faxitron x-ray

575 Bond Street
Lincolnshire, Illinois 60069
USA

TECHNICAL MANUAL

43855F Option CP160

Tel. 847-276-3427 Fax. 847-276-3437

Manual No. 5081-9529 Rev. B

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43855F Cabinet X-ray System
TECHNICAL MANUAL
CP160 Option

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Faxitron X-Ray LLC 575 Bond Street, Lincolnshire, Illinois U.S.A.

Rev. B

5081-9529

Installation Advisory

Faxitron Cabinet X-ray System Model 43855F with CP160 Option

Introduction

This system incorporates circuitry and additional cooling capacity, which allows the system to operate up to a power level of 1000 watts at a maximum 160 kVp. A dosimetry chart is included to indicate the radiation levels at different kVp's, shelf heights (SID) and filtration thickness. Two .5 mm. Al. filters and one .5 mm. Cu filter has been provided. These can be mounted directly to the x-ray tube with the four screws and spacer provided. It is recommended that additional dosimetry be done for the intended application.

Electrical Considerations

This system is typically set at the factory to operate on a 220 Vac, 50/60 Hz., single-phase line. Please refer to the label on the back of the unit for information specific to your model.
The system is fused using two T8A, 8 Amp., time delay fuses which are located on the back of the system near the power supply input.
WARNING: For proper and safe operation, this system must be connected to a properly grounded power source. Check the integrity of this ground before operating the system.

CE Marking

This system has been constructed using components that carry the CE mark indicating compliance with the European EMC and Low Voltage Directive. Refer to page 2 of the MP1 and FC160 technical manuals (included) for a listing of the applicable harmonized European standards.

Cooling considerations

Note: This system was shipped dry from the factory.
The cooling system must be filled prior to use!

This system incorporates a closed loop cooling system with pump and heat exchanger. The system has an outflow duct located at the rear of the control panel. The system should be installed with at least 6 inches of clearance between the face of this duct and any obstruction (wall, etc.). Ambient room temperature should not exceed 85°F if running the system at full power. Failure to heed these restrictions may result in loss of cooling capability and reduced x-ray tube life. **Only distilled water should be used (approx. 1 U.S. Gal).** A water level indicator is located on the rear of the control panel. This should be checked every month or after periods of extended use. Access to the water reservoir is accomplished by removing the four screws attaching the top cover above the heat exchanger. A funnel with a long flexible hose should be used to prevent spillage. Inspection and cleaning of the cooling duct and inspection of the cooling hoses for leaks should be performed periodically to maintain the system.

Casters and leveling feet

This system is equipped with casters that have integrated leveling feet. The system is shipped from the factory with the leveling feet extended. A rotating adjustment on each caster allows the leveling feet to be individually adjusted for leveling the system or to engage the caster wheels. Once the system has been installed the wheels should be retracted to prevent movement of the system during use. **Please read the caution label located on the left side of the cabinet near the caster.**

Contact Information

For further information please contact Faxitron X-Ray LLC at 1-847-276-3427.

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GENERAL INFORMATION

MAINTENANCE WARNING

TO BE SERVICED BY QUALIFIED PERSONNEL ONLY

Serious injury (both physical and genetic) can result if all X-ray shielding is not properly replaced or interlocks are not operating after maintenance. Proper shielding replacement and interlock operation can only be confirmed by performing a radiation survey before placing the system in operation, and before use whenever the system is moved or serviced.

INSTALLATION WARNING

Faxitron X-Ray LLC employees perform a radiation leakage survey during installation of your FAXITRON system. These persons are competent but may not be considered qualified experts. Check with your state radiation control authority to determine what the particular survey requirements are in your state. It might be required, that a qualified expert must survey the installation before placed in routine operation.

SAFETY SUMMARY

The following general safety precautions must be observed during all phases of operation, service, and repair of this system. Failure to comply with these precautions or with specific warnings elsewhere in this manual violates safety standards of design, manufacture and intended use of the system. Faxitron X-Ray LLC assumes no liability for the customer's failure to comply with these requirements.

To ensure personnel safety, it is necessary that a radiation meter be used to check for radiation leakage during installation, after extensive maintenance, periodically (not to exceed six months), and after moving the system. The radiation meter must be a Victoreen Model 450 P or equivalent.

Geiger-Mueller and certain other scintillator-type radiation meters are not acceptable for checking radiation from Faxitron Systems.

Faxitron X-Ray LLC Service Centers will perform this survey upon initial installation as well as provide operational checks and user instructions. This is an essential part of every sale in order to validate the system's warranty and ensure maximum radiation protection. The manufacturer considers the National Bureau of Standards Classification of Faxitron Systems a Protective Installation.

GOVERNMENT REGULATIONS

Certain states in the U.S. have radiation control regulations that require registration of radiation sources with cognizant state and/or local jurisdiction public health agencies. Registration normally must be made immediately or within 30 days of acquiring each such source. Please telephone or write your state or local public health agency for registration information pertinent to this installation.

OPERATOR SAFETY

Faxitron Systems should be operated only by personnel who have been instructed in radiation safety and in operating instructions set forth in this manual. Each operator should read (as a minimum) sections 1 and 2 of the manual. In addition, Faxitron X-Ray LLC recommends the use of a radiation film badge service for cumulative individual personnel monitoring. To obtain a film badge service and a radiation meter, contact the State Board of Health, a large hospital or an X-ray laboratory.

MOVING THE SYSTEM

It is permissible to move a Faxitron System after initial installation. However, due to possible mishandling, it is essential that a radiation survey be performed after any move to prevent hazards to personnel.

DO NOT OPERATE IN AN EXPLOSIVE ATMOSPHERE

Do not operate the system in the presence of flammable gases, fumes, or suspended dust particles. Fire or explosions could result because of ignition from electrical arcing.

GROUND THE SYSTEM

To minimize shock hazard, the system chassis and cabinet must be connected to an electrical ground. The instrument is equipped with a three-conductor AC power cable. The power cable must be plugged into an approved three-contact electrical outlet.

CHECK FOR PROPER WALL PLUG WIRING AND GROUNDING

To retain optimum safety of the system in the event of improbable but possible electrical failures, it is important that the system be connected to a properly wired and grounded outlet.

DO NOT SUBSTITUTE PARTS OR MODIFY SYSTEM

Because of the danger of introducing hazards, do not install substitute parts or perform any unauthorized modification to the system. Request assistance from a Faxitron X-Ray Corporation Sales and Service Office for service and repair to ensure that safety features are maintained.

KEEP AWAY FROM LIVE CIRCUITS

Operating personnel must not remove instrument covers. Component replacement and internal adjustments must be made by qualified maintenance personnel. Do not replace components with power cable connected.

DO NOT SERVICE OR ADJUST ALONE

Do not attempt internal service or adjustment unless another person, capable of rendering first aid and resuscitation, is present.

DANGEROUS PROCEDURE WARNINGS

Warnings, such as the example below, precede potentially dangerous procedures throughout this manual. Instructions contained in the warnings must be followed.

WARNING

During some maintenance procedures, dangerous radiation and high voltages, capable of causing death, are present in the system. Use extreme caution when handling, testing and adjusting.

CAUTION

CARE SHOULD BE TAKEN WHEN OPERATING THIS MACHINE WHEN HIGH ELECTROSTATIC POTENTIALS ARE PRESENT. ELECTROSTATIC DISCHARGES MAY CAUSE LOSS OF FUNCTION AND/OR FILM ARTIFACTS TO OCCUR.

FAXITRON® LIMITED WARRANTY STATEMENT

Faxitron X-ray LLC (FXL) warrants this Faxitron® X-ray Product against defect in material and workmanship for a period of one year from the date of first sale. If FXL receives notice of such a defect during the warranty period, FXL shall, at its option either repair or replace materials which prove to be defective.

If FXL is unable, within a reasonable time, to repair or replace any product to a condition as warranted, Buyer shall be entitled to a refund of the purchase price upon return of the Product to FXL at Buyer's expense.

LIMITATION OF WARRANTY

The limited warranty shall not apply to defects in the Product resulting from:

1. Improper or inadequate maintenance by Buyer;
2. Buyer-supplied software for interfacing;
3. Unauthorized modification or misuse;
4. Operation outside of the environmental specifications for the Product; or
5. Improper site preparation and maintenance.

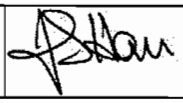
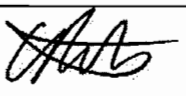
THE LIMITED WARRANTY SET FORTH ABOVE IS EXCLUSIVE AND NO OTHER WARRANTY, WHETHER WRITTEN OR ORAL, IS EXPRESSED OR IMPLIED, IS INTENDED. FXL SPECIFICALLY DISCLAIMS ANY IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE. IN NO EVENT SHALL FXL BE LIABLE UNDER THIS LIMITED WARRANTY FOR ANY CONSEQUENTIAL DAMAGES INCURRED BY ANY PERSON BY REASON OF USE OR DEFECT IN THE PRODUCT NOR SHALL FXL BE LIABLE HEREUNDER FOR MORE THAN THE PURCHASE PRICE PAID FOR THE PRODUCT.

February 2008

MP-1
Type 2

TECHNICAL MANUAL

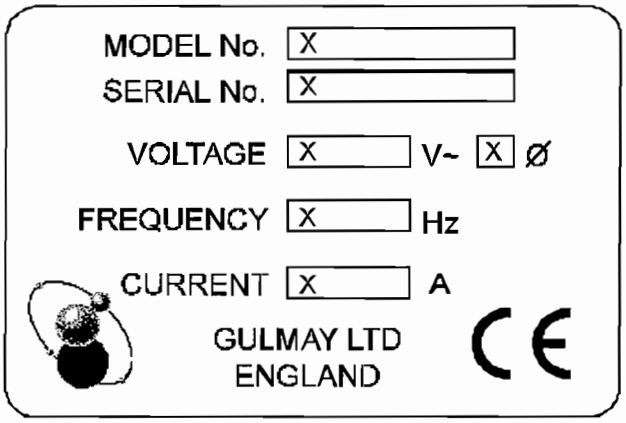
GULMAY Ltd 2006

CONTROLLED DOCUMENT © GULMAY LTD 2006			
File Name	CP2MANA.DOC	Date	4th July 2006
Issue	A	Change Number	First Issue
APPROVALS			
Engineering		Production	

GULMAY LTD,CHERTSEY,ENGLAND
E-mail: support@gulmay.co.uk

CE MARKING

Units with the CE Label applied (See below) are certified by Gulmay Ltd as complying with the European EMC & Low Voltage Directives.



Gulmay makes this statement on compliance based on measurements to the following harmonised European standards:-

Conducted Emissions to BS EN 61000-6-4:2001
Radiated Emissions to BS EN 61000-6-4:2001
Electromagnetic Field Immunity to BS EN 61000-6-2:2001
Electrical Fast Transient Immunity to BS EN 61000-4-4:1995
Electrical Safety to BSEN 61010-1
Electrical Testing to BSEN 60204-1 (Section 19 only)

J.S.Hall
Director

30th December 2005

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APPENDICES

MECHANICAL DESCRIPTION

Width 482mm

Height 133mm

Depth 240mm

Weight 5.3 Kg

CONNECTORS

GENERATOR I/O	25 WAY 'D' SKT
LAB I/O BOX	23 WAY CHASSIS PLUG BURNDY UTG0 18-23P
EARTH STUD	6 mm
RS232	9 WAY 'D' PLUG

OVERVIEW

The MP1 is a microprocessor based control panel to be used in conjunction with X-ray generators manufactured by Gulmay Ltd. Using the front panel, the MP1 can be set to run with a variety of X-ray tubes and generators at installation time.

In 2006 Gulmay introduced a new version of the CPU board and significantly enhanced the software. Users with software revisions below 6.0 and table selection switches on the CPU board should consult MP1 Technical Manual Revision F.

The panel interfaces directly to the generator through one connection.
The panel interfaces to a mains supply distribution unit which can incorporate safety interlocking, cooler interfacing and warning lamps. The design of such a unit is suggested in the LAB I/O BOX circuit and description. This is only an indication of the capability.

GULMAY CANNOT BE RESPONSIBLE FOR INTERPRETING THE PREVAILING SAFETY REQUIREMENTS FOR INSTALLED X-RAY SYSTEMS.

Each generator/X-Ray tube combination can have up to 3 warm up routines pre programmed at the factory. A real time clock in the MP1 then determines the most suitable, in line with the recommendations of the X-Ray tube manufacturer.

The panel is capable of operating in the following modes:-

Manual	(Front Panel Potentiometers)
Warm Up	
Radiographic	(Set kV, mA and Time)
Fluoro	(Set kV and mA only)
Auto Watt	(Set kV and Time)
Fluoro Auto Watt	(Set kV only)
RS232 controlled Fluoro	(Set kV and mA only)
RS232 controlled Radiographic	(Set kV, mA and time)

Additionally the Manual Modes are sub divided into manual versions of the latter four non RS232 modes ie.

Manual Radiographic
Manual Fluoro
Manual Auto Watt
Manual Fluoro Auto Watt

There is sufficient memory space to allow programmes of the principal techniques (kV, mA and time) to be stored as follows:-

Radiographic	200 locations
Fluoro	200 locations
Auto Watt	100 locations

Fluoro Auto Watt	100 locations

All of these programmes are loaded and retrieved by use of the front panel. Any additional information about the selected focus is also remembered.

Focus selection is allowed for when the X-ray tube and generator selection permit. The MP1 will limit the mA demand according to the allowed power for the selected focus.

Bipolar generators and X-Ray tubes are allowed for in the data tables stored in the MP1. The generator, when installed as a bipolar signals its status to the MP1.

The panel has an RS232 connector built in. This allows monitoring of the MP1 status at all times. Special modes can be selected which allows for external control of the panel including initiation, termination and technique selection.

Provision is made in the LAB I/O box interface for remote initiation and termination of X-Rays to enable the panel to be integrated into an automated system.

There are two prewarn intervals. The first is always counted and the second is only counted in the event of the safety 2 line being interrupted.

DIFFERENCES FROM MP-1 TYPE 1

The type 2 MP-1 does not use the internal switches found in the previous model for table selection and turning on the engineering switch. These functions are supported by software using new engineering codes. Tube current is also measured more accurately. The software now has a build ID which completely specifies the code and tables fitted.

Engineering switch

The engineering switch is turned on and off using engineering code 888. The engineering switch is always **OFF** at power on.

Specifying Tables

The type 2 MP-1 allows the generator and Xray tube to be specified separately. There are separate table numbers for unipolar and bipolar, but if both a unipolar and a bipolar table are specified they must use compatible generators. The table numbers are shown as a 6 digit code in the kV and mA display.The first 3 digits of the table number specify the generator (kV display) and the second 3 digits the Xray tube (mA display). If the first 3 digits are zero the table number is as used in previous versions.
The new engineering program 927 is used to select tables. To change the table the engineer switch must be set.

Configuration

Previously the MP-1 software came in a number of versions with normal, fast and user selectable clocks, with or without a table switch. These features have now been incorporated into a single build of software, using a new engineering programme 959 to select these features. This engineering programme is only selectable when the engineering switch is on.

Code	Options
0	Normal
1	User selectable clock
2	Fast Clock
4	Table Switch
5	Table Switch, User selectable clock
6	Table Switch, Fast Clock

Display changes

There are a number of new engineering codes with their associated displays, but there are only two cases where the existing displays change.

Generator type (906):-As the table number no longer fits into 3 digits it is no longer displayed in the time display.

Software ID (910):-The software ID display has been redesigned. The kV display shows the software revision level, the mA display the current option letters and the time display the build ID.

Tube Current Measurements

The type 2 MP-1 displays the current passing through the Xray tube. The previous version displayed the current sourced by the generator. The difference is small and is due to current in the kV measurement circuitry.

ENHANCEMENTS

Additions to the software have been made to enable the following new features;-

Medical Startup

Medical Startup can be run by setting 966 on. The engineering switch must be enabled first. When the X-Ray is subsequently turned on, kV will ramp up to full value before mA increases at all. This minimises radiation dose to a patient during the turn on period.

Warmup Type Override
A warm-up type can be specified using 965 settings. Again, these cannot be changed without an enabled engineering switch. The following warm-ups can be run, regardless of tube or generator type set:-

965 Setting	Warm-up Type
0	Sets warm up type to default value specified by table
1	Linear warm-up with normal ramp down
2	Exponential Warm-up with normal ramp down
3	Linear Warm-up with ceramic ramp down
4	Exponential Warm-up with ceramic ramp down

Logging
A program is available free of charge which runs under Windows™. This program is called the Gulmay Logging Client and can be used to extract data from the new MP1 via the serial port. Once extracted the data is automatically displayed. The program can be used to save log files which can then be emailed to a service centre, or as stand alone to open and view any log files:-

Tab Name	Information
Error	Logs the current date, time, total Xray hours on, generator and table type used, kV and mA at the time of an error occurance with th error number and description.
EHist	Records the frequency of Error Occurances, (in high-low frequency order), with each error number and description
Activity	Activities logged include any settings which have been changed, such as tube or generator type, kV or mA limits, calibration values etc.
Warmup	Logs the current date, time, total Xray hours on, generator and table type used, kV and mA, time warm-up started and reached maximum kV, percentage power, program type action (turn on, turn off) and warm up type
kV	Shows up to 8 graphs of kV/time over a 10 second period before an error occurs
mA	Shows up to 8 graphs of mA/time over a 10 second period before an error occurs

A record is also kept of the software build number and generator serial number.

Operation Inhibition After kV Breakdown (Dielectric Error)
If the unit detects 3 kV breakdowns at decreasing voltages, operation is inhibited to protect the generator. An Error 78 will be displayed if this occurs.

OPERATING INSTRUCTIONS

(SEE FIG 1.0 FOR MP1 PANEL LAYOUT)

1/ KEYSWITCH (SW)

There are three positions :
1 - NO POWER SWITCHED ON IN UNIT. (0)
2 - MAINS ON (~)
3 - HT ON ENABLE (lightening symbol)

2/ X-RAY ON (SW)

This is a green illuminated push button switch.
With the Key switch in position 3 and with all safety circuits closed, the X-RAY ON sequence will be initiated.

3/ X-RAY OFF (SW)

This is a red illuminated push button switch.
Terminates the X-RAY ON mode at any time. Does not reset the elapsed time display.

4/ MAINS ON (IND)

This is a White indicator and is illuminated as soon as the keyswitch is moved to position 2 or 3.

5/ SAFETY (IND)

This is a Green indicator that shows (when in the MAINS ON condition) that the safety interlocks and the cooler interlocks are made.

6/ PREWARN (IND)

This is a Blue indicator that shows when an X-RAY ON sequence has begun. It extinguishes after the PREWARN period (adjustable up to 30 Seconds) prior to the illumination of the X-RAY ON indicator. A different PREWARN period may be set which is triggered by safety line 2 being interrupted. In this case the processor will choose the longer of the 2 PREWARN times. The PREWARN is factory set to blink at 1Hz, this may be turned off using setting P904.

7/ X-RAY ON (IND)

This is an amber blinking indicator that illuminates at the end of the PREWARN period, it continues to blink at 1 Hz during the X-RAY ON period and after the X-RAY ON period is terminated until the generator output has fallen to 5kV. The blink may be turned off using setting P905.

8/ kV CONTROL (POTENTIOMETER)

This control is used to pre indicate and control the value of the high voltage output in the manual programming mode.The kV Control is alterable at all times in manual flouro programmes. The kV Control is non-alterable when the key is turned to the HT ON ENABLE position in manual Radiographic programmes. See programming modes.

9/ mA CONTROL (POTENTIOMETER)

This control is used to pre indicate and control the value of the output current in two of the manual programming modes. The mA Control is alterable at all times in manual flouro programmes. The mA Control is non-alterable when the key is turned to the HT ON ENABLE position in manual Radiographic programmes. See programming modes.

10/ TIME CONTROL (POTENTIOMETER)

This control is used to set the exposure duration in two of the manual programming modes (Radiographic). The Time Control is non-alterable when the key is turned to the HT ON ENABLE position. See programming modes.

11/ AUTO WATT (IND)

This indication shows that the output current is being limited to the maximum allowable under the X-Ray tube characteristic. This can occur in the programmed or manual Auto Watt modes or when the operator selects a load current in excess of that allowed by the X- Ray tube and focus combination.

12/ MANUAL (IND)

This indication occurs in the manual modes when data is being input by the front panel controls rather than the keyboard. See programming modes.

13/ FLUORO (IND)

This illumination occurs in the fluoro programmed and manual modes. Under this condition exposure time is unlimited and will only be determined by the X-RAY OFF switch. The timer display indicates elapsed time in this condition. See programming modes.

14/ WARM UP (IND)

This is illuminated during certain automatic warm up modes. These modes are pre-selected at switch on depending on the time that the system has been idle. The use of these modes is advisory not compulsory. See programming modes.

15/ **BIPOLAR (IND)**

Some generators are capable of being converted to bipolar operation that doubles the output voltage indication. This is illuminated when such systems are configured. Different power and technique limit factors are programmed for this mode.

16/ **FINE (IND)**

This is illuminated whenever the Fine/alternate focal spot is successfully selected.

17/ **CLEAR (SW)**

This switch will reset the exposure time to its initial value if the exposure has been terminated, only if the key switch is in position 3.

The switch will begin an update sequence for the data stored in a specific programme. The key switch must be in position 2 and some programmes will not have data which you can change, e.g. the warm up routines. Some programmes will require the engineering switch to be set on.

18/ **SET (SW)**

This switch is used when the key switch is in position 2 to set a new programme.

After pressing SET a new programme number can be keyed in. Pressing the ENTER button on the Keypad signifies you have finished entering the new programme number. A set of techniques will now be displayed if they have been pre programmed to that number. Pressing CLEAR at this time will allow you to re programme the techniques stored in that programme number.

19/ **FOCUS (SW)**

This is used to select the small focal spot, (if available), in an X- RAY tube. This switch is only enabled in the X-RAY OFF condition and with the key switch in position 2. Selecting this feature may cause the POWER LIMIT to be illuminated if the programme calls for a value of current in excess of that allowed for the focus. The mA will automatically be limited to the allowed maximum.

20/ **kV DISPLAY**

This is a 3 Digit 13 mm high LED display.
Prior to initiating the X-RAY ON sequence the kV display will show the value of the kV that will be output. This value will be determined by differing factors;

a) The kV control setting in manual mode.
b) The kV programme setting in programme mode.
c) The initial point in warm up mode.

The range of display will depend on the tube type selected.

At the start of the Prewarn mode the display will be switched to read the actual kV monitor signal and should therefore be zero

21/ mA DISPLAY

This is a 3 Digit 13mm high LED display. The last digit indicates tenths. Prior to initiating the X-RAY ON sequence the mA display will show the value of the mA that will be output. This value will be determined by differing factors;

a) The mA control setting in manual mode.
b) The mA programme setting in programme mode.
c) The initial point in warm up mode.

At the start of the Prewarn mode the display will be switched to read the actual mA monitor signal and should therefore be zero.

22/ TIME DISPLAY

This is a 3 Digit 13mm high LED display, the last digit indicates tenths. The display output shows the length of exposure time remaining in decimal minutes.

In fluoro modes, the display will show elapsed time. This will reset to zero at xray off.
In other modes, prior to initiating the X-RAY ON sequence, the display will indicate the exposure time.

