high while the R input is maintained high there will be no change in the state of the outputs. In this way it should not be possible to energise relay BK during a normal radiographic exposure.

The R input to the RS flip-flop is gated through IC9 pins 10, 9 & 8. As already stated the output at pin 8 is normally high and remains in this state until a fault condition occurs. As will be seen later, a fault condition will force input pin 10 high, to output a low from pin 8.

There is however a requirement to ensure that the flip-flop settles into the RESET state every time the generator is switched ON. If the R input is forced high automatically during switch ON, then this prerequisite will be guaranteed every time with the Q output always settling to a low. Recall that the S input is always low unless a radiographic exposure is ordered.

This automatic reset is obtained by connecting the junction of RC network R63/C24 to pin 9 on the preceeding NAND gate IC9.

At switch ON, C24 charges up and pin 9 is dragged low during the charging process. This quarantees a high from IC9 pin 8 which ensures that the R input of IC9 pin 5 is held high during switch ON in order to force the flip-flop into its reset state eg. Q output low, Q bar output high.

After C24 has charged, pin 9 of IC9 assumes a permanent high level and the RS flip-flop is then free to follow the laws of the circuit.

During standby prior to an exposure, the bottom left OP Amp outputs a low from pin 13 to maintain the high at pin 11 of NAND gate IC12. This prevents the lower right Op Amp in IC13 from changing state and in this way the RS flip-flop is held in the reset condition.

9.6.3.2 Overload During Exposure

If an overload situation occurs during radiography, the HT drive signal developed across Z7 will rise in excess of +10 volts to change the state of the top left Op Amp IC13 pins 8, 9 & 14.

Pin 14 in consequence will be driven high to lift pin 4 of the top right Op Amp high which then outputs a low from pin 2 to change the state of the following NAND gate in IC12 pins 1, 2 & 3.

The high from pin 3 causes pin 10 on the next gate in IC12 to seek high and with pin 9 on this gate also high, it will output a low from pin 8.

In this way the R input to pin 5 of the RS flip flop contained in IC9 is changed to a low which causes the outputs to change state.

A perusal of the truth table should reveal that a low R input and a high S input produces a high from pin 6, Q output.

Transistor T18 in consequence will turn ON to energise relay BK which deactivates contactor CL to switch the generator OFF line.

Recall that the S input pin 1 on IC9 was taken high by the expose order from the Bucky start circuit.

9.6.3.3 X-rays Outside Exposure (Premature Switching of SCRs in Fault Situation)

If the radiography expose button is pressed (C GR high) and the exposure commences during the phasing-in period prior to the timer command to the SCR switching gates (C X-ray high), there will be a normal HT drive signal across Z7. That is to say, it will be in the safe region of between 6 and 9 volts dc.

This is insufficient to change the state of the top left Op Amp in IC13 which has a +10 volt reference connected to pin 8. It is however, more than sufficient to exceed the +2.3 volt reference applied to the bottom left Op Amp in IC13, and pin 13 will now output a high to pin 12 on the following NAND gate in IC12.

The timer is still phasing itself in and has not as yet enabled the SCR gating circuits so the C X-ray signal to the other input on IC12 gate (pin 13) remains high.

With two highs present at its input, pin 11 will swing low to change the state of the bottom right Op Amp in IC 13 causing it to output a low from pin 1.

Following this low to NAND gate pins 2, 1 & 3 on IC12, there will be another change of state with pin 2 now low and pin 1 remaining high to output a high from pin 3.

The pin 10 and pin 9 inputs on the next gate in IC9 will now both be high and output pin 8 will in consequence swing low.

This sinks the R input to pin 5 of the RS flip-flop in IC9 low. The S input at pin 1 is maintained high by the expose order C GR signal thus if R swings low and S remains high, the Q output from pin 6 must change state to a high (refer to the truth table).

Again Transistor T18 and relay BK will turn on to switch the generator OFF line.

9.6.3.4 X-rays Outside Exposure (SCRs Remaining ON After Exposure Termination)

In this situation, the C X-ray signal will rise to +15 volts immediately the timer attempts to terminate the exposure (end of set exposure time).

If the exposure button is still pressed, Z7 will continue to receive a normal HT drive signal from the fault detection network and the bottom left Op Amp in IC13 will carry on outputing a high from pin 13.

The following NAND gate in IC12 will now be enabled with high logic levels on both input pins 12 and 13 causing the output at pin 11 to sink low.