During the Prewarn mode the display will show the exposure time. After the beginning of the X-RAY ON period and as soon as the generator output is within limits the display will count down. (radiographic only)

If an exposure is interrupted the time display will be frozen. The exposure may be continued by switching on again or reset by pressing CLEAR and then switching on again.

23/ PROGRAMME/ERROR DISPLAY

This is a 3 Digit 13mm high LED display.

During normal operation this display will continuously show the selected Programme number.

In the event of the programme being terminated by a fault then a 2 digit error code will be displayed preceded by an 'E'. This error code will be cleared by commencing the X-RAY ON sequence. Interruption of a safety line will be indicated by the display showing S1 or S2. Advisory codes will be preceded by 'A'. Some processor errors may be preceded by an 'F'. *See error number allocations Table 1.*

24/ PROGRAMMING METHOD

Pressing SET when the key switch is in position 2 will cause the Programme display to flash. The display will be updated from the right most digit as new numbers are keyed in. An unlimited amount of numbers can be keyed in as the display will only show the last three. Acceptance of the programme number is signified by pressing the ENTER button.

The other displays will now show the techniques stored under this programme number. These can be changed by pressing CLEAR and updating in the same manner as the Programme number. When a parameter is modifiable, it's display will flash. Pressing ENTER will accept the contents of this display and move on to make changes to the next parameter possible.

If a number entered is outside the specification of the X- Ray tube and/or focal spot, then it will be clipped to the maximum value. For instance,

- If Programme 233 is loaded as 100kV 30mA 10 min., when BROAD focus is selected, it will be accepted.
- Thereafter, if FINE is set, the mA will be clipped to, (e.g), 6.4mA but the programme value will not be altered.
- If FINE is set in the first instance and the values 100kV and 30mA are loaded, the mA will be clipped to 6.4mA and this will be the stored value.
- If a programme is keyed in with FINE selected it will automatically select FINE when recalled. To select FINE as part of a programme press the Focus select directly after setting the programme number.

25/ PROGRAMMING MODES

The programming modes are sub divided according to the first number into groups of 9 programmes.

These are subdivided again as follows:-

0xx	MANUAL PROGRAMMES	
002	MANUAL RADIOGRAPHIC	(kV, mA & TIME)
003	MANUAL RADIOGRAPHIC	
004	MANUAL,FLUORO	(kV & mA)
005	MANUAL,FLUORO	
006	MANUAL,AUTO WATT	(kV & TIME)

007	MANUAL,FLUORO,AUTO WATT	(kV only)
1xx	WARM UP PROGRAMMES	
2xx	RADIOGRAPHIC PROGRAMMES	(kV, mA & TIME)
3xx	MORE RADIOGRAPHIC PROGRAMMES	
4xx	FLUORO PROGRAMMES	(kV & mA)
5xx	MORE FLUORO PROGRAMMES	
6xx	AUTO WATT PROGRAMMES	(kV & TIME)
7xx	FLUORO, AUTO WATT PROGRAMMES	(kV only)
800	RS 232 FLUORO MODE	(kV and mA)
802	RS 232 RADIOGRAPHIC MODE	(kV, mA and time)
888	ENGINEER SWITCH ON/OFF	
9xx	ENGINEERING DATA SET MODES.	

26/ DIFFERENT X-RAY TUBES

Each panel has an internal PCB mounted IC socket for an EPROM that contains code and the X-Ray tube and generator data that can be combined to set range limits for the specified focal spots. The X-Ray tube data also contains warm-up data for the tube. To select a different tube and generator combination, the table ID must be changed using the front panel, *See Appendices for choices.*

Separate tables are specified for unipolar and bipolar operation

For both of these, separate values are maintained for the time of last use, total hours on the tube, warmup power percentage, soft kV limit and droop corrections.

If the table switch option is used, an alternate pair of tables can also be specified.

INSTALLATION AND INTERFACING REQUIREMENTS

INSTALLATION

The generator should be installed in accordance with the manufacturers recommendations.

The X-Ray tube should be installed in accordance with the manufacturers recommendations.

The MP-1 Control Panel should have a suitable, (20A rated), earth attached to the 6mm terminal on the rear panel.

The MP-1 should then be connected to the generator and a suitable interface unit.

INTERFACING REQUIREMENTS

A suggested circuit for the interface unit, (LAB I/O BOX), is shown on drawing MP3-042 and described later in this manual.

CHECKS BEFORE INITIALISING XRAYS

Refer to system manual to check for cooling, interlocks, radiation and electrical safety.

On the MP1 check the parameter limits for both focal spots against the X-Ray tube and generator data. Always use programme 907 to view limits for each focal spot . It is the responsibility of the installer to check this. Errors can cause irreparable damage to the X-Ray tube and possibly the generator.

X-Ray safety could be compromised by running at a higher kV than the system was designed for.

SETTING A TABLE

Engineering switch
The engineering switch is turned on and off using engineering code 888. The engineering switch is always OFF at power on. Press SET 888, Press CLEAR and 0 (OFF) or 1 (ON) to toggle.

Specifying Tables
The new MP-1 allows the generator and X-ray tube to be specified separately. There are separate table numbers for unipolar and bipolar, but if both a unipolar and a bipolar table are specified they must use compatible generators. The first 3 digits of the table number specify the generator, (as shown in the kV display). The second 3 digits specify the X-ray tube, (as shown in the mA display). If the first 3 digits are zero the table number is as used in previous versions. All selections must be entered as 6 digits in the kV and mA displays.

The new engineering program 927 is used to select tables. To change the table the engineer switch must be set.

For backward compatibility and ease of use, the old table numbers can be entered. A limitation of the old design was the quantity of tables in an EPROM before a new EPROM was required. The new design has much more space for additional data.

Example 1 (Existing table number in Unipolar or Bipolar)
With key in position 2 (vertical)

Press SET,888,ENTER	Engineering switch
Press CLEAR,1,ENTER	Turn on Engineering switch
Press SET, 927, ENTER	Table select mode
Press CLEAR,000, ENTER	(numbers in the kV display)
Press 002, ENTER	(numbers in the mA display)
	The old table 2 is now entered
Press SET,907,ENTER	Display kV, mA, Power Max
Press FINE	Display kV, mA, Power Max
Additional, optional checks.....	
Press SET,906,ENTER	Generator Type
Press SET,956,ENTER	Generator Type and Number Displayed
Press SET,957,ENTER	Tube Type and Number Displayed

Please note that Table 2 is entered as 6 digits and that 906 is really only used for backward compatibility. 956 and 957 can be used to view the generator and tube type by setting individual codes.
It is vital that the installer using programme 907 checks the maximum kV, mA and Power values.

Example 2 (New table in Unipolar)
With key in position 2 (vertical)

Press SET,888,ENTER	Engineering switch
Press CLEAR,1,ENTER	Turn on Engineering switch
Press SET, 927, ENTER	Table select mode
Press CLEAR, 022, ENTER	Select CP160
Press 003, ENTER	Select MXR160/22 (As old Table2)
Press SET,907,ENTER	Display kV, mA, Power Max
Press FINE	Display kV, mA, Power Max
Additional, optional checks.....	
Press SET,906,ENTER	Generator Type
Press SET,956,ENTER	Generator Type Displayed
Press SET,957,ENTER	Tube Type Displayed

Example 3 (New table in Bipolar)
Connect an Anode tank
With key in position 2 (vertical)

Press SET,888,ENTER	Engineering switch
Press CLEAR,1,ENTER	Turn on Engineering switch

Press SET, 927, ENTER	Table select mode
Press CLEAR,001, ENTER	Select CP320
Press 002, ENTER	Select MXR320/1.2,3.0
(as old No2 Bipolar)	
Press SET,907,ENTER	Display kV, mA, Power Max
Press FINE	Display kV, mA, Power Max
Additional, optional checks……..	
Press SET,906,ENTER	Generator Type
Press SET,956,ENTER	Generator Type Displayed
Press SET,957,ENTER	Tube Type Displayed

If the table selected uses a generator that is incompatible with the unipolar generator an error E83 will result.

The backward compatibility of being able to enter old table codes makes table selection easy for previous users. Also with the new table selection technique that has been incorporated, it is no longer necessary to wait for a factory request for new table combinations, plus a much greater number of table combinations are possible.

MP1 FEATURES AND OPTIONS SETTING

1 TURN ENGINEERING SWITCH ON or OFF

Press SET, 888, ENTER
Press CLEAR, 1, ENTER (ON)

Press SET, 888, ENTER
Press CLEAR, 0, ENTER (OFF)

2. SELECT TUBE/GENERATOR TABLE

(This operation can only be performed with the engineering flag set to ON.)

Press SET, 927, ENTER
Press CLEAR
Enter the table number
Press ENTER

3. CALIBRATION

The MP1 is supplied calibrated and this procedure is for information only.
Isolate MP1 generator I/O connector SK2
Fit links on I/O pcb as follows:-
R66 (either end) to TP10,
TP13 to TP16,
TP14 to TP15.

Connect a calibrated DVM, (4 digit meter), to the I/O PCB between TP13, (+ lead), and TP11, (- lead). Set the DVM to 20V FSD and turn the key to position 2.
Press SET, 888, ENTER
Press CLEAR, 1, ENTER (ON)
Press SET & 900 & ENTER a figure should appear in the kV display window.
Hit the CLEAR button. The display should flash "1Hi".
Load the digital number, (decimal 3 digits only), into the MP1 that the DVM displays and press ENTER. The display should flash "1Lo".
Load the digital number, (decimal 3 digits only), into the MP1 that the DVM displays and press ENTER.
Move the TP13 lead on theDVM (4 digit meter) to the TP14, the display should flash 2Hi. Load the digital number, (decimal 3 digits only), into the MP1 that the DVM displays and press ENTER. The display should flash 2Lo.
Again load the digital number, (decimal 3 digits only), and press ENTER.

The DVM should now return to 0V.
If the (Hi) voltages entered are less than 7.40 volts or greater than 7.60V then the MP1 will indicate an error E38.
If the (Lo) voltages entered are less than 2.40 volts or greater than 2.60V then the MP1 will indicate an error E39.

After calibration, switch off the MP1, remove the links and reconnect SK2.

4. PREWARN (NORMAL)

Press SET, 901, ENTER
Press CLEAR, 50, ENTER (5 seconds)

5. PREWARN (SAFETY 2)

Press SET, 902, ENTER
Press CLEAR, 100, ENTER (10 seconds)

6. BUZZER

Press SET, 903, ENTER
Verify that it is 'ON'
to change press CLEAR press 0 - OFF
1 - ON
Press ENTER

7. PREWARN FLASH

Press SET, 904, ENTER
Verify that it is 'ON'
To change press CLEAR press 0 - OFF
1 - ON
Press ENTER

8. X-RAY ON FLASH

Press SET, 905, ENTER
Verify that it is 'ON'
To change press CLEAR press 0 - OFF
1 - ON
Press ENTER

9. GENERATOR TYPE

Press SET, 906, ENTER
Verify displays are as expected for the generator selection NB. The table number is no longer supplied in the display of this programme. 906 is only provided for backward compatibility. See 927, 956 and 957.
eg. 'CP' '160'

10. MAX mA, kV, kW

Press SET, 907, ENTER
Verify displays are as expected for the tube/generator table selection

eg. '160' '30.0' '3.0'. Pressing the FINE button will display the limits for a smaller focus, (if available).

11. CLOCK HRS/MIN/SEC

Press SET, 908, ENTER
Press CLEAR, HR (0-23), ENTER
MIN (0-59), ENTER
SEC (0-59), ENTER

12. CLOCK DAYS/MONTH/YEAR

Press SET, 909, ENTER
Press CLEAR, DAY (1-31), ENTER
MTH (1-12), ENTER
YR (0-99), ENTER

13. PROGRAMME REVISION

Press SET, 910, ENTER
The revision number of the programme EPROM will appear in the mA display. The clock configuration is shown in the time display. The standard build is blank.
U indicates the User Clock option, F the Fast clock option, S as the Table Switch option. Two letters indicates that both options are incorporated. For details of these options, see function 959.

14. TIME OF LAST USE

Press SET, 911, ENTER
The time that the equipment was last used at 80% of its maximum warm up voltage, (or more), will be displayed.

This value is associated with the current generator/tube combination.

15. DATE OF LAST USE

Press SET, 912, ENTER
The date that the equipment was last used at 80% of its maximum warm up voltage will be displayed

This value is displayed for the current generator/tube combination.

16. CUMULATIVE X RAY HOURS

Press SET, 913, ENTER
The total X Ray On time will be displayed as xxx xx.d hours in the mA and Time displays.

This value is associated with the current generator/tube combination.

17. WARM UP POWER

Press SET, 918, ENTER
Press CLEAR enter a 3 digit number between 010 and 100 which represents the percent of full power that all warm ups will be run at.

Press ENTER

18. ADVISORY DATE

You may set a date which can act as a service reminder. When this date is reached the Code "A1" will flash for 10 seconds at power up in the PROGRAMME/ERROR display.
(This operation can only be performed with the engineering flag set to ON.)

Switch the Engineering switch to on.

Press SET, 888, ENTER
Press CLEAR, 1, ENTER (ON)

Press SET, 920, ENTER
Press CLEAR, DAY (1-31), ENTER
MTH (1-12), ENTER
YR (0-99), ENTER

Switch the Engineering switch to off.
Press SET, 888, ENTER
Press CLEAR, 0, ENTER (OFF)

19. UNIT SERIAL NO.

To identify the unit for logging purposes, there is provision for entering the Unit serial number.
(This operation can only be performed with the engineering flag set to ON.)
Press SET, 926, ENTER
Press CLEAR,enter four digits of the serial no. and ENTER

20. KV BREAKDOWN INFORMATION (Associated with Error 78)

In order to protect the Xray tube / Cable /generator, a feature is incorporated in the software to shut down the controller, if three errors related to excessive kV or mA (E4, E5, E11, E12, E14 or E13)occur at decreasing kV values. It causes an error E78 and the MP1 prevents further exposures.(Indicates kV and number of errors if read at program 928).

It is recommended that a Sevice Engineer is called to investigate this problem.

To clear the E78 error requires;-

This operation can only be performed with the engineering flag set to ON.

Press SET, 928, ENTER
Press CLEAR
The MP1 will revert to the previous program without Error 78. This action will be recorded in the activity log.

21. OFFSET ADJUSTMENT

With long interface cables it is possible to accumulate 20mV drops on kV and mA monitor signals.

On some systems (CP320 and CP450) this may represent a 1kV meter error. This feature allows you to enter an offset to kV and to mA to counteract the drop.

(This operation can only be performed with the engineering flag set to ON.)

Switch the Engineering switch to on.

Press SET, 888, ENTER
Press CLEAR, 1, ENTER (ON)

Measure the voltage drops on the monitor lines and add the offset correction (between 0 and 99mV) as follows.

Press SET, 940, ENTER
Press CLEAR, kV (0-99mV), ENTER
mA (0-99mV),ENTER

Switch the Engineering switch to off.
Press SET, 888, ENTER
Press CLEAR, 0, ENTER (OFF)

This value is associated with the current generator/tube combination.

22. DATE FORMAT

You may set a new date format depending on your national standard or preference. This modified date display will be used in Engineering codes 909, 912 and 920.

To check the current standard:

Press SET, 941, ENTER.

The display will read 1 of 3 ways, STD, ISO or USA. The shipping default is STD. To change the format:

Press CLEAR and 0, 1 or 2 where they represent the following:-

Enter	Name	Format
0	STD	DD/MM/YY
1	ISO	YY/MM/DD
2	USA	MM/DD/YY

When dates are entered under Engineering codes 909 or 920 then when CLEAR is pressed the flashing display alternates between the format and the value.

23. X RAY OFF BUZZER

You may require an audible warning of the MP1 changing to the X Ray Off mode. This can occur automatically due to the end of a programmed Radiographic procedure or due to an error in any mode. The normal termination of a Radiographic exposure will be indicated by a 3 second buzzer. The termination of any operation by an error will result in 3 discrete 1 second beeps. This feature may be useful when the control panel or external warning lights are not easily visible to the operator.

To enable this feature:

Press SET, 942, ENTER.

Verify that it is 'ON'
to change press CLEAR, 0 - OFF
1 - ON

Press ENTER

The shipping default is OFF, however if the Programme EPROM is changed from an old version (before 4.4) then this feature will be automatically enabled. Use this procedure to turn it off if it is not desired.

24. HARDWARE FLUORO INDICATOR

The difference between Radiographic (timed exposures) and Fluoroscopic (continuous real time) is indicated by a status LED on the MP1 front panel. The LED is labelled FLUORO and illuminated in that mode. There can be a need to have a hardware indication of this status. This is provided on the CPU PCB PL2 pin 3. Fluoroscopy would be represented as a high signal (5V) and Radiography by a low (0V).

To enable this feature:

(This operation can only be performed with the engineering flag set to ON.)
Press SET, 947, ENTER.
to change press CLEAR press 0 - OFF
1 - ON

Press ENTER.

The shipping default is OFF.

25. FILAMENT SELECT LOCK

There are some X Ray tubes available with identical filaments. The Table data programmed by Gulmay allows Warming Up on either spot. It may desirable to prevent customer use of the second focal spot until the first one is worn out or has failed. To enable this, a filament select lock has been added which is only effective on those tables that allow warming on either spot.

(This operation can only be performed with the engineering flag set to ON.)

To enable this feature:

Press SET, 948, ENTER

To change :

Press,CLEAR ,then 0,1 or 2 as follows

Function	Select	Indication
Both Allowed	0	2
Large Only	1	L
Small Only	2	F

Press ENTER.

The shipping default is 0.
This value is associated with the current generator/tube combination.

26. SYSTEM VOLTAGE LIMIT

A feature to limit the operating voltage of a system to a value below the maximum stated in programme 907. The kV is limited to this value and the Warm Up routines finish at this value. If the value is increased the system will automatically select the longest warm up available. This feature may prolong the X ray tube life according to one manufacturer (Comet). **IT MUST NOT BE USED TO LIMIT THE VOLTAGE OF A SYSTEM FOR RADIATION PROTECTION REASONS.**

To set a new value, such as 150:-

Switch the Engineering switch to on.

Press SET, 888, ENTER
Press CLEAR, 1, ENTER (ON)

Press, SET, 949, ENTER
Press CLEAR,150,ENTER

The value is applied to the current generator/tube combination.
Separate values are held for up to 4 generator and tube combinations.

27. DUAL SAFETY SWITCH
This functions when set requires that both Safety Lines (1&2) operate simultaneously. This may be required for redundancy.
This function requires that the Engineering Switch be set.
Press SET, 954, ENTER
Press CLEAR
Press 0-OFF
Press 1-ON
Press ENTER

28. GENERATOR TYPE
This function allows the generator Type and Number to be displayed. For example from Appendix C, if a Unipolar generator 22 had been entered with 927:-
Press SET, 956, ENTER
Display in the kV,mA and Time windows should be: "CP ", "160", "22U"

29. TUBE TYPE
This function allows the tube Type and Number to be displayed. For example from Appendix D, if a Unipolar tube 3 had been entered with 927:-
Press SET, 957, ENTER
Display in the kV,mA and Time windows should be: "160", "022", " 3U"

30. DISPLAY CHECK

This operation can only be performed with the engineering flag set to ON.
To test the MP1 display, an engineer facility is incorporated which sequences the LED segments. (excludes the Program display). To exercise this, press SET, 958, ENTER

31. CONFIGURATION

This Engineering function allows the software to configure the clock options. Changes to the options can only be performed with the engineering flag set to ON.

Press SET, 959, ENTER,CLEAR
0 - standard

1 – U (user) clock
2 – F (fast) clock
3 – (not valid)
4 – S (switched) clock {set up tables)
5 – US (user + switched) clocks
6 – FS (fast + switched) clock

32. WARM UP TYPE OVERRIDE

This function allows the standard warm up to be over ridden. There are 2 types:-

Linear (Constant Power)
Exponential (Rising Power)

There is also an additional feature at the end of the Warm Up cycle called Ceramic Rundown. This reduces the kV at the end to reduce the stored charge in a Ceramic tube.

Changes to the options can only be performed with the engineering flag set to ON.

Press SET, 965, ENTER
Press CLEAR
0 - warm up as the table
1 – Linear
2 – Exponential
3 – Linear with Ceramic Rundown
4 – Exponential with Ceramic Rundown
Press ENTER

33. MEDICAL START UP (966)

This features controls the mA to an idle value until the kV Feedback reaches 90% of demand. This reduces X Rays at energies other than the required value.

This function requires that the Engineering Switch be set.
Press SET, 966, ENTER
Press CLEAR
Press 0-OFF
Press 1-ON
Press ENTER

34. MAINS SAMPLING/ CALIBRATION

The collection of 256 data points at 4000 Hz as a sample of the mains voltage can be made on the log. To initialise the sample, set to Enginering Mode ON(program 888) and enter SET, 967,ENTER.
On the MP1 panel the kV window indicates the rms voltage measured.
A new calibration can be inserted by entering CLEAR, a number (RMS voltage value) and pressing ENTER.

35. TURN OFF UNDER ERRORS (968)

There are 4 under errors:

E18 kV less than demand by 3% or 3 counts
E54 kV less than 5
E19 mA less than demand by 3% or 3 counts
E89 mA less than 0.5

These errors are suppressed when the Engineering Switch is set to facilitate trouble shooting and diagnostics. On the original MP1 design the Engineering Switch was set internally. On this design the Engineering Switch is set in by command 888 and resets automatically when the power is cycled. To have 'Under Errors' permanently over ridden this function can be used.
This function requires that the Engineering Switch be set.
Press SET, 968, ENTER
Press CLEAR
Press 0-OFF
Press 1-ON (Under Errors Suppressed)
Press ENTER

36. FILAMENT LIMIT

Modifying the setting of RV1 on the I/O PCB can reduce the Filament limit setting on some types of generator.

TABLE 1 :ERROR NUMBER ALLOCATIONS

DISPLAY ERRORS	RS232 ERRORS	DESCRIPTION
S1	193	Safety 1 Broken
S2	194	Safety 2 Broken
A1	129	Advisory Code 1
E1	1	Illegal Programme Code
E2	2	Attempt to Divide by Zero
E3	3	Divide Overflow
E4	4	kV Feedback Exceeds Demand
E5	5	mA Feedback Exceeds Demand
E6	6	NOT USED
E7	7	NOT USED
E8	8	Programme not Defined for Use
E9	9	Focus Selected, not Returned
E10	10	Bipolar Status Mismatch (Table to generator Status)

E11	11	Over kV (Generator)
E12	12	Over mA (Generator)
E13	13	Converter Over Current
E14	14	Converter Over Voltage
E15	15	No Cooler Flow
E16	16	Cooler Over Temperature
E17	17	Contactor Pull In Failure
E18	18	kV Feedback less than Demand
E19	19	mA Feedback less than Demand
E20	20	Generator Not Powered
E21	21	No X-Ray On Status Returned
E22	22	kV Decay greater than 5 Seconds
E23	23	Contactor Drop Out In X Ray On
E24	24	kV Monitor >Min. in X Ray Off
E25	25	mA Monitor >Min. in X Ray Off
E26	26	X ray On Status from generator illegally
E27	27	Autobrightness selected but hardware not present.
	28-37	NOT USED
E38	38	Calibration voltage out of range (Hi)
E39	39	Calibration voltage out of range (Lo)
	40-53	NOT USED
E54	54	kV did not exceed 5
E55	55	X ray OFF signal open at power up
E56	56	X ray terminated by Safety 1
E57	57	X ray terminated by Safety 2
E58	58	X ray terminated by Cooler Flow
E59	59	X ray terminated by Cooler Temp
E60	60	Safety Contactor Engaged at power up
E61	61	X ray terminated by Focus change
E62	62	X ray terminated by Bipolar Status change
E63	63	Generator/tube table invalid
E64	64	Powered off not in mode 0, CPU Reset
E65	65	External Xrays on signal with no contactor
E66	66	Key switch not in position 3 during exposure
E67	67	Excessive kV demand in Xrays off
E68	68	Excessive mA demand in Xrays off
E69	69	Table switch hardware not present
E70	70	Table switch changed while running
E71	71	Droop calibration too high

E72	72	DAC zero offset too high
E73	73	DAC range too high
E74	74	ADC zero offset too high
E75	75	ADC range too high
E76	76	ADC calibration lost
E77	77	Bad generator table in PROM– (manufacturing test only)
E78	78	kV Breakdown lockout
E79	79	X Ray Off Switch Open When X Rays Initiated
E80	80-82	NOT USED
E83	83	Bipolar and unipolar generators incompatible
E84	84	dual door interlock failure
E85	85	NOT USED
E86	86	Exposure parameters error.
E87-88	87-88	NOT USED
E89	89	No mA on switch on
E90	90	Autobrightness parameters

See System Troubleshooting Manual for further assistance.

FATAL ERRORS

F1	Programme Eprom Checksum
F2	Ram Fault
F3	Table checksum fault
F4	Watchdog Triggered
F5	Background Timing Fault
F6	Illegal instruction
F7	Tube Switch Change Fault
F9	Other fatal error
F10	Stack overflow
F11	Clock monitor failure (CPU)
F12	RAM page error (– manufacturing test only)
F14	Generator Table Corrupted
F15	Xray Tube Table Corrupted
F16	Trip Levels Corrupted
F17	Unknown Fatal Error

TABLE 2: ENGINEERING CODE SUMMARY

888	Set/clear engineering flag
900 *	Calibration
901	Set Normal Prewarn Time
902	Set Safety 2 Prewarn Time
903	Enable Buzzer
904	Select Flashing Prewarn Light
905	Select Flashing X-Ray On Light
906	Display Generator Type
907	Display Max. kV, mA and Power (kW)
908	Display/Change Clock Hours, Mins and Seconds
909	Display/Change Clock Day, Month and Year
910	Display Software Revision and Type
911	Display Time of Last Use (See Note)
912	Display Date of Last Use
913	Display Elapsed X-Ray Hours
914	Special Function(ON/OFF Autobrightness)
915	Special Function(Autobrightness Lo kV)
916	Special Function(Autobrightness Hi kV)
917	Special Function(Autobrightness slew rate)
918	Warm Up Power Select
919	Special Function(seconds format)
920 *	Set an Advisory/Maintenance Date
926 *	Unit serial number selection
927 *	Table number selection
928 *	Display or Clear kV Breakfown Information
929 *	Select RS232 line format
940 *	Offset Adjust
941	Date Format Change
942	X Ray Off Buzzer Enable
947 *	Hardware Fluoro Status Indicator Enable
948 *	Filament Select Restrictor
949 *	System Voltage Limit
954*	Requires Simultaneous Action of Safety lines
956	Display Generator Type
957	Display Tube Type
958*	LED Test Cycle
959*	Configuration (Clock options)
965*	Warm Up Override
966*	Medical Start Up
967*	Sample Mains
968*	Inhibit Under Errors

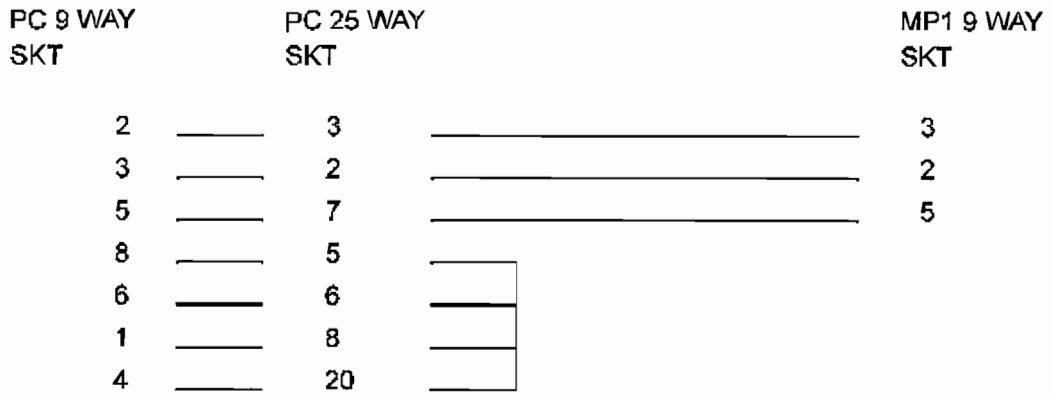
Note: Time of last use is up dated every warm up or each time a technique exceeds 80% of the maximum warm up voltage.
Codes marked with * require the Engineering switch to be set to on.
The code numbers do not run in sequence because of the use by other related products.

RS232 CONNECTIONS AND SETTING

SETTINGS

The RS232 interface is set to 9600 baud, 8 bits with 1 start bit and at least 1 stop bit. The most significant bit of the 8 is ignored and no handshake lines or software start/stop protocols are used.

TYPICAL PC CONNECTION



RS232 MESSAGE SUMMARY

The MP-1 responds to requests for data on the RS232 line at any time. Commands are only accepted when the MP-1 is in programme mode 800 (Remote RS232 fluoro) or 802 (Remote RS232 radiographic) and the keyswitch is in position 3.

Data request messages begin with a ? character. Command messages begin with a ! character. All messages end with a carriage return character which is denoted <CR>. Any characters not part of a legal message are echoed in brackets as soon as the illegality is detected.

Data formats

Old style messages use fixed length numeric fields without decimal points, usually of 3 digits. Thus !I100<CR> would demand 10.0 mA and the request ?M<CR> would receive the reply ?M000<CR> to indicate the unit being in mode 0. Some newer messages use variable length numeric fields with decimal points where present.

Engineering program 929 allows you to switch all messages to this form.

Some logging messages use a base 64 encoding to reduce the length of messages.

In messages with more than one field the fields are separated with commas.

Data request messages

All data request messages begin with ? and end with <CR>. The replies begin by echoing the request except for the carriage return, continue with the data requested and end with <CR>.

There are three classes of data request message.

Single Character requests

These are all of the form ?<capital letter><CR>. The format of the reply depends on the state of the flag set by program 929.

Program requests

These are of the form ?P9nn<CR> where nn are two digits completing the number for an engineering programme code. The data returned is similar to the displays shown when the same programme code is entered on the front panel. However the unit's programme is not changed and operation is not affected.

Logging requests

Since the introduction of the type 2 CPU card (units running software revision 6.0 or higher) the MP-1 has supported a logging facility to assist with troubleshooting and

maintenance. A program is available to view the logs on a PC, and the logs can be emailed or sent on a floppy disc to a support service centre.

A variety of types of data can be logged, but the logging configuration is factory set. Currently four types of log are supported, but provision has been made to extend these in future.

Command messages

All command messages begin with ! and end with <CR>. If the command is accepted it is echoed.

RS232 REQUEST SUMMARY

Single character data requests

Messages are of the form:
?<command character><carriage return>.
Carriage return is denoted by CR.

If the flag specified by engineering code 929 is 0 <number> is 3 digits with no decimal point.

If the code is 1 <number> is variable length and contains a decimal point if appropriate.
Recognised requests are:

V Requests kV voltage display. Response is ?V<number><CR>

I Requests current mA display. Response is ?I<number><CR>

T Requests elapsed time. Response is ?Tnnn<CR>. nnn is in deciminutes if the format flag is 0. If the flag is 1 Response is <minutes>,<seconds>

P Requests programme display. Response is ?Pnnn<CR>

M Requests current mode. Response is ?M<number><CR>

Valid modes are
- 000 Key in position 2
- 001 Key in 3 but no X-Ray On
- 002 Prewarning
- 003 X-Rays switching on or off
- 004 X-Ray On and Exposure being logged

E Requests currently displayed errors. Response is E<number>,<number>, <number>,<number><CR>. There may be no errors.

F Requests selected focus. Response is F (fine) or B (Broad) <CR>.

U Requests warm up power setting. Response is U<number><CR>

A Requests autobrightness setting. Response is A<number><CR>

N Requests needs(date/time/warmup). Response is N<number><CR>

R Requests software revision. Response is R<number><CR>

W Requests warm up programme. Response is W<number><CR>

S Requests table setting. Response is S<number>U(unipolar) or B(bipolar)<CR>

Program data requests

Messages are of the form:
?P9nn<carriage return>.
Carriage return is denoted by CR.

888 Requests status of engineering flag. Response is ?P888,<0 or 1><CR>

901 Requests Normal Prewarn Time. Response is ?P901,<secs><CR>

902 Requests Safety 2 Prewarn Time. Response is ?P902,<secs><CR>

903 Requests Buzzer enable status . Response is ?P903,<0 or 1><CR>

904 Requests Flashing status of Prewarn Light. Response is ?P904,<0 or 1><CR>

905 Requests Flashing status X-Ray On Light. Response is ?P905,<0 or 1><CR>

906 Requests Generator Type selected. Response is ?P906,<generator type>,<Table No><CR>. The table number will be up to 6 digits with a 'U' or 'B' suffix. It will represent the table entered using 927.

907 Requests Max. kV, mA and Power (kW), Response is ?P907,<kV>,<mA>,<power><CR>

908 Requests current time. Response is ?P908,<hours>,<mins>,<secs><CR>

909 Requests current date. Response is ?P909,<year>,<month>,<day><CR>

910 Requests EPROM Revision Number, Response is ?P910,<number><CR>

911 Requests last used time. Response is ?P911,<hours>,<mins>,<secs><CR>

912 Requests last used date. Response is ?P912,<year>,<month>,<day><CR>

913 Requests power on time. Response is ?P913,<hours>,<mins> <CR>

918 Requests warm up power setting. Response is ?P918,<percentage><CR>

919 Requests seconds format, Response is ?P919,<0 or 1><CR>

920 Requests Advisory Date, Response is ?P920,<year>,<month>,<day><CR>

926 Requests serial no.. Response is ?P926,<4 digit no><CR>

927 Requests Table number, Response is ?P927,<table no ><CR>

928 Requests no. of kV Breakdowns, Response is ?P928,<kV (4digits)>,<0 to 3><CR>

929 Requests remote mins and secs flag. Response is ?P929,<0 or 1><CR>

941 Requests Date Format type, Response is ?P941,<0,1 or 2><CR>

942 Requests X Ray Off Buzzer flag Response is ?P942,<0 or 1><CR>

949 Requests soft kV limit. Response is ?P949,<kV><CR>

956 Requests generator type. Response is ?P956,<Gen Type>,<Gen No>,CR.

957 Requests tube type. Response is ?P957,<Tube Type>,<Tube No>,CR.

959 Requests Configuration (Clock options), Response is ?P959,<0 to 6(see select choice)><CR>

RS232 COMMAND SUMMARY

Commands are of the form:

!<command character><CR> or
!<command character><number><CR>.

The MP1 must be in programme 800 or 802 and the Key on position 3.

If the flag specified by engineering code 929 is 0 <number> is 3 digits with no decimal point. If the code is 1 <number> is variable length and contains a decimal point if appropriate.

V !V<number><CR>. Set kV request.

I !I<number><CR>. Set mA request.

T !T<CR>. Reset timer.
!T<mins>,<secs><CR>.Set time (programme 802 only).

X !X<CR>. Initiate X-Ray.

O !O<CR>. Terminate X-Ray.

F !F<CR>. Set Fine focus.

B !B<CR>. Set Broad focus.

LOGGING REQUESTS

PC CLIENT PROGRAM

A program is available free of charge which runs under Windows™. This program is called the Gulmay Logging Client and can be used to extract data from the new MP1 via the serial port. Once extracted the data is automatically displayed. The program can be used to save log files which can then be emailed to a service centre, or as stand alone to open and view any log files:-

The concept of the log is that details of errors, warm ups and significant changes are recorded. In addition when an error occurs, snap shots of the proceeding 10 seconds of kV, mA (sampling at 80 Hertz) and mains input voltages (sampling at 320 Hertz for 0.8 sec) are stored in buffers.

The display screen has two areas, the control `buttons` and the log entries details/buffer waveform.

The entry size of log types supported is dependant on the software build. Typically there can be 2000 of both Error Logs and Warm Up Logs, 1000 Activity Logs and 8 logs each for Voltage, Current and Mains Buffers. The logs are cyclic buffers which

fill until full and then replace the oldest entry, and hence there is no provision for clearing any logs.

Date format is as Day/Month/Year.

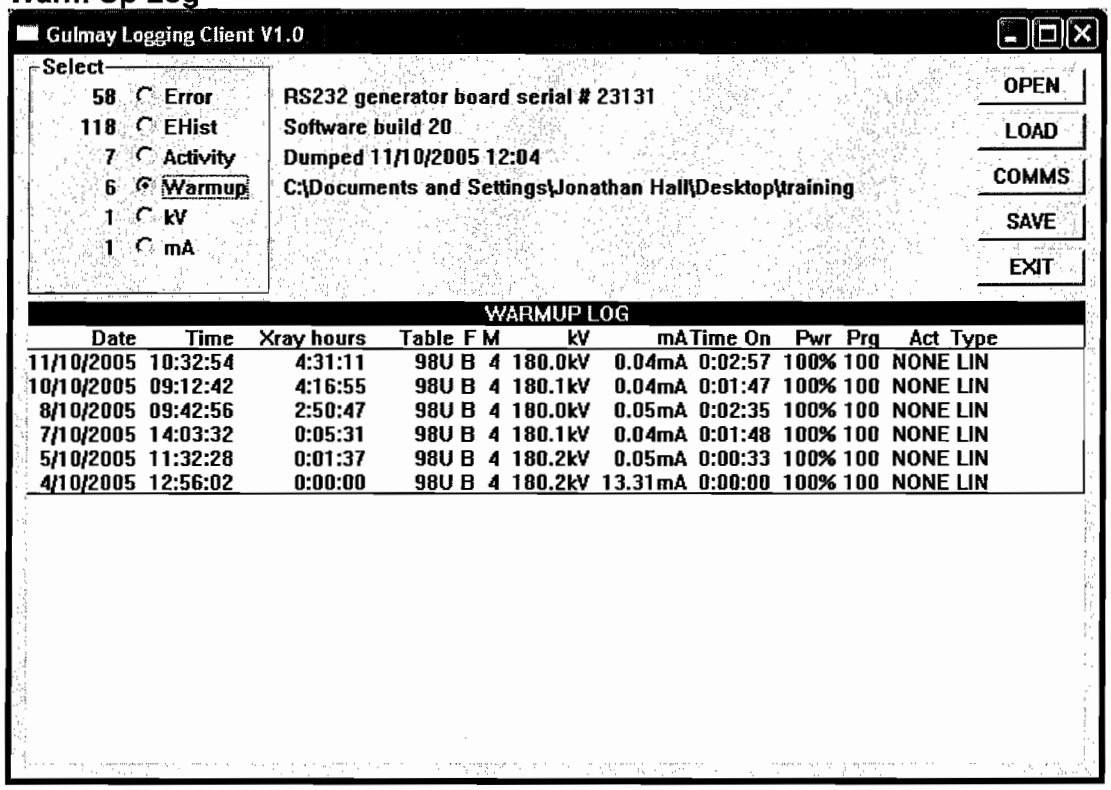
Selection of the type of logs is by clicking on radio buttons as follows:-

- Error
- Ehist (histogram)
- Activity
- Warm up
- kV
- mA

INTERPRETATION OF LOGS

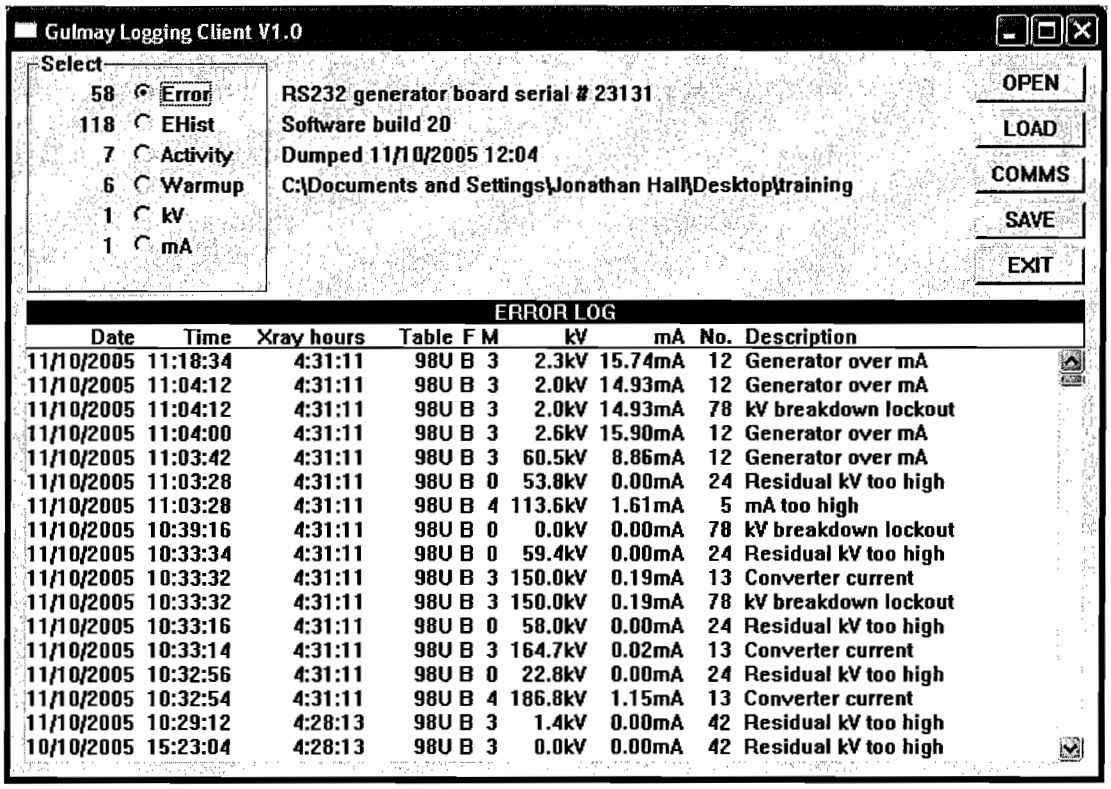
Currently four types of log are supported, warm up log, error log, error histogram and activity log and Buffers. The format of the displayed entries are as illustrated below :-

Warm Up Log

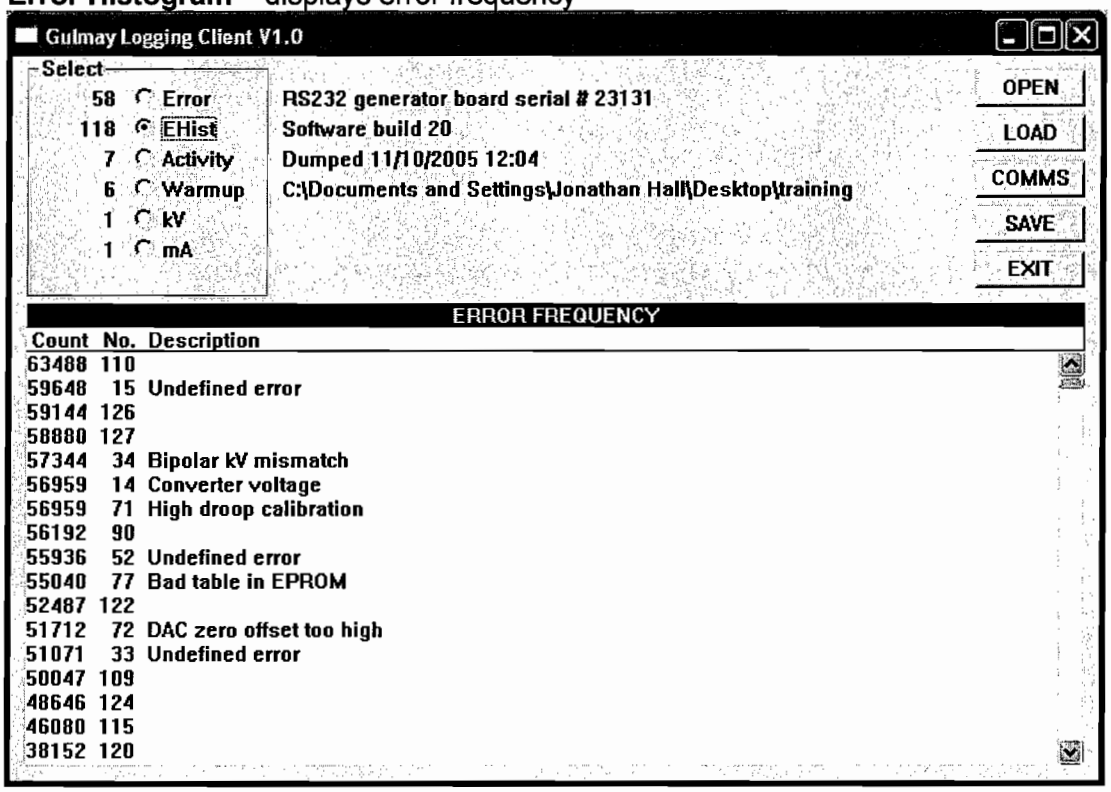


DATE	DD/MM/YY
TIME	Hrs/Min/Secs
TUBE XRAYON HOURS	Hrs/Min/Secs
TABLE	(xx) U unipolar (xx) B bipolar
SPOT SIZE	F fine B broad
MODE	0 key position 2 1 HT enabled 2 Prewarn on 3 Xray ramping (up/down) 4 Xray on and stable
kV	xxx.x kV
mA	xx.xx mA
TIME RUN	Hrs/Min/Secs
% POWER	xx %
PROGRAM	xxx
STATUS	ON started warm up but not completed BACK warm up set back (existing kV decreased by 5kV) DONE completed NONE offered warm up but not used
WARM UP TYPE	LIN linear ramp EXP exponential ramp CERAMIC ceramic tube with specified controlled ramps