This in turn will enable capacitor C25 to discharge into this low via R58.

After a short delay, pin 7 on the bottom right Op Amp in IC13 will become sufficiently low to change the state of its output from pin 1.

This output which is now at 0 volts dc, is applied to pin 2 input of another NAND gate in IC9 and consequently the output from pin 3 must be forced high.

The following NAND gate in IC9 pins 10, 9 & 8 will now be enabled to produce a low from output pin 8, which in turn sinks the R input to pin 5 of the RS flip-flop low.

The S input at pin 1 is still high under the influence of the C GR signal from the expose order circuits and one final perusal of the truth table will confirm that the Q output from pin 6 is again raised to the high set state which in turn enables transistor T18 and relay BK to switch the generator OFF line.

Under normal circumstances, C25 is in circuit to hold pin 3 on the bottom right Op Amp in IC13 high during the dead time that elapses following an exposure termination command and zero cross-over extinction of the conducting SCRs.

Without this short delay the bottom right Op Amp in IC13 would change state and activate the circuit breaker before the SCRs get time to switch OFF.

When the SCRs finally extinguish, the fault detection signal applied to Z7 and pin 11 of the bottom left Op Amp in IC13 drops to below the +2.3 volt reference at pin 10, causing the output from pin 13 to swing low.

The output from pin 11 on the NAND gate in IC12 which follows, is thus forced high to maintain the high stored momentarily by C25 on pin 2 of the bottom right Op Amp in IC13. C25 also gets rapidly recharged via D70 in preparation for the next exposure.

It should be borne in mind that the other input pin 13 on IC12 goes high with the expose terminate signal C X-ray which occurs before SCR extinction. The output from pin 11 of IC12 is therefore pulled low during this dead time and without C25, the X-rays fault detection signal applied to Z7, would trigger unwanted X-rays after exposure shut down.

R500 Series 2

SECTION 10

SERVICING

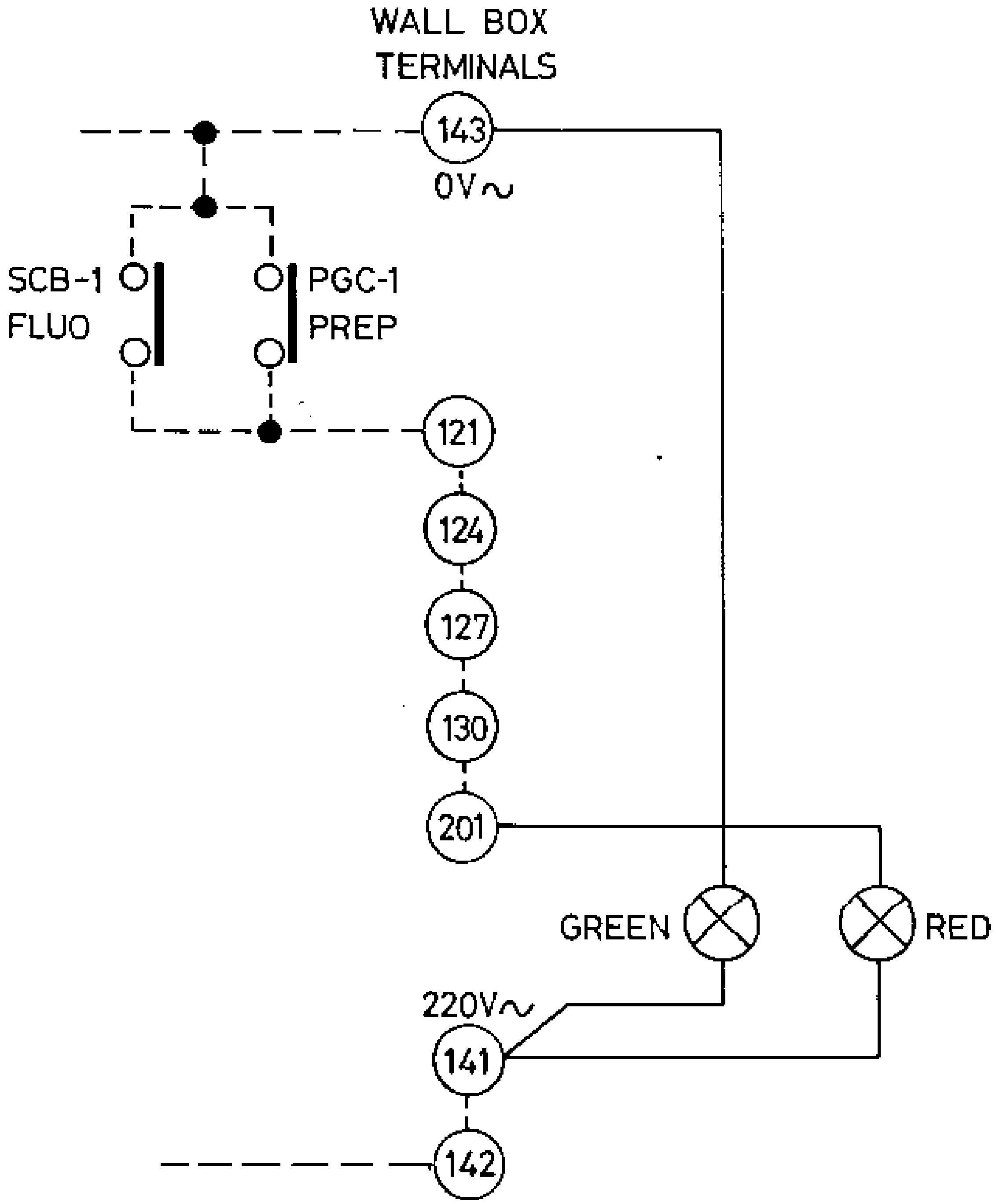
(Notification will be given when this section is available)

APPENDIX 1

R500 Series 2

INTERFACING CONNECTIONS

(2450/1/385)

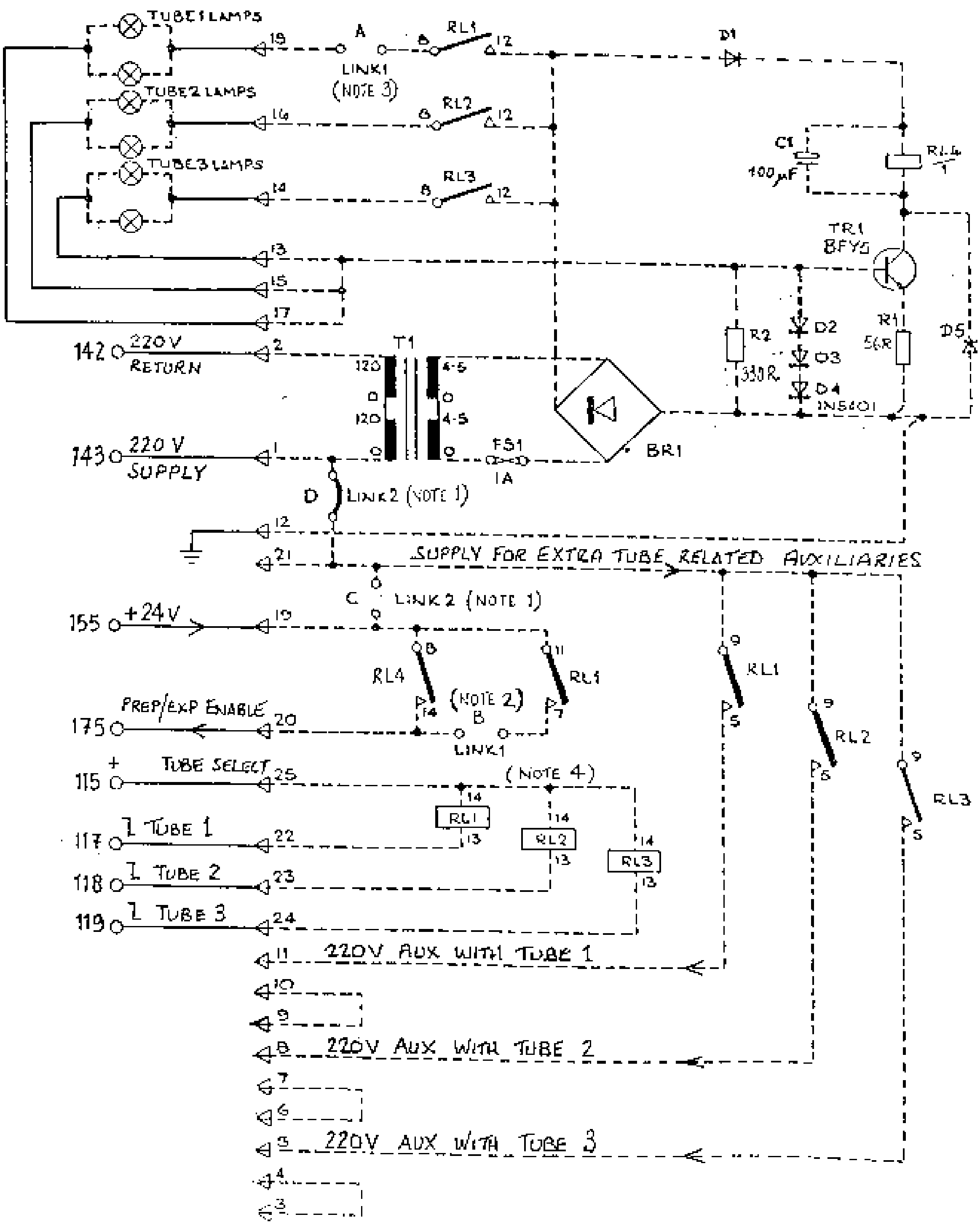


ROOM HAZARD WARNING LAMPS

Refer to R500 Series 2 circuit No 3761-B

(2450/1/785)

TUBE SELECTED WARNING LIGHTS – Kit No 1286-718