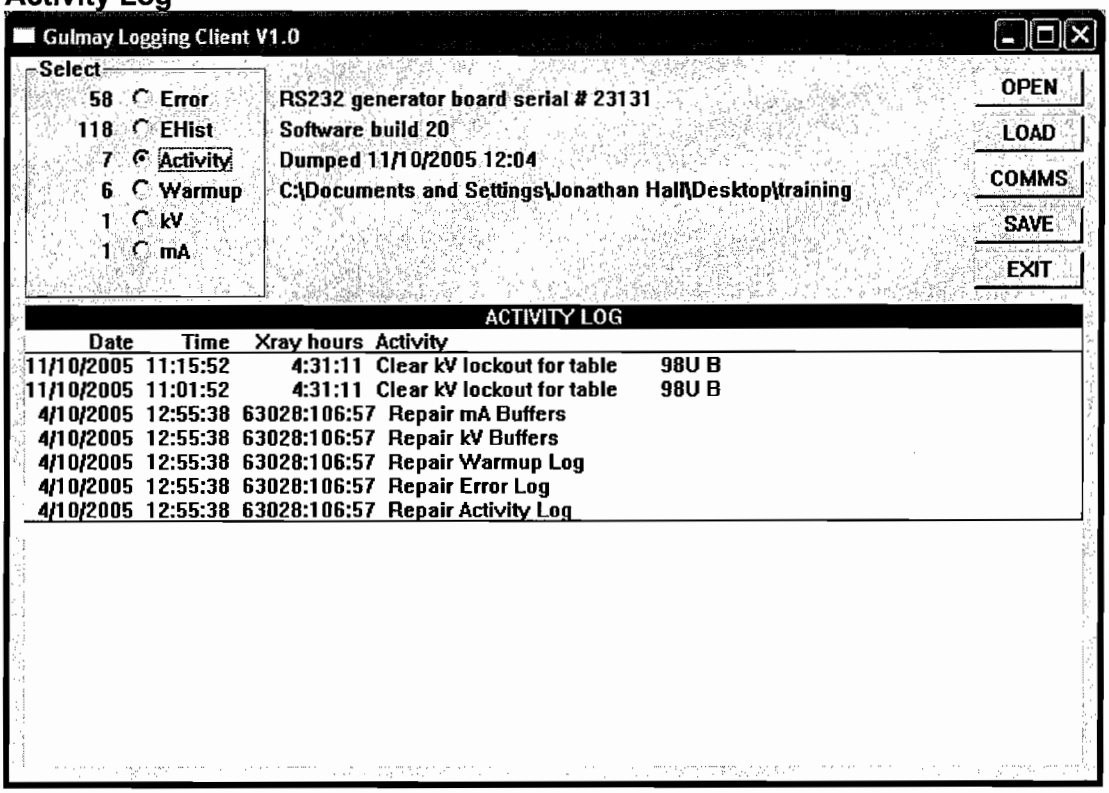
Error Logs



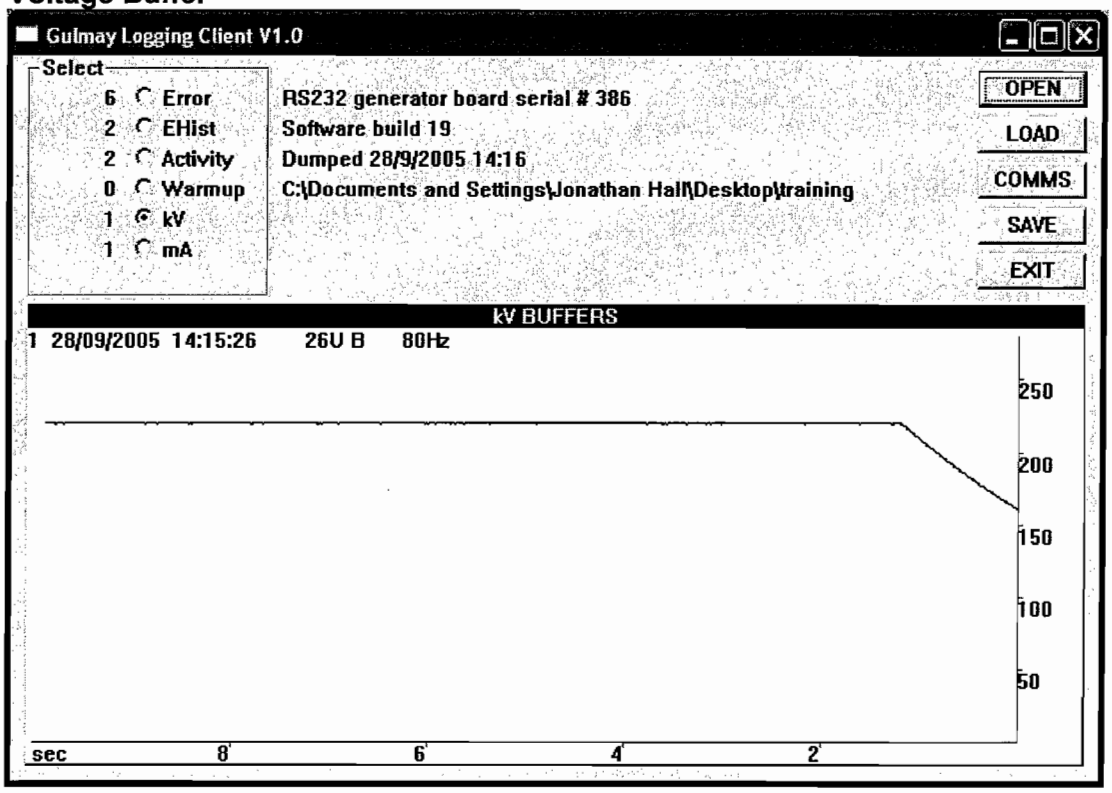
Error Histogram – displays error frequency



Activity Log

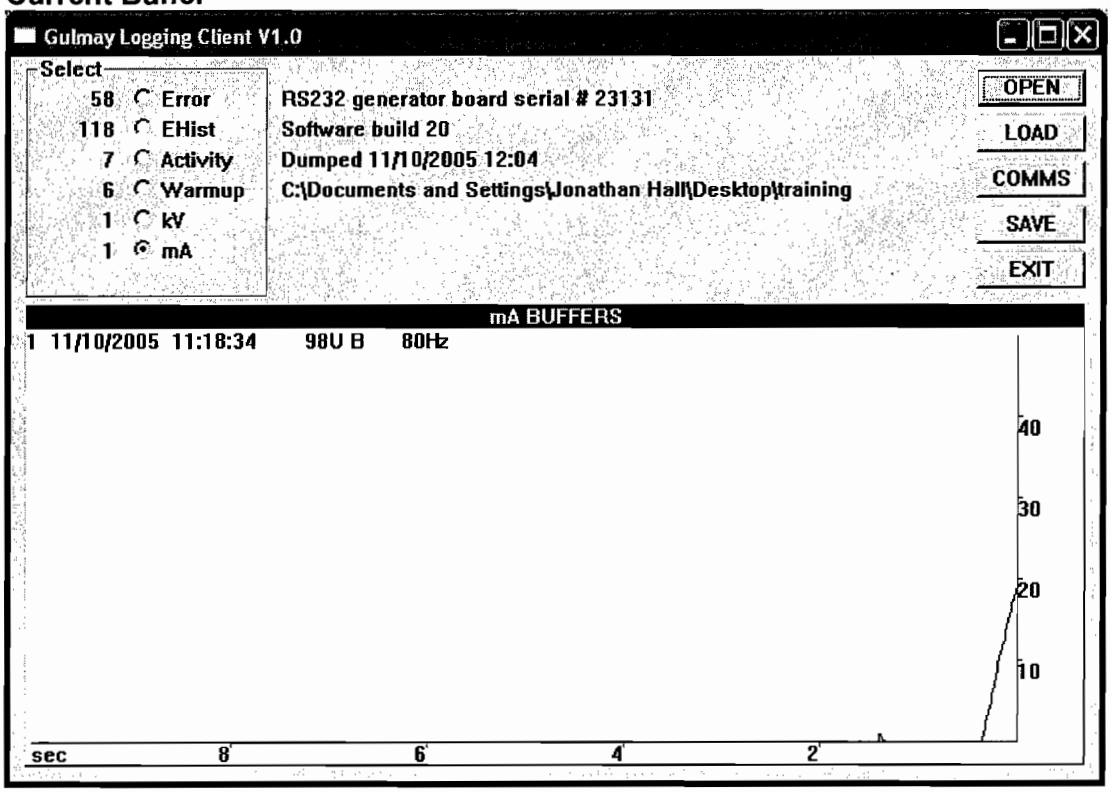


Voltage Buffer



If an error is generated, the Voltage buffer, Current buffer and the Mains voltage buffer are sampled, ie A 10 second snap shot of behavior prior to an error is taken.
The Voltage buffer shows the number of the buffer, the date/time sampled, the table number, Unipolar/Bipolar tube, Fine/Broad focus and sampling rate.
The buffer rotation is presented with oldest buffer at the top of the list. To view the waveform enter the buffer number and press <carriage return>.
The voltage buffer display is a sample of a kV waveform, terminating by an error and it is 800 data points at 80 Hz.
The display also indicates its scale.

Current Buffer



Mains Voltage Buffer

An optional detection module can be fitted which will monitor the auxillary supply, an output is fed to the A/D converter of the MP1 CPU card to provide a monitor of the mains voltage.

It can provide two modes of acquiring data:-

The first is after an error when the Voltage buffer, the Current buffer and the Mains voltage buffer are sampled , ie taking a 10 second snap-shot of the previous information.

The Mains voltage buffer shows the number of the buffer, the date/time sampled, the table number, Unipolar/Bipolar tube, Fine/Broad focus sampling rate, and RMS mains voltage. The mains buffer is a sample of a mains voltage waveform, terminating by an error and it is 256 data points at 320 Hz.(0.8secs)

The second mode is to trigger the collection of 256 data points at 4000 Hz as a sample of the mains voltage. To initialise the sample, set to Enginering Mode (program 888) and enter SET, program 957,ENTER. On the MP1 panel the kV window indicates the rms voltage measured. If required a new calibration can be inserted by entering a number and pressing ENTER.

The display indicates its rms voltage.

The buffer rotation is presented with oldest buffer at the top of the list. .

NEW LOGS

LOAD

If the load button is clicked then the data from the MP1 that the computer is connected to will be loaded and displayed. This will happen automatically if the programme is initiated after the MP1 is connected.

OPEN

If the open button is clicked then any log can be opened from a file select menu and viewed.

COMMS

The required Com port can be selected in the range of 1-10.

SAVE

The log that is currently loaded can be saved to a name. This file can be emailed to a service support engineer who can view the log with another copy of the Logging client.

EXIT

This exits the logging client.

INTERCONNECTION DIAGRAM DWG No. MP2-003 (Issue F Onwards)

This drawing details the connections in the MP1. At the top can be seen the three interface connections. The left hand connector, (for RS232 serial communication), is not required for normal operation.

The generator I/O Connector has to be connected via an external cable to the generator.

The Lab I/O Box Connector has to be connected via an external cable to the Lab I/O Box.

There are four principal circuit boards.

I/O PCB	This contains all protection and 24V interface circuitry for the LAB I/O, generator and RS232 link. All signals are then processed on the CPU PCB with the exception of the power and front panel switch connections.
CPU PCB	This PCB processes all signals from the IO PCB and also interfaces to the DISPLAY PCB.
DISPLAY PCB	This PCB mounts on the inside of the MP1 front panel and includes the LED displays and the keyboard.
PSU PCB	This PCB rectifies, smoothes and regulates the +24V DC, +5V DC and +12V DC supplies.

The AC supply enters via PL2-B and PL2-C. This supply is fed from a contactor in the Lab I/O Box which is energised via the key switch SW3A. This contact of the key switch is closed when the key is in positions 2 and 3.

SW3B is made when the key switch is in position 3 and it is used to energise the HT Contactor in the Lab I/O Box in conjunction with interlock circuitry on the I/O PCB.

SK3 on the I/O PCB is the interface to 220V rated relay contacts used for switching externally supplied warning lamps.

PL2 on the I/O PCB interfaces the 24V signals to the LAB I/O BOX.

The RS232 and generator connectors are mounted directly on the I/O PCB and protrude through the rear panel of the MP1 enclosure.

RV1, 2 and 3 are the manual controls on the front panel.

X-RAY ON and OFF switching is made with either SW1 and 2 on the front panel or using the remote switches in the LAB I/O BOX (or RS232). LP1 to 4 are the front panel warning lamps

Options -MAINS MONITOR PCB This PCB mounts above I/O PCB and provides a transformer isolated mains signal.

SUGGESTED MP1 INTERFACE CIRCUIT DIAGRAM
(LAB I/O BOX) **DWG No.MP3-042**

The circuit shown here utilises fully the interface options of the MP1 controller. THE CIRCUIT DOES NOT DEFINE A MEANS OF SATISFYING PREVAILING SAFETY REGULATIONS AS THIS IS THE RESPONSIBILITY OF THE INSTALLER OR SYSTEMS INTEGRATOR.

The power rating of the AC supply depends on the type of generator being controlled. That shown implies a 3kW system with allowances for additional power to a cooler, the controller and warning lamps.

Contactor K1 is energised when the KEYSWITCH on the panel is in position 2 and 3. The connection is made via pins D and E. When energised, power is switched to the panel via B and C and also to the cooler and as auxiliary power to the generator (220V AUX).

Contactor K2 is energised via a relay and key switch in the panel and this is the 220V MAIN supply to the generator. K2 is energised via pin F and a sense signal is returned as +24V DC via pin H. THIS SUPPLY FEEDS THE EHT PRODUCING PART OF THE GENERATOR. THIS SUPPLY CAN BE ADDITIONALLY INTERLOCKED BY FEEDING TO THE GENERATOR VIA A DOOR SWITCH.

A +24V DC feed from the panel is input at pin G. This can then be returned by safety and cooler interlocks via pins M,N,J and K. These connections must be made to enable the panel.

An external lamp supply is shown as L2 and N2. Separate contacts are provided by the interface to switch 220V lamps. The PRE WARN contacts are pins S and T. The HT ON (X-RAY ON) contacts are pins P and R. There is provision for a bulb fail circuit to interface to the panel on pins U and V. A link is fitted to the panel as standard but an option exists to remove this link and open circuit these pins with a relay contact in the event of bulb failure.

The connections for remote X-RAY ON/OFF switching are shown on pins W and X. THE PANEL CANNOT BE SWITCHED TO X-RAY ON IF THE REMOTE X-RAY OFF IS OPEN CIRCUIT.

N.B. THE USE OF THIS INTERFACE UNIT DOES NOT GUARANTEE ADHERENCE TO ANY PREVAILING REGULATIONS. OBSERVANCE OF SUCH REGULATIONS IS THE RESPONSIBILITY OF THE INSTALLER.

I/O PCB CIRCUIT DIAGRAM **DWG No.MP2-020 (Issue F On)**

This drawing is divided into three sheets. Note- +24V and EXT+24V are linked at LK5 and similarly 0V1 and EXT0V at LK4

SHEET 1

PL2 interfaces to the LAB I/O BOX. SK2 interfaces to the generator. SK1 interfaces to the CPU PCB.

Safety 1 and 2 are both returned as +24V DC by the safety circuits in the installation via the LAB I/O BOX.

Cooler 'TEMP' and 'FLOW' are both returned as +24V DC by the sense circuits in the cooler via the LAB I/O BOX.

HT Contactor sense is returned as +24V DC when the HT contactor is energised in the LAB I/O BOX.

All the above signals are clamped by 12V zeners and then they source current into the optodiodes of isolators. The isolator outputs source current from the +5V DC logic supply and are then diode clamped and filtered before being buffered by schmitt inverters which interface the signals directly to the CPU PCB.

The generator signals in SK2 are all open collector (normally on) signals which pull current from the 'OPTO +12V' supply through the optodiodes of isolators. The isolator outputs are processed in the same way as the interface to the LAB I/O BOX.

SHEET 2

The HT OFF (X-RAY OFF) signal at PL4-15 is normally +24V DC. If either HT OFF switch (front panel or remote) is depressed this signal will become open circuit and no current will flow into IC9:D-1. In this event the +5V signal will be cut off from the CPU PCB at SK1-27.

The AUDIBLE WARNING signal from the CPU at SK1-20 energises the buzzer BZ1 via IC1:1 and IC4:1.

The BLINK signal at SK1-15 energises the solid state relay SSR1 via IC1:2 and IC4:2 to switch an external supply to an X-RAY ON warning lamp and the front panel HT ON indicator is driven by TR2. This signal is normally switching on and off at 1Hz but may be continuous if the panel is so set. (See engineering codes)

The PRE WARN signal at SK1-16 energises the solid state relay SSR2 via IC1:3 and IC4:3 to switch an external supply to a PRE WARN lamp and the front panel PRE WARN indicator is driven by TR3. The signal is present prior to the X-RAY ON

period. This signal is normally switching on and off at 1Hz but may be continuous. The duration of PRE WARN depends on panel settings and whether SAFETY-2 has been interrupted. (See engineering modes)

For the Remote Bulb Fail option, alternative SSR`s are fitted (together with flying links to PL5 and PL6) ,and LK1 is removed.

The X-RAY ON (CONTROL) signal at SK1-21 sends a 12V DC signal to the generator at SK2-2 (TP19), and also energises the bulb in the X-RAY ON switch on the panel via IC13:1 and TR1 and PL4-2.

The INTERLOCK signal does three things. It energises the lamp in the SAFETY indicator via IC1:5, IC4:5 and PL4-5. From the same node it also energises RL3 via RL5 only if the SAFETY-1 line is returned as +24V DC. When RL3 is energised a +12V DC INTERLOCK signal is sent to the generator via SK2- 8.

The KEYSWITCH is connected between PL4-1 and 12. This is the contact made when the KEYSWITCH is in position 3. Turning the KEY to this position will energise RL4 only if the SAFETY-2 line is returned as +24V DC and the interlock relay RL3 is energised.
Energising RL4 will switch on the external HT ON relay in the LAB I/O Box. This will connect the MAIN power to the generator without which EHT cannot be produced. When RL4 is energised the X-RAY OFF switch on the panel is illuminated via PL4-13 and 14.

The X-RAY ON signal is initiated by switching PL2-10 or PL4-3 to +24V DC. The former is remote and the latter is on the panel. The signal is momentary and its interface circuit is shown on sheet 1 of the drawing.

The link between the remote and panel mounted, normally closed, X-RAY OFF switches is from PL2-9 to PL4-10.

When a focus selection is permitted by the X-RAY tube selection and panel conditions, the signal is input at SK1-17. A low signal to select the FINE focus is buffered by IC13:2, IC4:6 and isolated and inverted by IC5:2. A +12V DC signal is sent to the generator via SK2-11.

SHEET 3

The RS232 interface connector PL1 is protected by series of zeners and opto-isolated driver/receivers.
The MP1 bypasses optional COM1 and COM2 connectors by LK2 and LK3.

The three analogue outputs from the panel are kV-DEMAND, mA-DEMAND and FIL-LIMIT. The first two are sourced from the CPU PCB and connected to the generator via SK2-22 and SK2-10. The latter is set by RV1 (MAX=+12V DC) and connected to the generator via SK2-9 (TP20).

The three analogue inputs from the generator are mA-MONITOR, kV- MONITOR and the 12V REFERENCE. These are connected to the CPU PCB.

The power from the PSU PCB is input to PL3. The test points, protection zeners and decoupling capacitors are shown.

All power for the CPU PCB is routed from the PSU PCB via the I/O PCB. The outputs to the CPU PCB are shown in SK1.

CPU PCB CIRCUIT DIAGRAM **DWG No.MP2-223**

SHEET 1

The CPU PCB has two main connectors, PL4 connects to the DISPLAY PCB and PL1 which connects to the I/O PCB. The I/O PCB PL4 cable is connects to the CPU PCB connector PL7, and the CPU PCB connector PL6 links to the front panel indicators and switches. There are connectors for future expansion, PL5 and SK5.Connector PL8 allows connection to the mains sensing input.

At the top of Sheet 1 part of PL4 is shown with the power supply from the CPU PCB to the DISPLAY PCB and the interface to the keyboard. The keys are normally open circuit and their outputs are pulled up by resistor arrays RP4 and RP7. The keys are read by the microprocessor (Sheet 2 IC4) via two PALs IC14 and IC15 as are the other input signals listed below.

X RAY ON SWITCH	INPUT
X RAY ON STATUS	INPUT
X RAY OFF SWITCH	INPUT
COOLER TEMP	INPUT
SAFETY 1	INPUT
SAFETY 2	INPUT
OVER kV	INPUT
OVER mA	INPUT
CONVERTER O/CURRENT	INPUT
CONVERTER O/VOLTAGE	INPUT
320/160 STATUS	INPUT
FINE/BROAD STATUS	INPUT
HT ON SENSE	INPUT
COOLER FLOW	INPUT

Similarly the PL1 output signals and PL4 DATA ENABLEs 1-4 are routed via PAL IC13 to the microprocessor IC4

AUDIBLE WARNING	OUTPUT
BROAD/FINE SELECT	OUTPUT
PRE WARN	OUTPUT
BLINK	OUTPUT

The remaining two output signals go directly to the microprocessor IC4 port A.

X RAY ON (CONTROL)	OUTPUT
INTERLOCK	OUTPUT

SK5 is for future expansion.

On the lower part of sheet 1 there are group of buffers, scaling and filtering the following signals:-

kV POT WIPER, mA POT WIPER and TIME POT WIPER – 0 -10V signals scaled down (10/21) before being fed to the A/D converter (sheet 2 – IC17).

mA FEEDBACK,kV FEEDBACK - 0 - 10V signals scaled down (1/2) before being fed to the A/D converter (sheet 2 – IC17).

+12V INPUT – input signal indicating `generator present`. An opamp (IC22/1) acts as a comparator, triggering at 11.2V indicating a switch to the microprocessor (sheet 2) IC4 port A bit 0.
MAINS MONITOR – mains input signal (about 7V rms).from MAINS MONITOR PCB via PL8 and scaling down the input to the A/D coverter to about 2V p/p centring around 2.5V.

MA DEMAND,kV DEMAND - buffer opamps (IC21/3 and IC21/4) from the dual D/A converter, rescaling the output to 0 - 10V range to the I./O PCB at testpoints TP13 and TP14.

+10V – a buffer output +10V, rescaled from the reference +5v, supplied to the front panel selection potentiometers

SHEET 2

PL6 is a connection to the indicators and switches on the front panel.PL7 links to PL4 on the I/O PCB. The optocoupler IC24 and associated resistors allows the HT keyswitch to be sensed and read to the microprocessor IC4 via the PAL IC7 at KEY3BAR signals
The microprocessor IC4 is configured in the expanded multiplexed form and has the associated address latch IC8, EPROM IC11 and SRAM/RTC IC10.

IC4 Port C of the processor is the 8 bit data bus multiplexed with the low order address bits. The address bits are latched IC8 which is controlled by the address strobe signal AS originating from IC4-13.

The high order address bits (bits 8 to 13) originate from IC4 port B.Address bits 14 and 15 are routed to a PAL IC12 and the data bus to provide an extension of the address space (AP-14,AP-15,and AP-16)by a memory paging system.

The EPROM IC11 incoporates both the software programme and the Xray tube tables.

The SRAM IC10 contains progam workspace and logging information and is battery backed. This also incorporates a REAL TIME CLOCK (RTC) for logging and Warm-up details.

The EEPROM IC5, a serial SPI bus device, provides a secure store for the system parameters and a reset supervisor IC1 monitors the +5V supply, protecting the system.

IC4 Port A comprise some of the control and option pins, while Port D supports its two serial busses. The serial communication interface (TX, RX) carries the RS232 connections, and the serial peripheral interface (SPI) links data to and from the A/D, D/A and EEPROM.

The D/A convertor IC19 (and its +5V reference diode IC18) is a dual 12 bit device providing the voltage outputs for the kV and mA DEMANDs. The A/D convertor IC17 (and its +5V reference device IC16) is an 8 channel 12 bit device that samples the mA, kV and Time Pots,
mA and kV Feedbacks, mA and kV Demands and mains monitor signals (Sheet 1).

On the lower part on this sheet are the 7 PALs (programmable array logic devices). They are coded to control, latch and route signals from the microprocessor and the external connections

IC4 Port A comprises some of the control and option pins, while Port D supports its two serial busses. The serial communication interface (TX, RX) carries the RS232 connections, and the serial peripheral interface (SPI) links data to and from the A/D, D/A and EEPROM.