1 For R500/2 Generator fit link 2 to socket D. Socket C MUST be left unfitted.

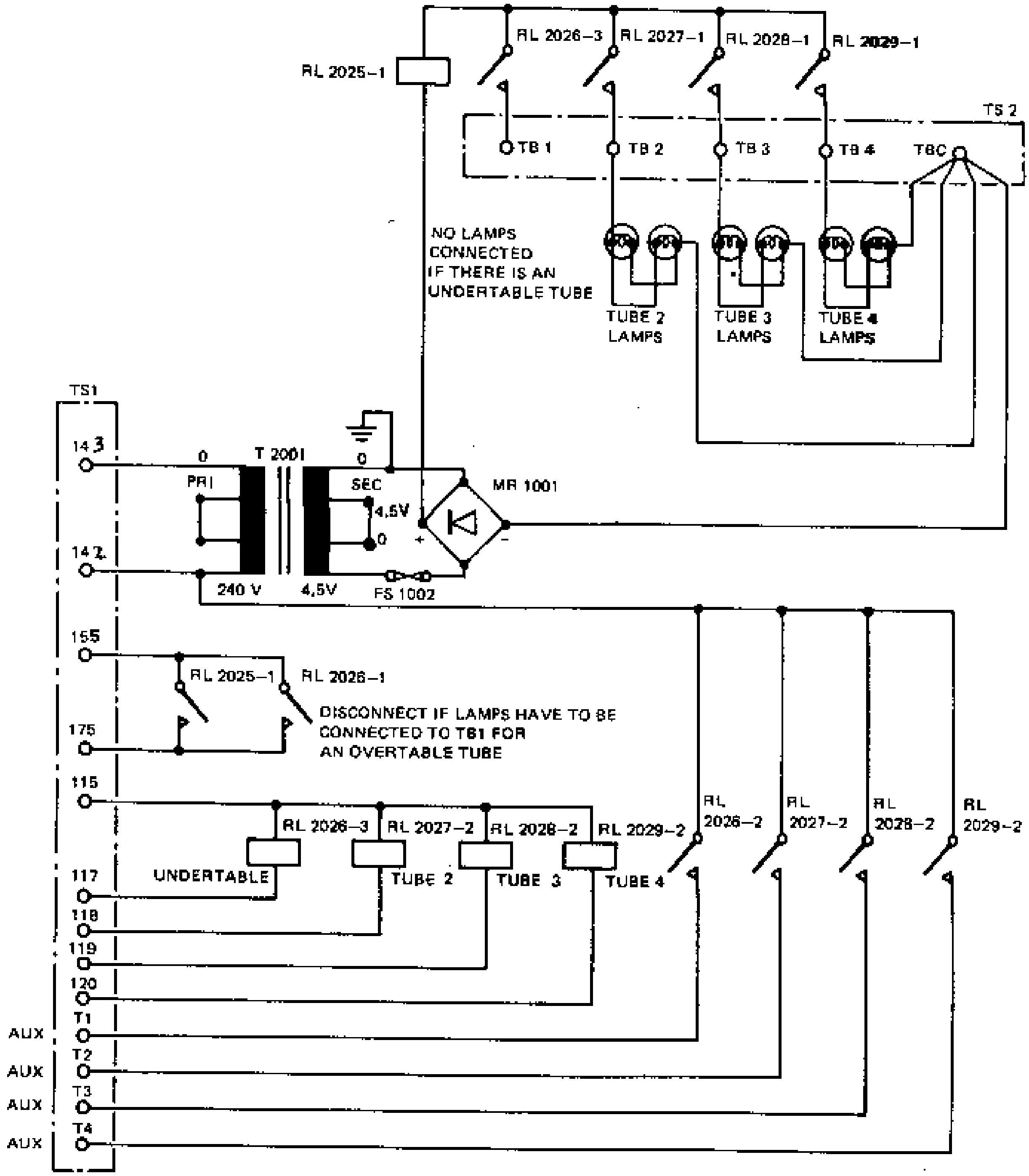
2 For tube 1 undercouch (with no warning lights) fit link 1 to socket B.

3 For tube 1 with warning lights fit link 1 to socket A.

4 In RL1, RL2 and RL3 sockets fit the 24V relays provided in Kit 1286-718. Transfer the three 240V relays to Branch stock.

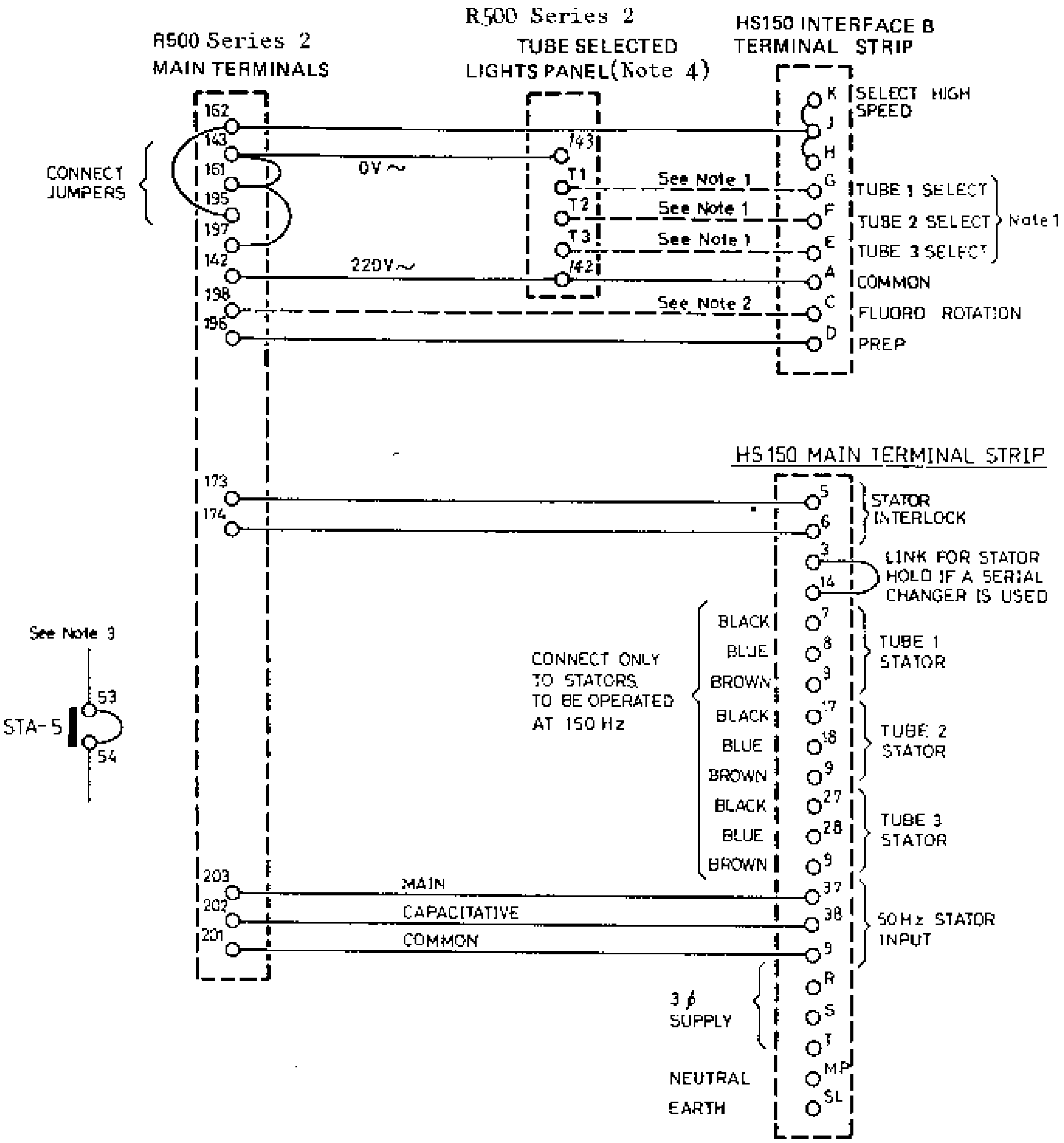
5 DISCARD 'VECTOR LOOM' IN KIT 1286-718