The RS232 signals Tx,Rx IC4 Port D are buffered by IC2 and output on PL1/1 and PL1/3.
The second part of the buffer is connected on PL5 as an optional RS232 link and is driven/received by an SPI device IC3.

IC19 is a dual 12 bit D/A converter. The 2 outputs are buffered by IC20:2 and IC20:1. The 2 analogue outputs are kV DEMAND and mA DEMAND. These are output to the I/O PCB at SK1-45 and SK1-44 and also to the ADC at IC17-11 and IC17-15. This allows the processor to calibrate the D/A converters.

IC18, (MC1403), is a +2.5V voltage reference for the DAC and IC23, (REF02), provides a +5V reference for the ADC.

A +10V reference is generated for the potentiometers on the DISPLAY PCB. The outputs of the potentiometers are input at PL4 pins 1,2 and 3. They are buffered by IC20:2,3 and 4 and input to the ADC.

Analogue signals from the generator mA FEEDBACK, kV FEEDBACK and +12V INPUT are connected at PL1 pins 48, 47 and 46. These are buffered and then input to the ADC.

The mains monitoring option is connected 7VAC from a mains transformer on pins PL8-4 and PL8-3. The signal is then scaled and offset by IC22-3 and fed, (via TP17), to the ADC.

DISPLAY PCB (2) CIRCUIT DIAGRAM **DWG No MP2-054**

On recent units the Display PCB has been changed and divided into a Display PCB and a Keyboard PCB. The Display PCB has the same circuit as previously but now has discrete instead of integrated decoder driver ICs.

KEY BOARD PCB CIRCUIT DIAGRAM **DWG No MP3-048**

On recent units the Display PCB has been divided into this PCB and a separate Display PCB. The circuit function is as before.

P.S.U. PCB CIRCUIT DIAGRAM **DWG No MP3-026**

The P.S.U. PCB includes 3 regulator ICs which control the +5V DC, +12V DC and +24V DC.

This PCB contains the fusing, rectification and smoothing for each supply.

An optional power output connector is fitted providing +5V and +24V.

MAINS MONITOR PCB CIRCUIT DIAGRAM **DWG No MP3-242**

The Mains Monitor PCB provides a 230V mains to 7V transformer to scale the auxillary mains i/p to be sampled on the CPU PCB for logging purposes.

RECOMMENDED SPARE PARTS

DESCRIPTION	PART_No.
FUSE	F002 (20mm 1A A/S)
BULB	H174
KEYSWITCH	H175
ON/OFF SWITCH	H168
RED LENS	H171
GREEN LENS	H170
P.S.U. PCB	AS1052
I/O PCB	AS1051
CPU PCB (New Type)	AS1064
DISPLAY PCB (2)	AS1055
KEY BOARD PCB	AS1053
MAINS MONITOR PCB	AS1065

APPENDIX A: APPLICATIONS DATA (OLD COMPATABILITY NUMBERS)

TABLE No.	GENERATOR	X-RAY TUBE TYPE	POWER/FOCUS
1	FL160	MXR-160/0,4-1,5	640W
2	CP160	MXR-160/0,4-3,0	640W/3000..
2 BIPOLAR	CP320	MXR-320/1,2-3,0	1000W/3200W
3	CP160	MXR-160/0,4-1,5	640W/1600W
3 BIPOLAR	CP320	MXR-320/1,2-3,0	1000W/3200W
4	CP160	MXR-161	3000W
4 BIPOLAR	CP320	MXR-320/1,2-3,0	1000W/3200W
5	CP225	MXR-210/0,4-1,5	640W/1600W
5 BIPOLAR	CP450	MXR-320/1,2-3,0	1000W/3200W
6	CP225	MXR-210/0,4-3,0	640W/3000W
6 BIPOLAR	CP450	MXR-320/1,2-3,0	1000W/3200W
7	FL100	CIR-100/0,6	600W
8	FL100	CIR-100/0,6	600W
9	DMF160	MXR-160/0,2	320W
10	FL160-2	MXR-160/0,4-0,4	640W/640W
11	FL100	MCT 120-4A	480W
12	CP160	MXR-160/0,4-0,4	640W/640W
12 BIPOLAR	CP320	MXR-320/0,8-1,8	640W/1600W
13	CP160	MXR-160/0,4-0,4	640W/640W
13 BIPOLAR	CP320	MXR-320/1,2-3,0	1000W/3200W
14	CP160	MXR-160/0,4-3,0	640W/3000W
14 BIPOLAR	CP320	MXR-320/0,8-1,8	640W/1600W
15	CP160	MXR-160/0,4-1,5	640W/1600W
15 BIPOLAR	CP320	MXR-320/0,8-1,8	640W/1600W
16	CP160	MXR-160/0,2	320W
16 BIPOLAR	CP320	MXR-320/0,8-1,8	640W/1600W
17	FL160	MXR-160/0,2	320W
18	CP160	MXR-160/0,2	320W
18 BIPOLAR	CP320	MXR-320/1,2-3,0	1000W/3200W
19	CP225	MXR-210/0,4-3,0	640W/3000W
19 BIPOLAR	CP450	MXR-320/0,8-1,8	640W/1600W
20	CP225	MXR-210/0,4-1,5	640W/1600W
20 BIPOLAR	CP450	MXR-320/0,8-1,8	640W/1600W
21	CP102	MXR-160/0,4-3,0	640W/3000W
22	CP101	MXR-160/0,4-1,5	640W/1600W
23	CP101	MB101/1	3000W

APPENDIX A: APPLICATIONS DATA (OLD COMPATABILITY NUMBERS)

TABLE No.	GENERATOR	X-RAY TUBE TYPE	POWER/FOCUS
24	DMF160	MBF161/1	320W
25	DMF100	MBF161/1	320W
26	CP225	MXR-225/0,4-3,0	640W/3000W
26 BIPOLAR	CP450	MXR-320/1,2-3,0	1000W/3200W
27	CP225	MXR-225/0,4-1,5	640W/1600W
27 BIPOLAR	CP450	MXR-320/0,8-1,8	640W/1600W
28	CP160	MXRP160C	1000W
29	FL160-1	CXR150/0,6	600W
30	FL160-1	CXR150/0,6	600W
31	FL160-2	CXR 100/0,6	600W
32	CP225	MXR-160/0,2	320W
33	CP225	MXR-225/0,4-3,0	640W/3000W
33 BIPOLAR	CP450	MXR-420/1,5-4,0	1500W/4200W
34	CP225	MXR-225/0,4-1,5	640W/1500W
34 BIPOLAR	CP450	MXR-420/1,5-4,0	1500W/4200W
35	CP225	MCN225	675W/2250W
35 BIPOLAR	CP450	MCN451	900W/4200W
36	CP225	MCN225	675W/2250W
36 BIPOLAR	CP450	MCN421	1260W/4200W
37	CP160	MCF160	1600W
37 BIPOLAR	CP320	MCN322	640W/1600W
38	CP160	MCN166	640W/1600W
38 BIPOLAR	CP320	MCN322	640W/1600W
39	CP160	MCN165	640W/3000W
39 BIPOLAR	CP320	MCN321	960W/3200W
40	CP160	MCN167	160W/3000W
40 BIPOLAR	CP320	MCN322	640W/1600W
41	FL160-2	MCN168	480W/480W
42	FL225	MCN225	640W
43	CP160	MCN101	640W/1500W
44	DMF160	MCN167	160W
45	CP225	MXR-225/0,4-3,0	640W/3000W
45 BIPOLAR	CP450	MXR-350/1,5-4,0	1500W/4200W
46	CP225	MXR-225/0,4-3,0	640W/3000W
46 BIPOLAR	CP450	MXR-350/1,2-3,0	1000W/3000W
47	CP225	MXR-225/0,4-1,5	640W/1600W
47 BIPOLAR	CP450	MXR-350/0,8-1,8	640W/1600W
48	CP225	MXR-225/0,2	320W
48 BIPOLAR	CP450	MXR-420/1,5-4,0	1500W/4200W
49	FL225	MXR-225/0,2	320W
50	DF160	MXR-160/0.2	320W
51	CP160	MXR-160/0,4-3,0	640W/3000W
51 BIPOLAR	CP320	MXR-320/1,5-4,0	1500W/4200W

APPENDIX A: APPLICATIONS DATA (OLD COMPATABILITY NUMBERS)

TABLE No.	GENERATOR	X-RAY TUBE TYPE	POWER/FOCUS
52	CP100	MXR-100/3,0	3000W
53	CP100	MCT-120/3x3	900W
54	FL100-2	MXR-160/0,4-0,4	640W/640W
55	FL225-2	MXR 225/0.4-1.5	640W/640W
56	NOT USED		
57	FC160HP-1	MXR160HP/20	1000W
58	FC160HP-2	MXR160HP/20	1000W/1000W
59	FC160HP-2	MXR160/21	1000W/640W
60	CP225	MXR225/0.4-3.0	3000W/640W
60 BIPOLAR	CP450	MXR451	4500W/900W
61	FC100-1	MCT100F-1.5x0.5	300W
62	CP225	MXR225/22	640W/3000W
62 BIPOLAR	CP450	MB450/1	
63 63 BIPOLAR	CP225 CP450	MXR225/22 MB450/3	640W/3000W

APPENDIX B: IMPLEMENTATION OF OLD TABLE NUMBERS

Unipolar

Codes above 63 invalid.

Code	Generator		Xray Tube	
0	0	Invalid	0	Invalid
1	4	FCF160	2	MXR-160/21
2	22	CP 160	3	MXR-160/22
3	22	CP 160	2	MXR-160/21
4	22	CP 160	4	MXR-161
5	24	CP 225	5	MXR-210/0,4-1,5
6	24	CP 225	6	MXR-210/0,4-3,0
7	2	FC 100	7	CIR-100/0,6 (75kV)
8	2	FC 100	16	CIR-100/0,6
9	28	DµF 160	8	MXR-160/01
10	6	FC2160	9	MB161/6
11	2	FC 100	33	MCT120-4A
12	22	CP 160	17	MXR-160/20
13	22	CP 160	17	MXR-160/20
14	22	CP 160	3	MXR-160/22
15	22	CP 160	2	MXR-160/21
16	22	CP 160	8	MXR-160/01
17	5	FC 160	8	MXR-160/01
18	22	CP 160	8	MXR-160/01
19	24	CP 225	6	MXR-210/0,4-3,0
20	24	CP 225	5	MXR-210/0,4-1,5
21	16	CP 102	3	MXR-160/22
22	13	CP 101	2	MXR-160/21
23	13	CP 101	41	MB 101/1
24	28	DµF 160	42	MBF 161/1
25	28	DµF 160	46	MBF 161/1 (100kV limit)
26	24	CP 225	29	MXR-225/22
27	24	CP 225	45	MB225/5
28	22	CP 160	21	MXRP-160C
29	4	FCF160	12	CXR-150
30	4	FCF160	47	CXR-150 (130kV)
31	5	FC1160	16	CIR-100/0,6
32	24	CP 225	8	MXR-160/01

33	24	CP 225	29	MXR-225/22
34	24	CP 225	28	MXR-225/21
35	24	CP 225	40	MCN225
36	24	CP 225	40	MCN225
37	22	CP 160	35	MCF160
38	22	CP 160	37	MCN166
39	22	CP 160	36	MCN165
40	22	CP 160	38	MCN167
41	6	FC2160	39	MCN168
42	9	FC 225	40	MCN225
43	22	CP 160	34	MCN101
44	27	DµF 160	38	MCN167
45	24	CP 225	29	MXR-225/22
46	24	CP 225	29	MXR-225/22
47	24	CP 225	28	MXR-225/21
48	24	CP 225	27	MXR-225/01
49	8	FC1225	27	MXR-225/01
50	28	DµF 160	8	MXR-160/01
51	22	CP 160	3	MXR-160/22
52	11	CP 100/1	15	MXR-102
53	12	CP 100	32	MCT-120/3x3
54	3	FC2160	17	MXR-160/20
55	9	FC2225	28	MXR-225/21
56	0	Invalid	0	Invalid
57	30	FCH 160-1	20	MXR-160HP/20
58	31	FCH 160	20	MXR-160HP/20
59	31	FCH 160	2	MXR-160/21
60	32	CP 225 (20mA)	29	MXR-225/22
61	2	FC 100	31	MCT100F
62	32	CP 225 20mA limit	29	MXR-225/22
63	32	CP 225 20mA limit	29	MXR-225/22

Bipolar
All unspecified codes invalid.

Code	Generator		Xray Tube	
0	0	Invalid	0	Invalid
2	1	CP 320	2	MXR-320/1,2-3,0
3	1	CP 320	2	MXR-320/1,2-3,0
4	1	CP 320	2	MXR-320/1,2-3,0
5	3	CP 450	2	MXR-320/1,2-3,0
6	3	CP 450	2	MXR-320/1,2-3,0
12	1	CP 320	3	MXR-320/23
13	1	CP 320	2	MXR-320/1,2-3,0
14	1	CP 320	3	MXR-320/23
15	1	CP 320	3	MXR-320/23
16	1	CP 320	3	MXR-320/23
18	1	CP 320	2	MXR-320/1,2-3,0
19	3	CP 450	3	MXR-320/23
20	3	CP 450	3	MXR-320/23
26	3	CP 450	2	MXR-320/1,2-3,0
27	3	CP 450	3	MXR-320/23
33	3	CP 450	10	MXR-420/25
34	3	CP 450	10	MXR-420/25
35	3	CP 450	15	MCN451
36	3	CP 450	17	MCN421
37	1	CP 320	13	MCN322
38	1	CP 320	13	MCN322
39	1	CP 320	14	MCN321
40	1	CP 320	13	MCN322
45	3	CP 450	20	MXR-350/25
46	3	CP 450	19	MXR-350/24
47	3	CP 450	8	MXR-350/23
48	3	CP 450	10	MXR-420/25
51	1	CP 320	18	MXR-320/1,5-4,0
60	3	CP 450	11	MXR-451
62	3	CP 450	16	MB450-1
63	3	CP 450	21	MB450-3

APPENDIX C: SETTING GENERATOR BY TYPE

Generator codes

Unipolar

The MP1 ID is displayed with program 956 for generator tubes.

	MP1 ID	Generators	Maximum kV	Maximum mA	Maximum Power (W)	Foci
0		Not used				
1	FCF100	FC100-1/1	100	12	600	F
2	FC1100	FC100-1/2,FL100-1/6,FC100-1/9	100	12	600	B
3	FC2100	FC100-2/1	100	12	600	B/F
4	FCF160	FC160-1/1,FL160-1/2,FL160-1/5,FC160-1/6	160	10	640	F
5	FC1160	FC160-1/3	160	10	640	B
6	FC2160	FL160-2/1,FL160-2/2,FC160-2/4	160	10	640	B/F
7	FCF225		225	7	640	F
8	FC1225	FC225-1/2,FC225-1/4	225	7	640	B
9	FC2225	FL225-2/2,FC225-2/3	225	7	640	B/F
10	CPF100	CP100-1/4	100	30	3200	F
11	CP1100	CP100-1/3	100	30	3200	B
12	CP 100	CP100/2	100	30	3200	B/F
13	CP 101	CP101/1,CP101/2	100	45	3200	B/F
14	CPF102		100	75	3200	F
15	CP1102	CP102-1/1,CP102-1/3	100	75	3200	B
16	CP 102	CP102/1,CP102/2,CP102/3	100	75	3200	B/F
17	CP1103	CP103/1	100	75	3000	B
18	CP1104		100	75	3200	B
19	CP1105		100	75	3200	B
20	CP1106		100	75	3200	B
21	CP1160	CP160-1/9	160	30	3200	B
22	CP 160	CP160/1,CP160/2,CP160/3,CP160/4,CP160/5,CP160/5,CP160/6,CP160/7, CP160/13,CP160/14,CP160/15,CP160/16	160	30	3200	B/F
23	CP1225		225	30	3000	B
24	CP 225	CP225/1,CP225/2,CP225/3,CP225/4,CP225/5,CP225/6,CP225/9, CP225/10,CP225/11,CP225/12,CP225/17,CP225/18	225	30	3000	B/F

25	CP 250		250	30	3200	B
26	CF1225	CF225-1/1,CF225-1/2	225	16	1600	B
27	DμF16F		160	4	320	F
28	DμF160	DμF160/1,DμF160/8,DμF160/10,DμF160/10	160	4	320	B
29	FCH16F	FCHP160-1/1,FCH160-1/6	160	16	1000	F
30	FCH161	FCHP160-1/3	160	16	1000	B
31	FCH160	FCHP160-2/4	160	16	1000	B/F
32	CPr225	CP225/9	225	20	3000	B/F

Bipolar

#	MP1 ID	Generators	Maximum kV	Maximum mA	Maximum Power (W)	Foci
0		Not used				
1	CP 320		320	30	4200	B/F
2	CP 350		350	30	3000	B/F
3	CP 450		450	20	4500	B/F
4	CP 500		500	30	3200	B/F
5	FCS320		320	8	1000	B/F

APPENDIX D: SETTING TUBE BY TYPE

Xray tube codes
Unipolar
The MP1 ID is displayed with program 957 for X Ray tubes.

#	MP1 ID	Xray tube	Maximum kV	Maximum mA	Maximum Power(W)	Foci
0		Bad value				
1	bL PLg	Blanking plug	∞	0	0	B/F
2	160 21	MXR-160/21 (was MXR-160/0,4-1,5)	160	50/16	1600/640	B/F
3	160 22	MXR-160/22 (was MXR-160/0,4-3,0)	160	65/15	3000/640	B/F
4	161	MXR-161	160	30	3000	B
5	210 21	MXR-210/0,4-1,5 (/21)	210	30/15	1600/640	B/F
6	210 22	MXR-210/0,4-3,0 (/22)	210	30/15	3000/640	B/F
7	100 C	CIR-100/0,6 (limited to 75kV)	75	12	600	B
8	160 01	MXR-160/01 (was MXR-160/0,2)	160	3	320	B
9	161 6	MB 161/6	160	10/10	640/640	B/F
10	102 C	CXR-102 (was CXR-100/0,6/20)	100	12	600	B
11	105 C	CXR-105 (was CXR-100/1,5/20)	100	24	1000	B
12	150 C	CXR-150 (was CXR-150/0,6/15)	150	12	600	F
13	100 12	MXR-100/12 (was MXR-100)	100	40	1000	B
14	101	MXR-101	100	40	1000	B
15	102	MXR-102	100	120	3000	B
16	100 C	CIR-100/0,6	100	12	600	B
17	160 20	MXR-160/20 (was MXR-160/0,4-0,4)	160	150/150	640/640	B/F
18	160 Fb	MXR-160/FB	160	19	640	B
19	160HPF	MXR-160/HP FB	160	24	1000	B
20	160H20	MXR-160HP/20	160	35/35	1000/1000	B/F
21	P 160C	MXRP-160C	160	12	1000	B
22	160 G	MXR-160G	140	35	1200	B

23	165	MXR-165	160	100	6000	B
24	180	MXR-180	180	20	2700	B
25	202	MXR-202	220	20/20	3200/2000	B/F
26	222	MXR-222	200	30	3200	B
27	225 01	MXR-225/01 (was MXR-225/0,2)	225	3	320	B
28	225 21	MXR-225/21 (was MXR-225/0,4-1,5)	225	50/15	1600/640	B/F
29	225 22	MXR-225/22 (was MXR-225/0,4-3,0)	225	30/15	3000/640	B/F
30	226	MXR-226	225	75	3000	B
31	100F15	MCT-100F/1.5x0	100	6	300	B
32	120	MCT-120/3x3	100	9	900	B
33	120 4A	MCT-120-4A	120	8	480	B
34	101	MCN-101	100	45/15	1500/640	B/F
35	160	MCF-160	160	40	1600	B
36	165	MCN-165	160	75/15	3000/640	B/F
37	166	MCN-166	160	50/15	1600/640	B/F
38	167	MCN-167	160	75/4	3000/160	B/F
39	168	MCN-168	160	8/8	480/480	B/F
40	225	MCN-225	225	30/15	2250/675	B/F
41	101 1	MBF-101/1	100	45	3000	B
42	161 1	MBF-161/1	160	4	320	B
43	225 4	MB-225/4	225	30/19	3000/640	B/F
44		UNUSED				
45	225 5	MB-225/5	225	55/15	1600/640	B/F
46	161 1	MBF-161/1 (with 100kV limit)	100	4	320	B
47	150 C	CXR-150 (with 130kV limit)	130	12	600	B
48	160 21	MXR-160/21 (with 100kV limit)	100	50/16	1600/640	B/F
49	160 20	MXR-160/20 (with 100kV limit)	100	15/15	640/640	B/F

Bipolar

#	MP1 ID	Xray tube	Maximum kV	Maximum mA	Maximum Power (W)	Foci
0		Bad value				
1	bL PLg	Blanking Plug	∞	0	0	B/F
2	320 24	MXR-320/1,2-3,0 (/24)	320	30/12.5	3200/1000	B/F
3	320 23	MXR-320/23 (was MXR-320/0,8-1,8)	320	20/9	1600/640	B/F
4	320 26	MXR-320/26	320	30/15	4200/1500	B/F
5	320H21	MXR-320HP/21	320	54/15	2000/900	B/F
6	321	MXR-321 (was MXR-324)	320	30	3200	B
7	322	MXR-322	320	30	3200	B
8	350 23	MXR-350/23 (was MXR-350/0,8-1,8)	350	20/9	1600/640	B/F
9	350 26	MXR-350/26	350	30/15	4200/1500	B/F
10	420 25	MXR-420/25	420	30/10	4200/1500	B/F
11	451	MXR-451	450	20/9	4500/900	B/F
12	452	MXR-452	450	20/9	4500/900	B/F
13	322	MCN-322	320	20/10	1600/640	B/F
14	321	MCN-321	320	40/12	3200/960	B/F
15	451	MCN-451	450	40/10	4200/90	B/F
16	450 1	MB-450/1	450	40/10	4500/1500	B/F
17	421	MCN-421	420	40/12	4200/1260	B/F
18	320 25	MXR-320/25	320	30/15	4200/1500	B/F
19	350 24	MXR-350/24	350	20/12.5	3200/1000	B/F
20	350 25	MXR-350/25	350	20/15	4200/1500	B/F
21	450 3	MB-450/3	450	12/6	2250/900	B/F
22	420 3	MB-420/3	420	12/6	2250/900	B/F
23	350 3	MB-350/3	350	12/6	2250/900	B/F
24	450 1	MB-450/1	450	30/8	4000/1500	B/F
25	420 1	MB-420/1	420	30/8	4000/1500	B/F
26	350 1	MB-350/1	350	30/8	4000/1500	B/F

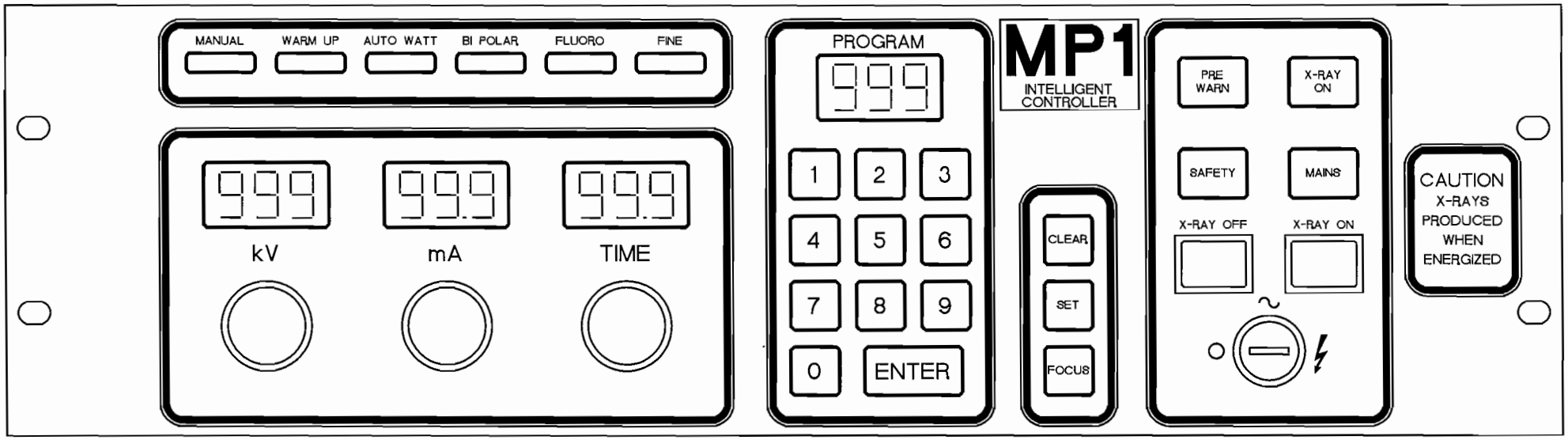
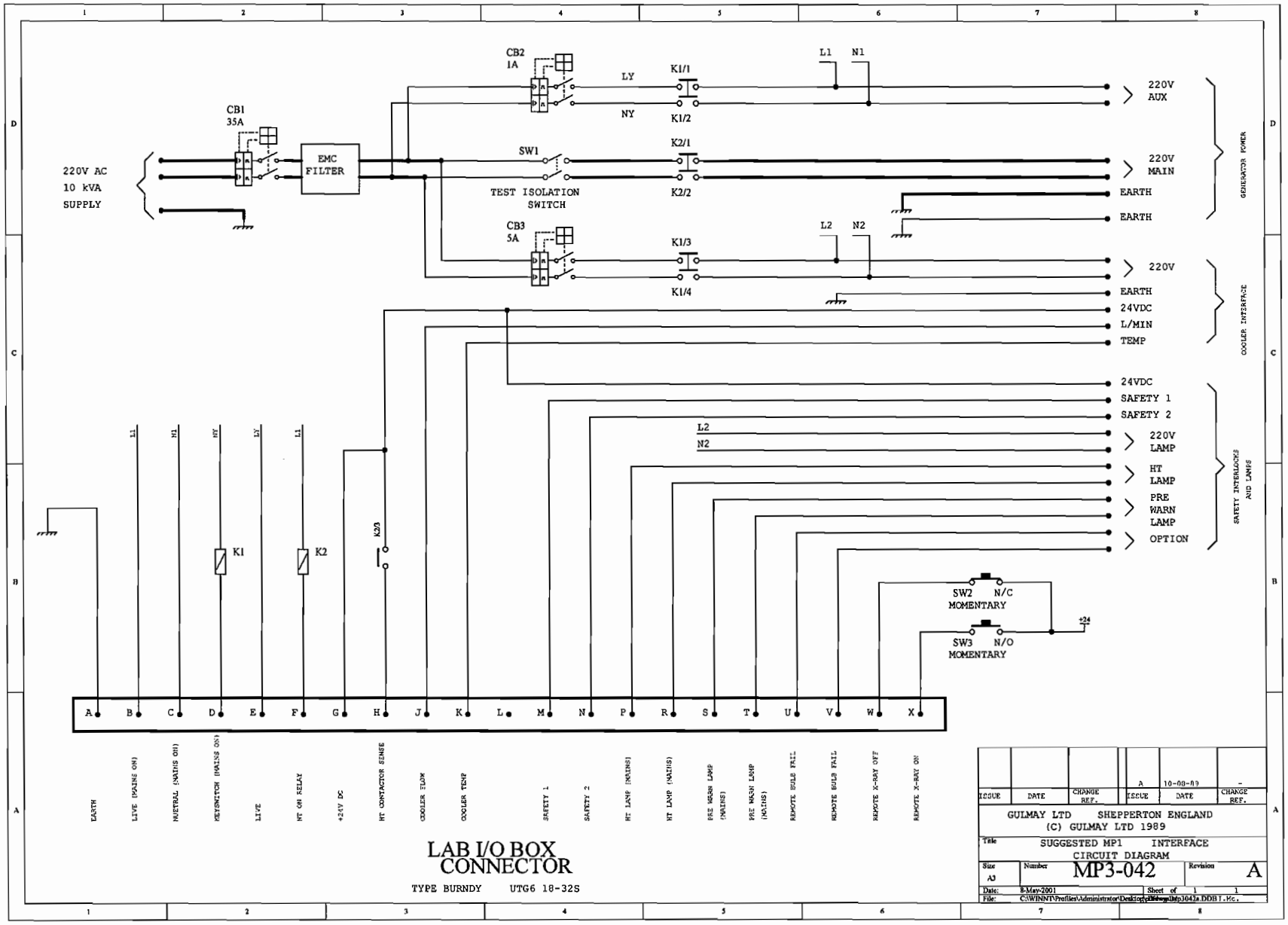


FIG. 1.0

MP1 CONTROL PANEL
FOR RADIOGRAPHIC APPLICATIONS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EMC
FILTER
SW1
TEST ISOLATION
SWITCH
K2/1
K2/2
220V
MAIN
EARTH
EARTH
GENERATOR POWER
CB3
5A
K1/3
K1/4
L2
N2
220V
EARTH
24VDC
L/MIN
TEMP
COOLER INTERFACE
24VDC
SAFETY 1
SAFETY 2
L2
N2
220V
LAMP
HT
LAMP
PRE
WARN
LAMP
OPTION
SAFETY INTERLOCKS
AND LAMPS
K1
K2
K2/3
SW2 N/C
MOMENTARY
SW3 N/O
MOMENTARY
+24
A
B
C
D
E
F
G
H
J
K
L
M
N
P
R
S
T
U
V
W
X
EARTH
LIVE (MAINS ON)
NUETRAL (MAINS ON)
KEYSWITCH (MAINS ON)
LIVE
HT ON RELAY
+24V DC
HT CONTACTOR SENSE
COOLER FLOW
COOLER TEMP
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SAFETY 2
HT LAMP (MAINS)
HT LAMP (MAINS)
PRE WARN LAMP (MAINS)
PRE WARN LAMP (MAINS)
REMOTE BULB FAIL
REMOTE BULB FAIL
REMOTE X-RAY OFF
REMOTE X-RAY ON
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ISSUE
DATE
CHANGE REF.
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10-08-01
GULMAY LTD SHEPPERTON ENGLAND
(C) GULMAY LTD 1989
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CIRCUIT DIAGRAM
Size
A3
Number
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Revision
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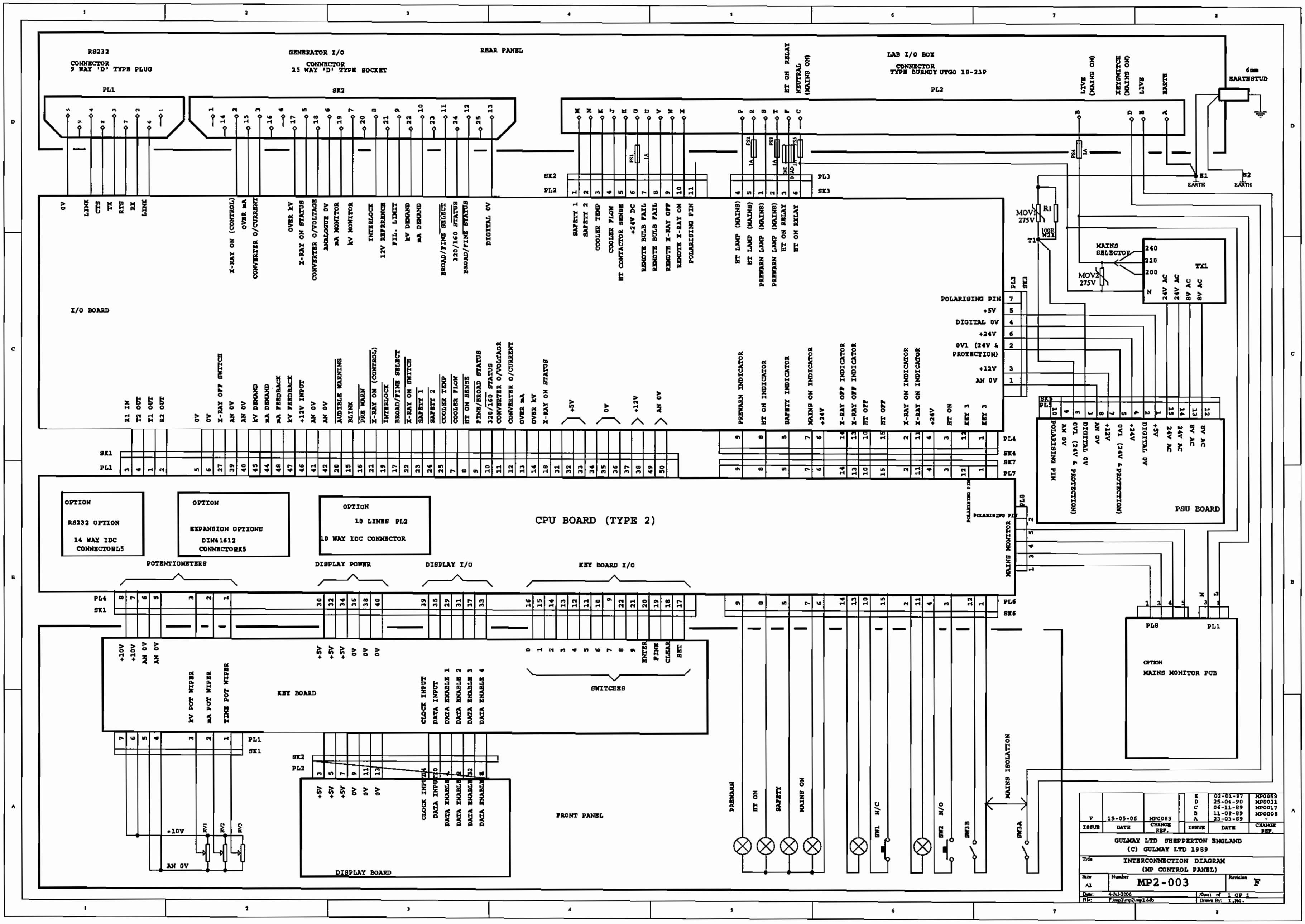
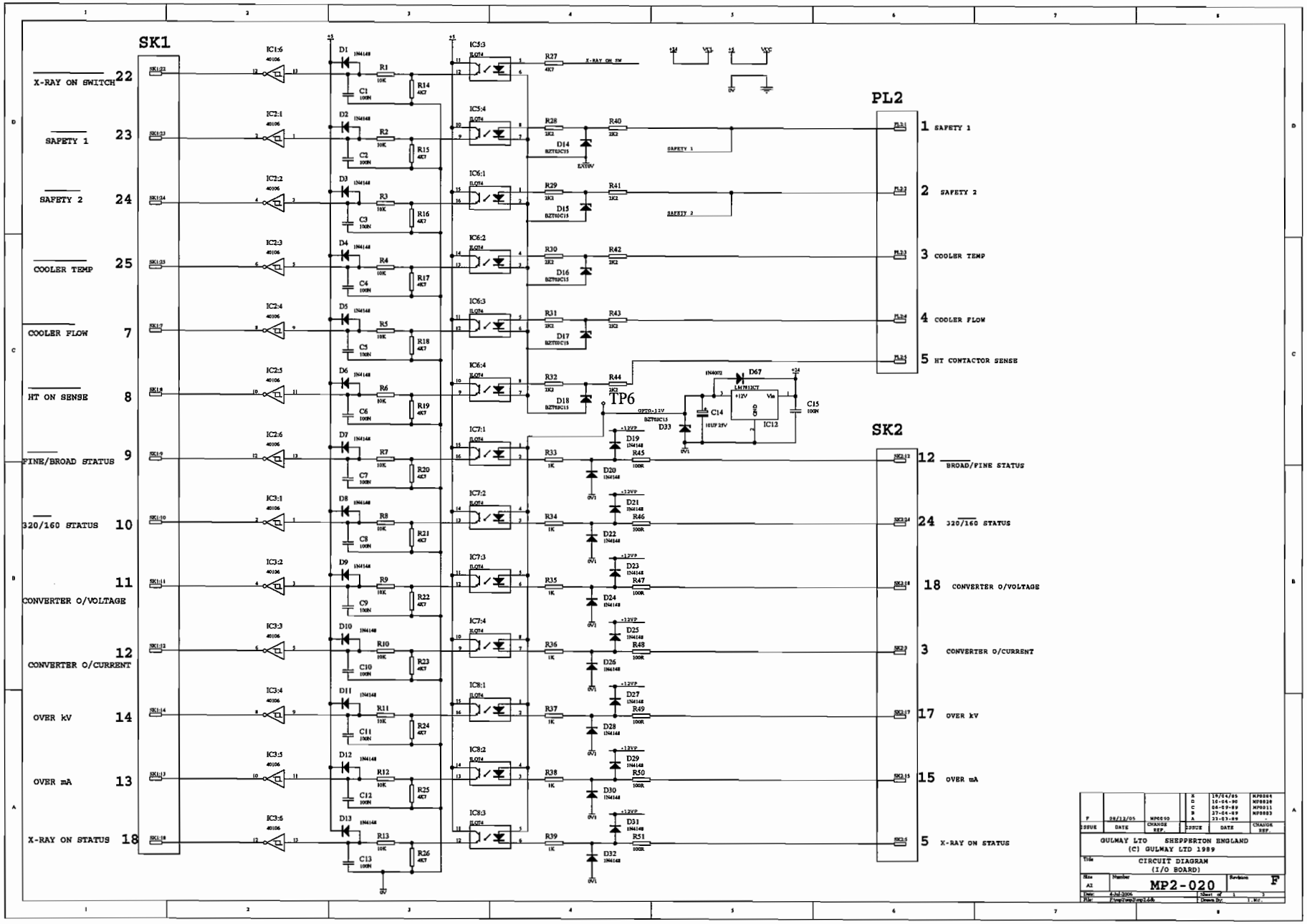


RS232 CONNECTOR 9 WAY 'D' TYPE PLUG PL1
GENERATOR I/O CONNECTOR 25 WAY 'D' TYPE SOCKET SK2
REAR PANEL
LAB I/O BOX CONNECTOR TYPE BURNDY UTGO 18-23P PL2
6mm EARTHSTUD
I/O BOARD
PSU BOARD
TX1
MAINS SELECTOR
CPU BOARD (TYPE 2)
OPTION RS232 OPTION 14 WAY IDC CONNECTORL5
OPTION EXPANSION OPTIONS DIN41612 CONNECTORK5
OPTION 10 LINES PL2 10 WAY IDC CONNECTOR
POTENTIOMETERS
DISPLAY POWER
DISPLAY I/O
KEY BOARD I/O
KEY BOARD
SWITCHES
DISPLAY BOARD
FRONT PANEL
OPTION MAINS MONITOR PCB
MAINS ISOLATION
PREWARN
HT ON
SAFETY
MAINS ON
GULMAY LTD SHEPPERTON ENGLAND
(C) GULMAY LTD 1989
INTERCONNECTION DIAGRAM
(MP CONTROL PANEL)
MP2-003
F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SAFETY 2 24
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320/160 STATUS 10
CONVERTER O/VOLTAGE 11
CONVERTER O/CURRENT 12
OVER kV 14
OVER mA 13
X-RAY ON STATUS 18
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1 SAFETY 1
2 SAFETY 2
3 COOLER TEMP
4 COOLER FLOW
5 HT CONTACTOR SENSE
SK2
12 BROAD/FINE STATUS
24 320/160 STATUS
18 CONVERTER O/VOLTAGE
3 CONVERTER O/CURRENT
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5 X-RAY ON STATUS
TP6
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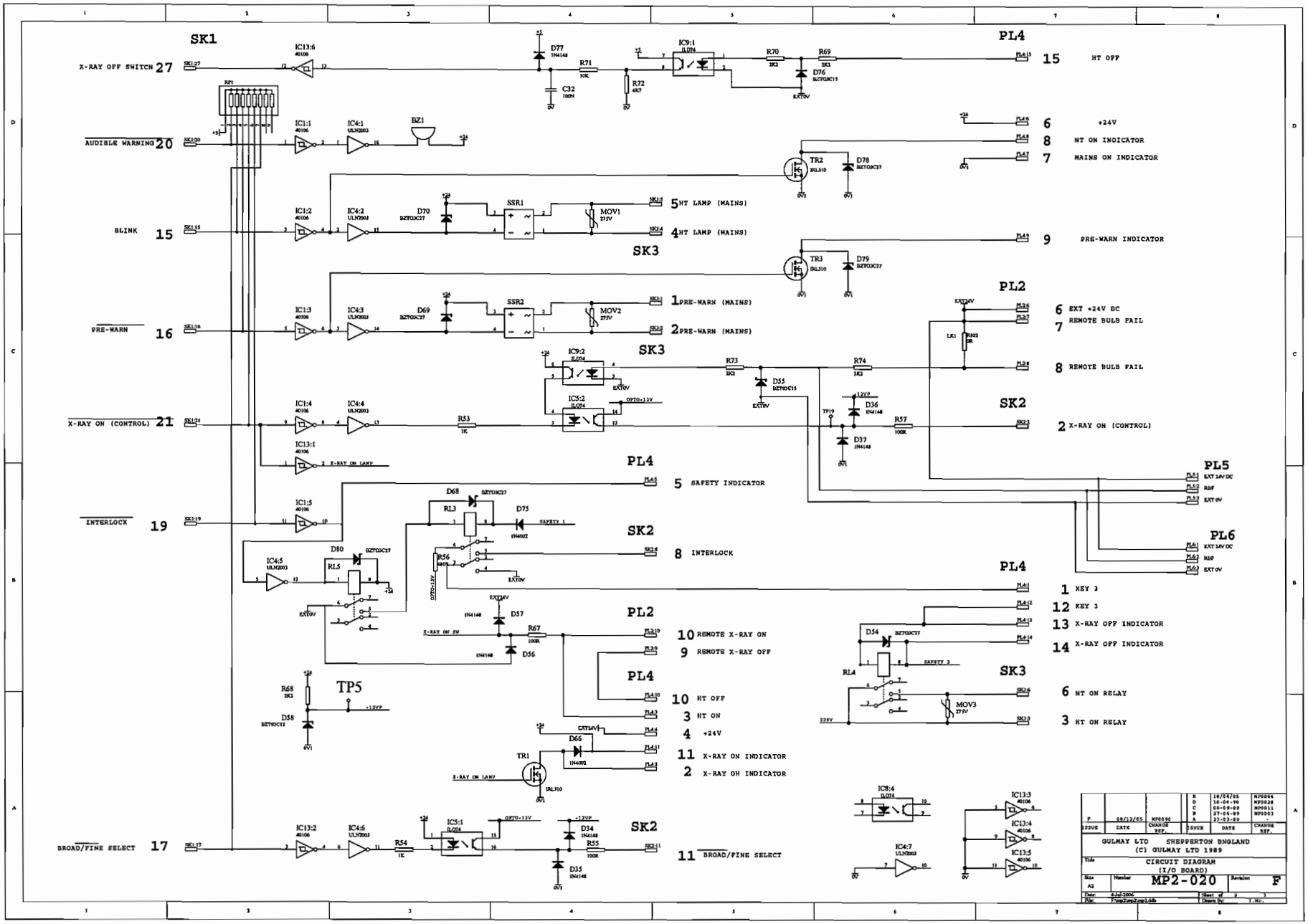
(C) GULMAY LTD 1989
CIRCUIT DIAGRAM
(I/O BOARD)
MP2-020
F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(C) GULMAY LTD 1989
CIRCUIT DIAGRAM
(I/O BOARD)
MP2-020
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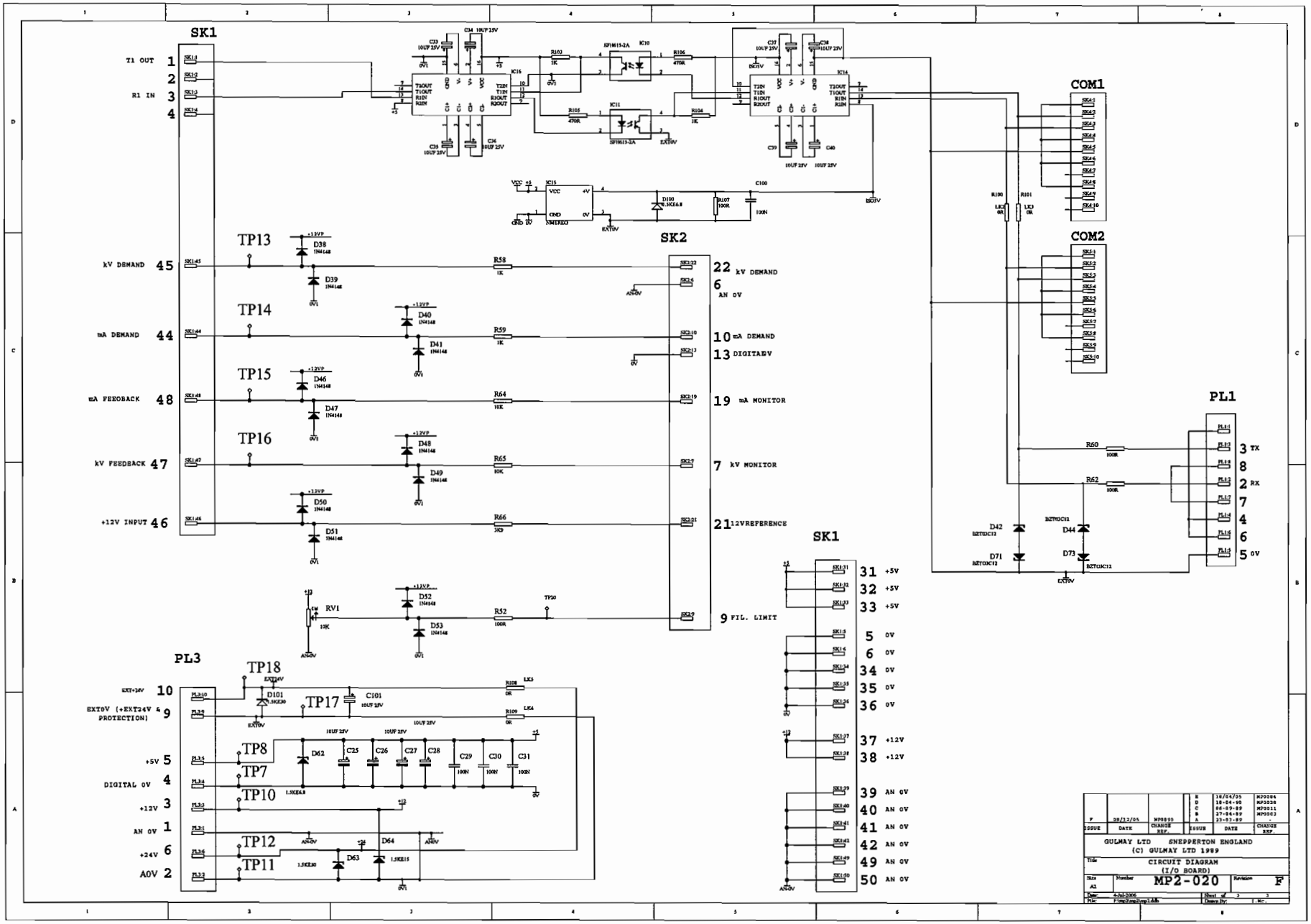