(2450/1/0487)



R500 SERIES 2 TUBE SELECTED LIGHTS AND RELAY PANEL WIRING

(2450/2/985)



Note 1 CONNECT ONLY FOR TUBES TO
BE RUN AT HIGH SPEED.

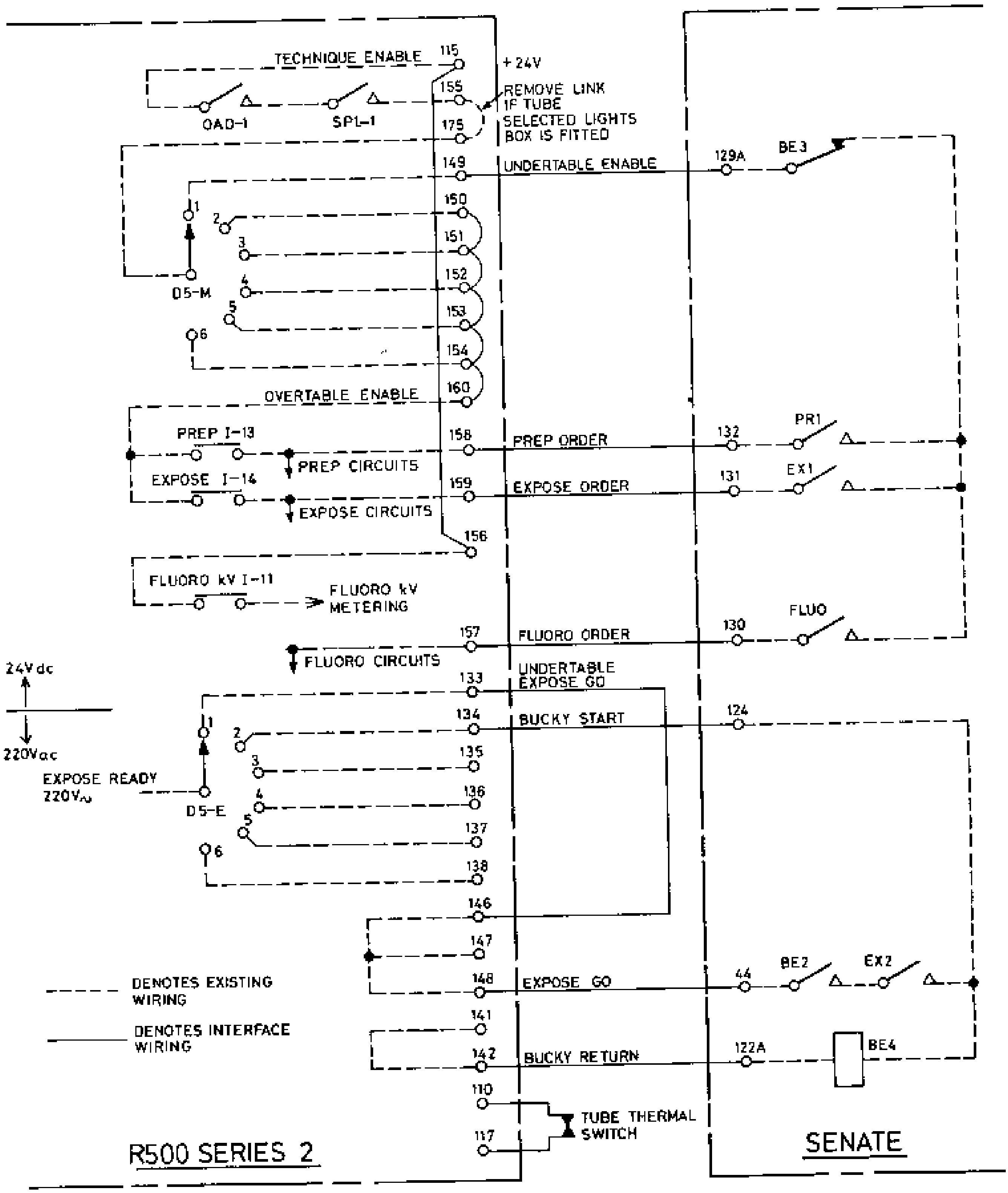
Note 2 CONNECT ONLY IF ANODE ROTATION
IS REQUIRED DURING FLUOROSCOPY
eg 0·3mm FOCUS.