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Title: CIRCUIT DIAGRAM (I/O BOARD)

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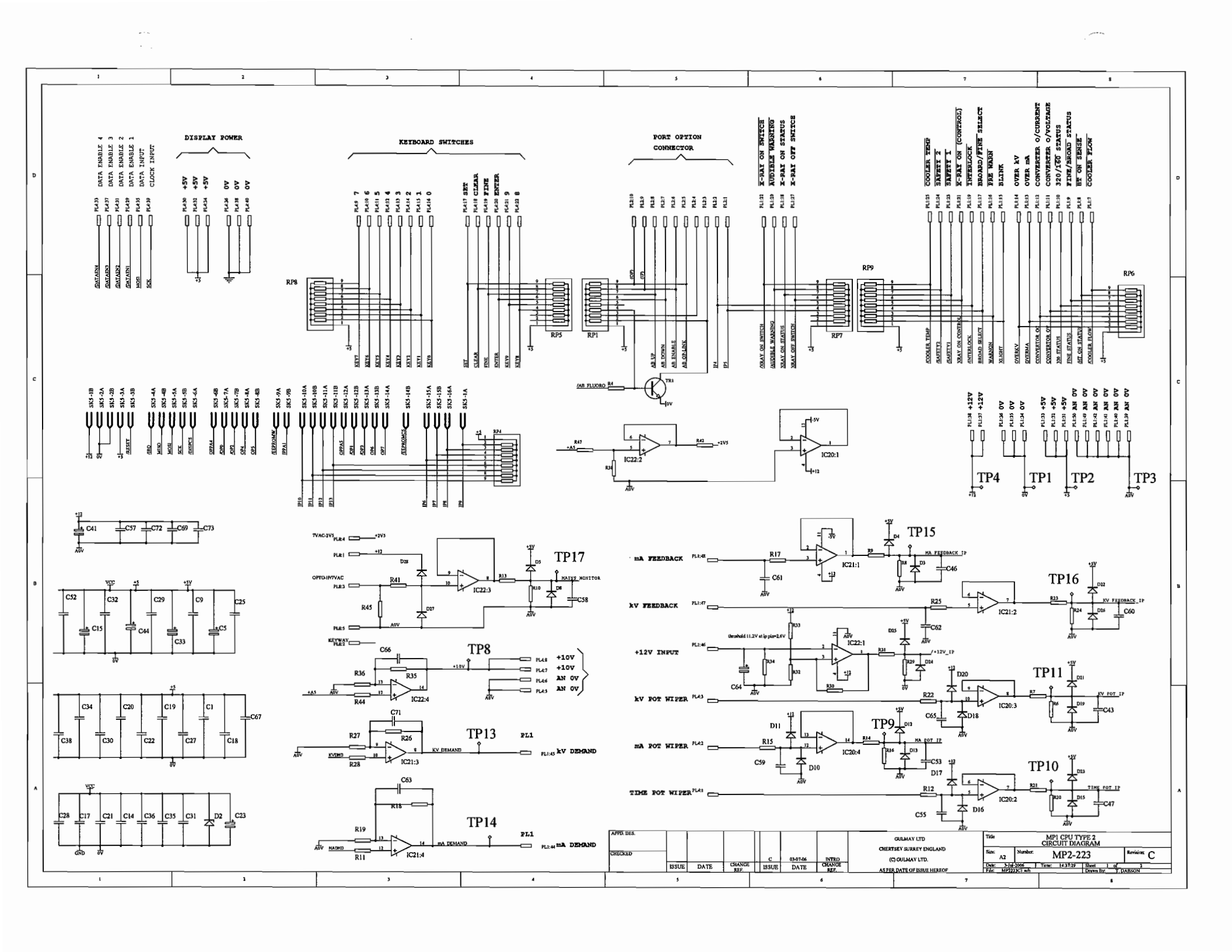
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AN 0V
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GULMAY LTD
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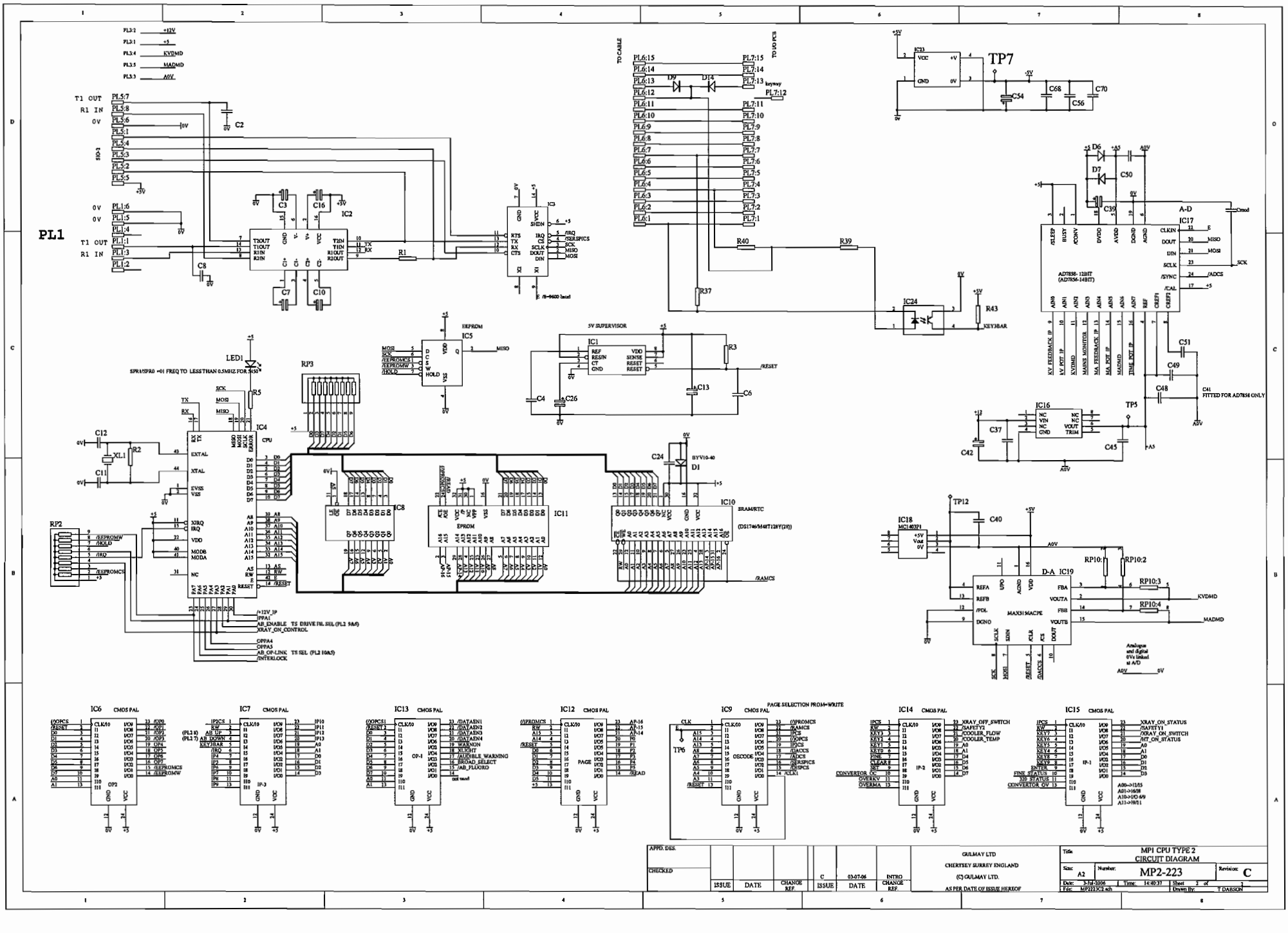
T. DABSON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AS PER DATE OF ISSUE HEREOF
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Revision: C
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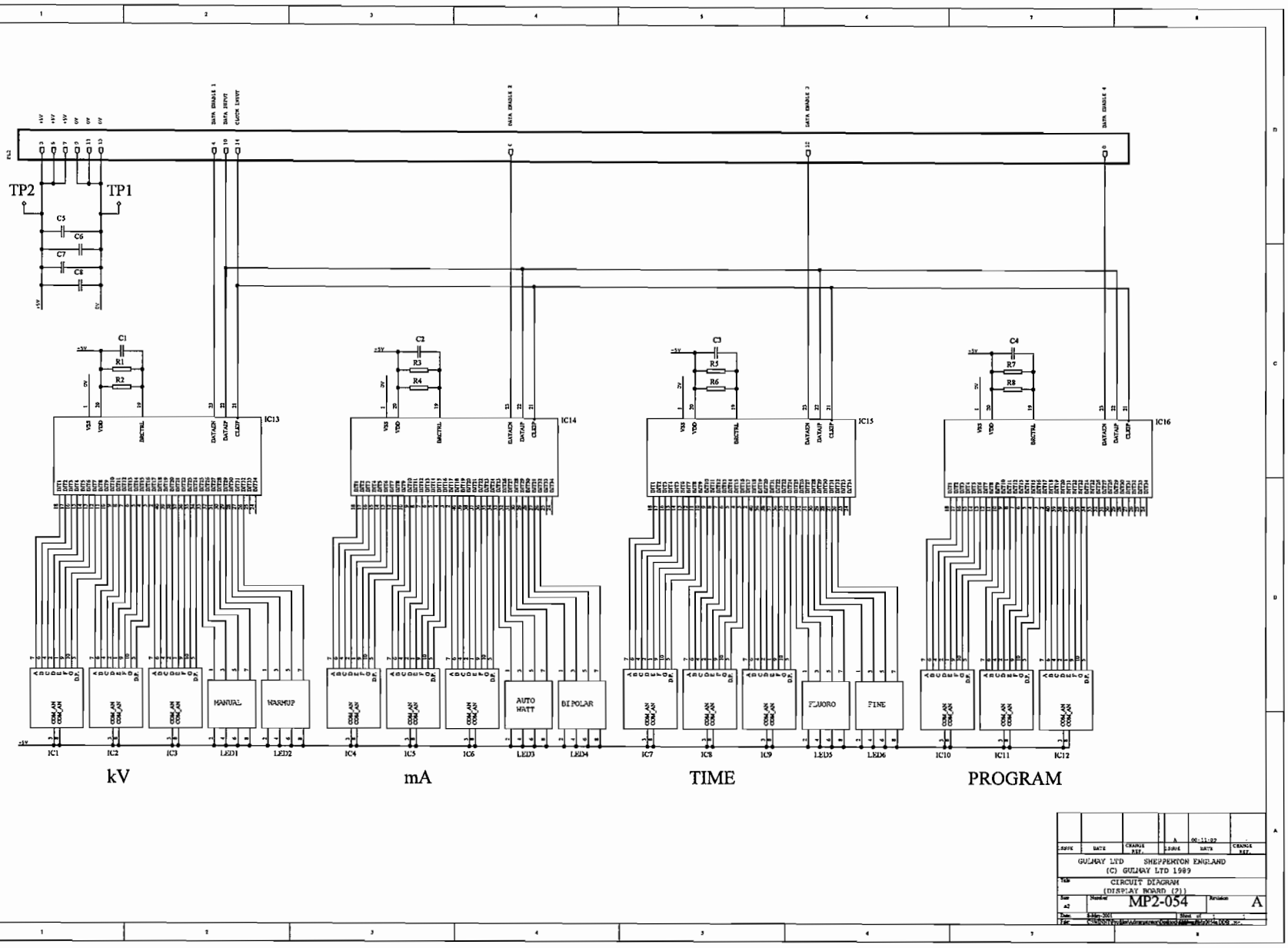
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PROGRAM
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CIRCUIT DIAGRAM
(DISPLAY BOARD (2))
MP2-054
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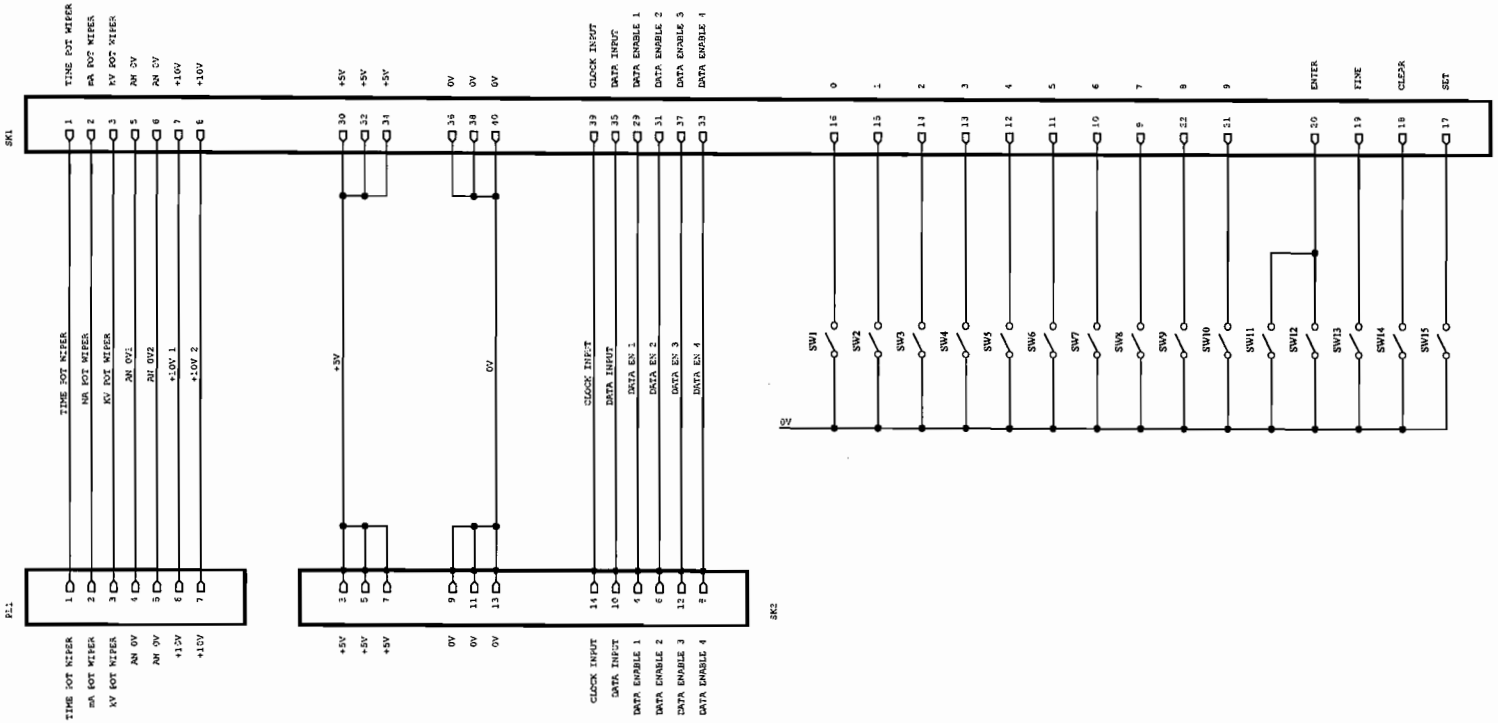

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GULMAY LTD SHEPPERTON ENGLAND
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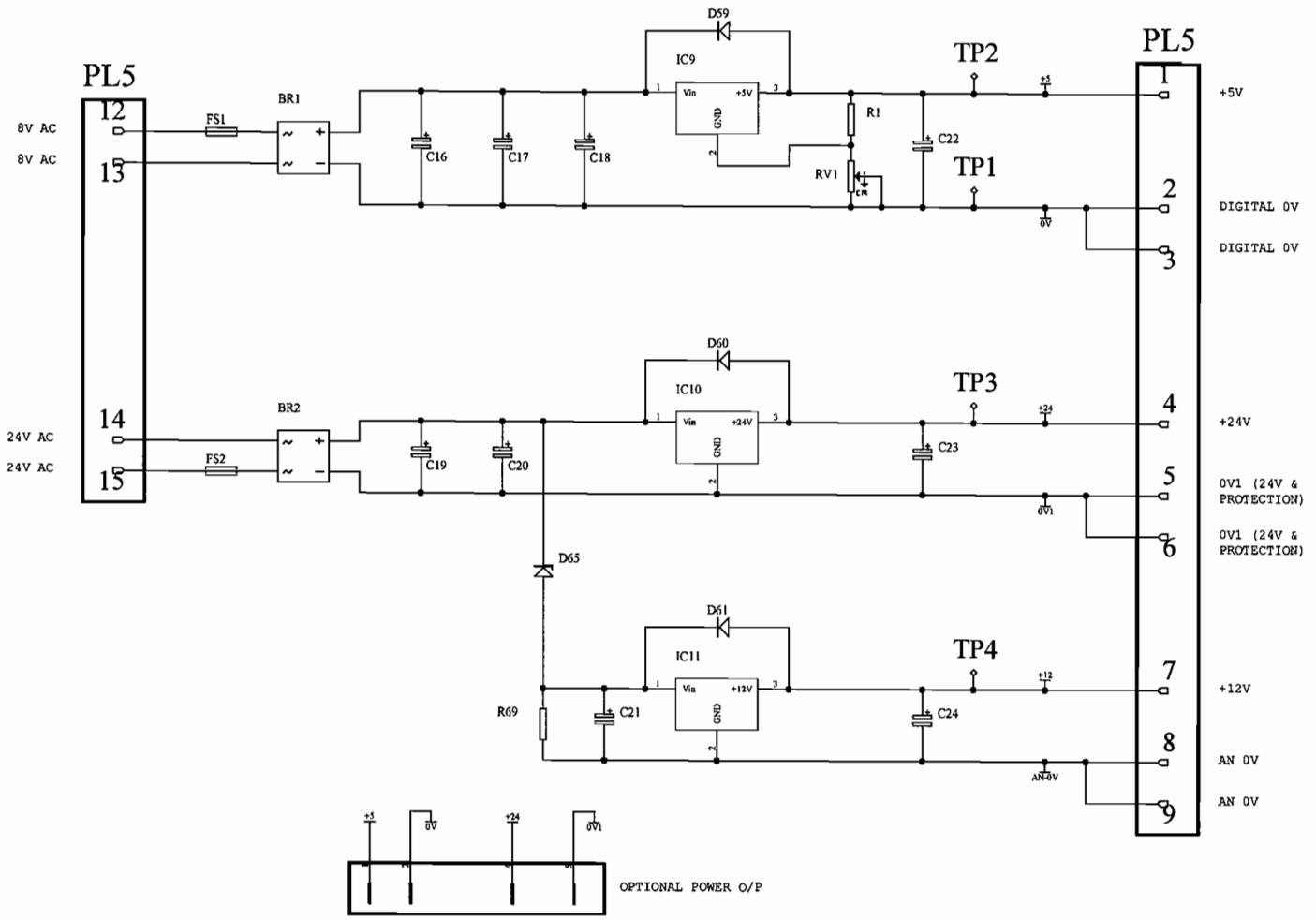

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GULMAY LIMITED
CHEPPERTON MIDDLESEX ENGLAND

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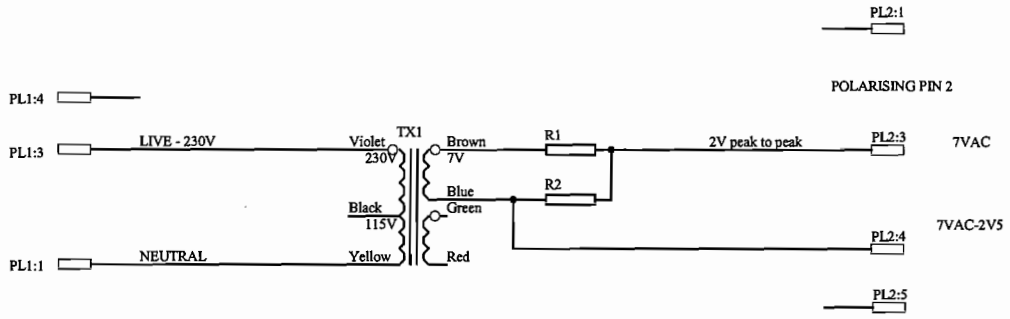

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				A	17/08/2004	INTRO	AS PER DATE OF ISSUE HEREOF	File: MP3242A.SCH		Drawn By: A. DABSON

FC SERIES

TECHNICAL MANUAL

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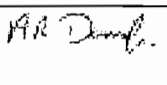
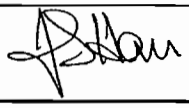
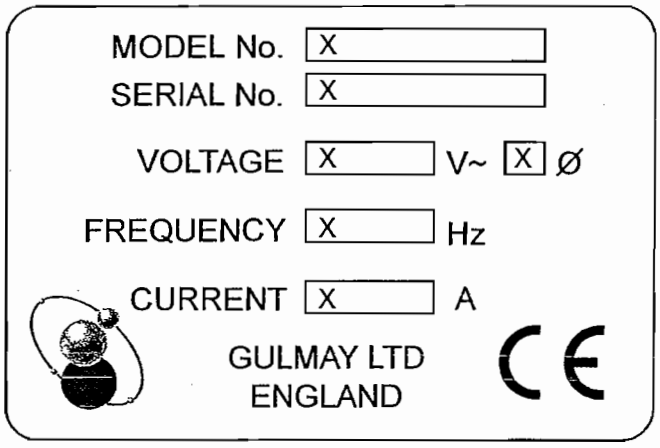
Issue	C	Change Number	DC139
APPROVALS			
Engineering		Production	

GULMAY LTD
CHERTSEY
ENGLAND

CE MARKING

Units with the CE Label applied (See below) are certified by Gulmay Ltd as complying with the European EMC & Low Voltage Directives.



Gulmay makes this statement on compliance based on measurements to the following harmonised European standards:-

Conducted Emissions to BS EN 50081-2
Radiated Emissions to BS EN 50081-2
Electromagnetic Field Immunity to BS EN 50082-2
Electrical Fast Transient Immunity to BS EN 50082-2
Electrical Safety to BSEN 61010-1
Electrical Testing to BSEN 60204-1 (Testing section only)

J.S.Hall
Director

17th December 2001

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17G - E031	GENERATOR TANK SCHEMATIC (FL100-1)
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17G - E033	FL 100-1 FILAMENT OUTPUT PCB CIRCUIT DIAGRAM
CP4 - 059	FL 160-2 FILAMENT OUTPUT PCB CIRCUIT DIAGRAM

FIGURE LIST

PCB WAVE FORMS:

TROUBLE - SHOOTING CHARTS:

FIRST AID TREATMENT FOR ELECTRIC SHOCK

Switch off. If this is not possible protect yourself with dry insulating material and pull the casualty clear of the conductor.

WARNING: DO NOT TOUCH THE CASUALTY WITH YOUR BARE HANDS UNTIL HE OR SHE IS CLEAR OF THE CONDUCTOR.

Carry out the following procedure:-

Open the airway by lifting the chin forwards with the middle fingers of one hand while pressing the forehead backwards with the heel of the other hand.