Note 3 ON STA CONTACTOR LINK CONTACTS 53-54
AS PER R500 DRAWING 3761B

Note 4 For PCB version:-

Terminal	143	should	read	Terminal	1
"	T1	"	"	"	11
"	T2	"	"	"	8
"	T3	"	"	"	5
"	142	"	"	"	2

R500 Series 2 to HS150 MCU



R500 SERIES 2 TO SENATE TABLE (BASIC INTERFACE)

([illegible]/1/38[illegible])

SECTOGRAPH 40 ATTACHMENT

FITTING AND CONNECTION DETAILS

i ON THE MAIN JUNCTION BOX PAXOLIN TERMINAL BOARD, MOUNT THE RELAY ADJACENT TO TERMINAL 210.

ii WIRE THE COIL OF THE RELAY TO TERMINALS N AND 208.

iii WIRE THE POLE OF THE RELAY CONTACT TO TERMINAL 134.

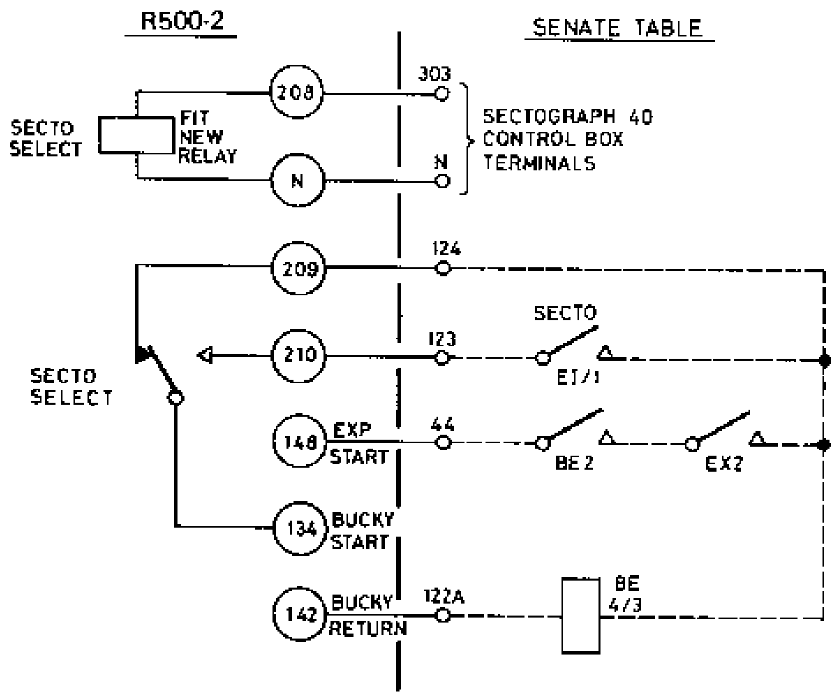
iv WIRE THE NORMALLY CLOSED CONTACT TO TERMINAL 209.

v WIRE THE NORMALLY OPEN CONTACT TO TERMINAL 210.

vi TRANSFER TABLE CONNECTION 124, LOCATED ON TERMINAL 134. TO TERMINAL 209.

vii CONNECT TERMINAL 123 ON THE TABLE TO TERMINAL 210.

viii FROM THE SECTO CONTROL BOX, WIRE TERMINALS 303 AND N TO TERMINALS 208 AND N ON THE WALL BOX.



R500 SERIES 2 SECTOGRAPH 40 ATTACHMENT

(2450/1/355)