Place your ear above the casualty's mouth and look along the chest and abdomen. If the casualty is breathing you will hear and feel any breaths and see movement along the chest and abdomen. If the casualty does not start to breathe, begin mouth-to-mouth ventilation

MOUTH-TO-MOUTH VENTILATION

a. Open your mouth wide and take a deep breath.

b. Pinch the nostrils together with your fingers and seal your lips around the mouth (for mouth-to-nose close the mouth with your thumb and seal lips around nose)

c. Blow into casualty's lungs looking along the chest until you see the chest rise to maximum expansion.

d. Remove your mouth well away and breathe out any excess air while watching the chest fall. Repeat inflation.

e. After two inflations check the pulse to make sure the heart is beating.

N.B. ALLOW CHEST TOTALLY TO DEFLATE BETWEEN FIRST TWO INFLATIONS.

If the heart is beating continue to give inflations at 12-16 times per minute until natural breathing is restored.

If the heart is NOT beating start External Chest Compression **IMMEDIATELY**.

EXTERNAL CHEST COMPRESSION

Before commencing External Chest Compression it is important to establish that there is NO heart beat. The only reliable way is to check the pulse at the neck = CAROTID PULSE. This can be felt by placing the fingertips gently on the voice box and sliding them down into the hollow between the voice box and the adjoining muscle. It must be checked after the initial two inflations, then after the first minute and then every three minutes thereafter.

a. Take up a position at the side of the casualty.

b. Find the junctions of the rib margins at the bottom of the breastbone.

c. Place the heel of the hand two fingers above this junction.

d. Cover this hand with your other hand interlocking the fingers.

e. Keeping the shoulders directly above the hands and the arms straight, press down vertically on the breastbone, moving it 4-5cms/1½-2 inches for the average adult. Release pressure. Compressions should be regular and smooth and not jabbing and jerking.

f. Fifteen heart compressions should be given (at a rate of 80 per minute) followed by two deep lung inflations and repeat the cycle (15 compressions to two inflations).

g. The carotid pulse should be checked after a minute and then every three minutes.

If the casualty's pulse returns naturally, stop the external chest compressions, but continue mouth-to-mouth ventilation until the breathing restarts. Then place the casualty in the recovery position, (on their side), ensuring that no more than half his chest is in contact with the ground, and head remains tilted, jaw forward to maintain open airway position.

1.0 INTRODUCTION

This high voltage generator has been designed to meet the requirements of fractional focus sealed X-Ray tubes up to 640W and 225kV.

The 100kV version is designated FC100.
The 160kV version is designated FC160.
The 225kV version is designated FC225.

The family of generators is designated FC Series.

The FC Series is a development of the FL series. The main difference is the new power pcb with new sub and drive pcb's. The main benefits are in cooling and regulation.

The FC Series generators are totally enclosed, free standing high voltage units operating from a single phase input supply. They employ solid state technology and high frequency techniques to enable precise control and monitoring of the output parameters.

Interfacing is readily adaptable to microprocessor control.

The user controls are to be found in the system console, hence control layout and operating information is not included in this document.

The FC Series incorporates extensive fault annunciation and automatic cut out circuitry and is designed to comply with relevant regulations.

1.1 WARNINGS

The information in this document is solely for the use of engineers employed by customers of GULMAY LTD., or their agents who have been trained by them. Service and maintenance on this equipment must be carried out by trained competent personnel, owing to the lethal voltages existing within the equipment.

WARNINGS

BEFORE REMOVING THE E.H.T. CABLE FROM THE OUTPUT SOCKET, CARRY OUT THE FOLLOWING PROCEDURE:-

REMOVE THE POWER CONNECTOR [PL-B] FROM THE SIDE OF THE CHASSIS.

ALLOW 2 MINUTES FOR ANY INTERNAL VOLTAGES TO DECAY TO SAFE LEVELS.

REMOVE THE CABLE AND DISCHARGE ANY VOLTAGE STORED IN THE CABLE CAPACITANCE TO A SUITABLE PROTECTIVE EARTH POINT SUCH AS THE CONNECTOR FLANGE RING ON THE GENERATOR TANK.

OBSERVE THIS POLICY WHEN HANDLING ANY E.H.T. CABLES EVEN WHEN THEY HAVE NOT PREVIOUSLY BEEN RUN.

E.H.T. VOLTAGES

THE VOLTAGES IN THIS EQUIPMENT ARE LETHAL. THE GENERATED VOLTAGE AT THE E.H.T. OUTPUT CAN BE TWO HUNDRED THOUSAND VOLTS WITH RESPECT TO EARTH.

1.2 SAFETY PROCEDURES

1.2.1 RADIATION

No attempt should be made to make measurements on the generator whilst powering the X-ray Tube unless the generator is in a radiation - safe environment.

1.2.2 ACCIDENTAL SWITCH ON

Four conditions are required to generate E.H.T.

1. The main supply [in PL-B] is connected to a suitable source.
2. The auxiliary supply [in PL-B] is connected to a suitable source.
3. The INTERLOCK signal is present.
4. A "kV ON" control signal is present.

The most important thing to remember is that the generator cannot produce E.H.T. with the main supply disconnected. Both wires of the main supply in PL-B should be isolated by a safety switch or radiation - enclosure door switch.

ALWAYS OBSERVE THE WARNINGS IN 1.1 WHEN INSTALLING OR REMOVING E.H.T. CABLES.

1.3 SPECIFICATION (FC160)

	FC Series X-Ray Power Supply
FUNCTION	To power a unipolar, sealed X-ray tube up to 160kV [FC 160 only] at 640 W with a controlled filament supply isolated to the E.H.T. potential. (The FC160-2 has twin filament supplies)
PHYSICAL	The power supply consists of two major elements, an E.H.T. tank and a converter chassis.
E.H.T. TANK	This contains all the high voltage circuitry required to produce E.H.T. output and associated filament supplies. The high voltage isolation is obtained by means of resin encapsulation and transformer oil [e.g. SHELL DIALA BG] immersion.
CONVERTER CHASSIS	This unit fits directly onto the E.H.T. tank. It contains all the electronic circuitry to produce the controlled 640W drive for the E.H.T. supply together with the drives for the Filament Transformer.
DIMENSIONS (TOTAL UNIT) (FC100 and FC160)	360 mm WIDE 613 mm LONG 482 mm HIGH 102 kg WEIGHT
ELECTRICAL	
INPUT POWER	Single Phase AC. Supply 220V +/-10% 47-63 Hz, 1000 VA Maximum.
OUTPUT VOLTAGE	FC100 - 100kV FC160 - 160kV FC225 - 225kV Programmable in the range 10 - 160KV (UC 160 only).
OUTPUT CURRENT	12mA max (FC100) 10mA max (FC160) 7mA max (FC225) Limited by internal circuitry and programmable from 100uA.
E.H.T. RIPPLE	The E.H.T. ripple is defined as 170V pk-pk at full rated output and is the sum of low frequency, line frequency and high frequency. The line frequency contribution to the ripple will be less than 50V pk-pk.
LINE STABILITY	Better than 0.2% change in output voltage for a +/- 10% change in AC supply (long term) .

LOAD REGULATION	Better than 0.2% change in output voltage for a charge load current from 100uA to 10mA.
E.H.T. DRIFT	Better than 0.2% over operating temperature range

CALIBRATION ACCURACY

KV MONITOR	The measurement of E.H.T. voltage is derived by a resistive potential divider from the output. This results in an overall accuracy of +/- 2.5%.
MA MONITOR	The measurement of tube-current is made directly by means of a sense resistor in the earth return of the high voltage circuit. This results in an overall accuracy +/- 1%

ENVIRONMENTAL

TEMPERATURE	The equipment will operate to its specification over the temperature range 10- 35 deg. C.
HUMIDITY	The equipment will operate to its specification with relative humidity up to 80% non condensing.

PROTECTION

Operation of any of these protection circuits results in immediate shut down of the E.H.T. supply from the generator and the appropriate fault annunciation's via the interface to the host controller.

OVER kV	Operates when exceeding maximum rated voltage by 5%
OVER mA	Operates when exceeding maximum rated current by 5%.
CONVERTER OVER-VOLTAGE	Operates if the internal DC supply in the converter exceeds 250V.
CONVERTER OVER-CURRENT	Operates if the internal current in the converter exceeds 8A.

2.0 INSTALLATION

2.1 INTRODUCTION

Installation should only be carried out by designated employees of the X-ray System supplier or manufacturer. The FC Series generator is only a subsystem.

2.2 POWER SUPPLY

On the converter chassis the mains selector allows for 3 different supply voltages:-

200 V AC
220 V AC
240 V AC

The correct selection should be made.

There is a bonding stud (8mm) below the E.H.T. output receptacle on the E.H.T. tank. Connect a 10mm copper braid from the stud to a suitable (100A) protective earth point.

Now proceed to install the generator end of the E.H.T. cable.

2.3 CABLE INSTALLATION

The high voltage, filament and grid supplies are connected via a high voltage cable and plug to the receptacle in the generator tank. In order to prevent voltage flash overs in the receptacle, the termination of the cable has to be carefully greased with an appropriate high voltage insulating grease (e.g. DOW CORNING MS4).

DISCHARGE ANY STATIC FROM THE CABLE END TO A SUITABLE EARTH POINT.

Make sure there is a uniform layer of grease without any bubbles on all rubber parts of the termination and that all metal parts, used for electrical contact are clean.

As you enter the cable end into the receptacle rotate the cable back and forth to distribute the grease. Unscrew the flange on the cable end sufficiently for there to be a 4mm gap between the two flanges with the cable fully home. Screw in the four fixing screws gradually in rotation to compress the cable end evenly, until the two flanges are together.

2.4 INTERFACE CONNECTION

Connect the 25 Way "D" type interface connector [PL -A] to the plug on the converter chassis.

2.5 POWER CONNECTION

The power connection is PL-B on the side of the converter chassis. Two separate supplies are required as follows:-

Auxiliary Supply	100VA
Main Supply	500VA

The auxiliary and main supplies should be derived from an interface control unit in such a way that the auxiliary supply is fed all the time and the main supply is interrupted via a door switch or safety contactor when E.H.T. output is not required.

THE GENERATOR AND TUBE MAY NOW BE RUN UP WITHIN THE TUBE MANUFACTURERS GUIDELINES. THIS MUST BE CONTROLLED FROM A RADIATION SAFE ENCLOSURE.

3.0 SYSTEM DESCRIPTION

A simplified block diagram is shown in Fig. 3.1. Single phase power is fed into a pulse width modulated switching regulator and then into an averaging filter to produce a variable and controlled DC supply to a sine wave inverter running at approximately 25kHz.

The inverter is transformer coupled to a multiplier which produces the required E.H.T. output in direct proportion to the DC supply at the inverter input.

The combination of input rectifier and inverter is called a converter.

The E.H.T. output voltage is fed via a standard receptacle and cable to the X-ray tube.

Commoned to the E.H.T. output is the filament supply which is derived from the rectified output of an isolation transformer.

The filament supply is adjusted automatically to regulate the beam-current.

The auxiliary power supplies all the electronic circuits for control, interfacing and filament drive.

The main power is analogous to the primary feed to a conventional mains frequency E.H.T. transformer rectifier system.

There are six main PCBs inside the converter. These are :-

(i) IGBT Power PCB
(ii) IGBT Sub PCB
(iii) IGBT Drive PCB
(ii) PSU PCB
(iii) Control PCB
(iv) Filament PCB

In addition, there is another PCB in the oil inside the stress ring at the E.H.T. output. This is the Filament Output PCB.

3.1 FC CHASSIS INTERCONNECTION DIAGRAM (Dwg. No. 17C-E343)

This drawing shows the electrical connection within the converter chassis, Dwg 17C-A344 shows the physical layout.

The auxiliary supply enters via PLB pins A and B. It powers the auxiliary transformer TX1 via a 1A circuit breaker (CB) F2 and an RFI filter FL1. TX1 powers all the electronics from 5 secondaries. 3 of these are referred to earth and are shown on the right hand side (secondary side) of TX1. 2 of these are isolated from earth and are shown on the left-hand side (primary side). The two 15V secondaries on the right hand side are rectified on the PSU PCB to +/- 18 VDC and are then regulated to +12 V and -12 V DC on the Control PCB. The 24 V secondary is protected by a 5A CB (F3) and is rectified and smoothed to a nominal 30 V supply to power the Filament drive PCB.

All the circuit 0V signals are commoned at T1 and are earthed via the earth wire in PLB. They are isolated from chassis earth to reduce noise. A 100 ohm resistor and M.O.V. provide a reference to chassis for safety reasons.

The two primary side 15V secondaries are rectified to +/- 18VDC on the PSU PCB and are then referenced to the isolated drive circuitry on the Power PCB. They are designated V-Y and V-X and are referenced to V-COM.

The main supply enters at PLB pins D and E via a 10A CB (F1) to the Power PCB PL1.

The Power PCB contains the following sub-circuits:-

An input filter
An input rectifier.
A regulator.
A high frequency inverter.
mA and kV feedback filtering and clamping.
Control and protection circuits on a Sub PCB.
Isolated IGBT drive signals on a Drive PCB

Interfacing to the Power PCB from the other electronics is via PL3.

Interfacing to the Power PCB from the EHT tank is via a flying lead connected to SK2.

The Filament drive PCB output is connected via a flying lead to its isolation transformer in the top of the EHT tank.

On twin filament units (eg FC160-2) the filament drive is switched via a relay PCB between two isolation transformers. This Relay PCB interfaces to the Control PCB.

The Control PCB interfaces to PL-A and controls all circuitry.

3.2 POWER PCB INCLUDING SUB AND DRIVE PCB
(Dwg. Nos 17C–E280, 17C–E285, 17C–E302)

PLEASE NOTE THAT SOME OF THESE TEST POINTS AND VOLTAGES ARE ISOLATED FROM EARTH. THESE POINTS ARE NOTED ON THE CIRCUIT DIAGRAM.

The power pcb contains two, 3 terminal linear regulators, IC1 and IC2. IC1 is configured to provide +15V, adjustable with RV1. IC2 provides a non adjustable −12V. Diodes D1, D2, D7, and D8 provide protection against reverse polarity as the unit powers down.

The Main AC power input (200-240VAC) is at PL1-1 and PL1-5. The supply is filtered by C5, C15, C16, C17 and a common mode filter choke CL1. The supply is then rectified by DB1. The rectified supply is connected to smoothing capacitors C24, C25, C30 and C33 via an inrush limiting resistor R11. SCR1 is turned on when the main supply is fully established to short circuit R11 and therefore reduce dissipation.

THE VOLTAGE ACROSS C24, C25, C30 AND C33 IS IN THE RANGE OF 280 TO 380 VDC AND GREAT CARE SHOULD BE TAKEN MAKING MEASUREMENTS WITH THIS VOLTAGE PRESENT. NEON BULB N1 INDICATES THE PRESENCE OF HIGH VOLTAGE ACROSS THESE CAPACITORS.

MOST CIRCUIT OPERATIONS CAN BE CHECKED AND MEASURED SAFELY BY REMOVING THE MAIN SUPPLY BY SWITCHING OFF CB F1 AND REMOVING THE CONNECTOR SKC FROM THE POWER PCB INPUT PLUG PL1.

The voltage across C24, C25, C30 and C33 is fed to a pulse width modulated switching regulator comprising transistor TR5, diode D24, inductor L5 and smoothing capacitors C32, C27, C23, C36, C39 and C41. Components L4, D25, C28, R27, R26 and C31 are included for EMI reduction. R25 is included to discharge the smoothing capacitors. TR6, driven by TR4 ensures that the discharge resistor R25 is disconnected once the main supply is established, thus reducing power dissipation.

TR5 is driven with a floating driver chip - IC3. The floating supply for this is derived from an unsynchronised oscillator on the drive pcb which feeds transformer TX3. The output of TX3 is rectified and smoothed with D26, D27, and C38, to provide the floating supply for IC3.

The switching regulator output is designated V-REG and is measured at TP11 with respect to (wrt) V- COM at TP10. This voltage is controlled in the range of 5-240V DC.

A half bridge IGBT inverter comprising TR2, TR3, commutation components L2, L3, C9, and C10 is fed by V-REG and produces a high frequency sine wave via capacitor C14 at the output connector SK2 which interfaces to the EHT tank. The sine wave is approximately twice the value of V-REG in peak amplitude. The sine wave frequency is

approximately 25 kHz and is half the frequency of the switching regulator. Diodes D12, D13, D15, and D17, provide over voltage protection for the IGBT's. This condition may be expected during a tube arc. Should this happen, the current transformer TX1 provides a signal across R13, to alert the sub pcb that this condition has arisen.

The feedback signals from the EHT tank are input to the Power PCB at SK2.

The mA feedback is input at PL2-2, clamped by transorbs D5 and D3 and smoothed by a high frequency filter comprising C12, L1 and C11. Resistors R3, R5, R6 and R7 total the reference value to give the correct mA calibration voltage which is normally 10V for 5mA, or 10V for 2.5mA of current, depending on build. The kV feedback is input at PL2-3, clamped by transorbs D4 and D6, and filtered by C8. Resistors R1, R2, R6 and R7 comprise the terminating resistor for the kV feedback. R6 and R7 are common to both mA and kV feedbacks and is a compensation for the voltage drop across the EHT surge resistor. The combined value of R1 and R2 varies according to generator type to maintain a calibration voltage which is 10V for 200kV of output. (See section 6.1 for different assembly part numbers).

SUB PCB

The Sub PCB plugs into the Power PCB using SK4 and SK5. In addition to this there is a 2 way cable which connects PL10 on the sub pcb to PL6 on the power pcb.

The signals on SK5 pins 10 - 15 are all referenced to 0V and interface to the Control PCB. The signals on PL10, SK4, and all other pins of SK5 are isolated from 0V.

ISOLATED CCT.

The Isolated section of the Sub PCB has 2 regulated voltage rails derived from the power pcb. +15V, and –12V. These supply power to all circuitry which is isolated from 0V

IC5 generates a 50kHz clock pulse (available at IC5 pin 4), and includes a pulse width modulator (PWM) for controlling the switching regulator on the power pcb. The clock frequency can be adjusted to 50kHz with RV1.

The PWM outputs of IC5 (pins 11 and 14), are fed to a voltage divider (R72, R73, and R71) to be fed to the power pcb.

The control of the PWM employs average current control. The current in L5 of the switching regulator (power pcb) is fed as a voltage to IC2:2, which amplifies the signal differentialy. This signal, together with the error voltage signal (IC4:2 pin 7), is fed to an integrator – IC2:2. It is the output of this integrator which controls the PWM

The regulated output voltage V-REG is fed to a voltage divider comprising R18 (power pcb), and R58 with R68 (sub pcb) to give the signal V-MON. V-MON is 5V when V-

REG is 250V. The V-MON signal is input to IC4:2 which is the voltage error amplifier and compared to a voltage demand at TP44.
The inverter IGBT's require signals of 50% duty cycle. The signals also need to be in anti-phase. 50kHz clock pulses are obtained from IC5 pin 4. TR5 and TR4 amplify the pulses before being fed to IC8:1 which provides the 25kHz signals for the inverter IGBT's.

IC1:2 forms an astable circuit which produces the SCR-FET signal. When this signal is active, TR1 on the power pcb switches an isolating transformer to fire the inrush current thyristor – SCR1. The SCR-FET signal also disables the active discharge circuit on the power board (TR4 and TR6) to disconnect the discharge resistor – R25. The SCR-FET signal is always active unless either the –12V is not established (IC1:4), or the main supply is not established (IC1:1).

PROTECTION.

The sub board contains a considerable amount of protection circuitry, both to protect the user from hazardous situations, and to protect the electronics from damage during tube arcs.

The voltage demand at TP44 is derived from the output of the opto isolator IC12. V-MON can be measured at TP39 and is monitored by the comparator IC3:2. When V-MON exceeds V-REF (5.1V) TR1 will turn on and immediately shut down IC1 which causes the output V-REG to limit to 250V DC in a fault. This situation can be seen visually by the illumination of LED1. If the switching regulator is uncontrollable then IC7:1 turns on and an Over Voltage signal is sent. The current into the switching regulator is measured by the voltage across R22 (power pcb) and is input to the Sub PCB at SK4-3 and amplified by IC4:1 to the signal I-MON. I-MON is connected to TP41 and is compared with hysteresis to 4.5V (derived from the 5.1V reference) by IC3:1 which also turns on TR1 and causes a current limit of approximately 6A. This situation can be seen visually by the illumination of LED2.

If the current is uncontrollable then IC7:2 turns on and an Over Current signal is sent. IC3:3 is the X-RAY ON comparator and controls TR1 to enable or disable the switching regulator and inverter. IC3:4 controls the isolated error signal at TP44 so that the switching regulator starts softly from zero volts.

To avoid damage to the inverter, it is important that the inverter drive signals are established before the switching regulator develops an output voltage. This function is provided by TR6 and TR7. The SOFTSTART signal is held low, until switching signals are established at the output of IC8:1. Pin 2 of this chip is low if inverter drive signals are not established.

IC6 protects the inverter from overload from a tube arc, or damaged tank electronics. When the inverter becomes overloaded, one of the IGBT's will turn off before the current in it's associated inductor has decayed to zero. In this situation, instantaneous protection

is provided by D12, D13, D15, and D17 on the power pcb. Longer term protection is provided by IC6. A CLAMP DET signal is received, which will cause TP49 to go low. This signal is latched by IC6:3, causing TP47 to go low, activating the FREEZE signal, and discharging C31. If the CLAMP DET signal is cleared, then IC6:3 is allowed to recover, but since the time constant of R81 and C31 is relatively large, the FREEZE signal will still be held high, causing inverter drive signals to stop switching. Since TR6 and TR7 monitor the inverter drive signals, the SOFTSTART signal is held low causing the switching regulator to shut down. When the overload is cleared, C31 is allowed to charge via R81, to a point whereby IC6:4 is released from it's high output state where sequencing of the switching regulator and inverter is allowed to initiate.

EARTHED CCT

18V DC is supplied from the Control PCB and is input at SK5-12. This is the power for the collectors of the opto transistors in IC9 and IC10. When an Over Current or Over Voltage signal is sent to the control PCB it is a high signal (18V) buffered by resistors R85 and R89 and referred to 0V.

0V is input at SK5-13 and is the return for the cathodes of the opto diodes of IC11 and IC12. The Control PCB sends a logical high (12V) via SK5-15 to the opto isolator IC11. This provides a logical low signal on the isolated side at the input to IC3:3 to start the switching regulator and inverter.

The kV error signal is input with respect to 0V at SK5-14, this is a linear signal from zero to 10V and on the isolated side of IC12. RV2 is adjusted to make TP44 equal to 6V wrt TP36 when SK5-14 is 10V wrt 0V.

DRIVE PCB

The purpose of the drive pcb is to provide isolated, low impedance drive signals to the inverter IGBT's. TR1 and TR2 receive drive signals from the sub pcb to switch the opto diodes inside IC1 and IC3. R2 and R12 are included to define the opto diode currents, while R3 and R13 are included to ensure fast turn off. The outputs of the opto couplers connect to the IGBT gates via R4 and R9 and connector SK7. Power for the opto couplers is derived from independent isolated supplies generated by IC2, TX1, and associated components. The output of IC2 is passed to SK8 so that it can also supply TX3 on the power pcb to provide an isolated supply for the switching regulator driver – IC3.

3.3 CONTROL PCB (Dwg No. 17C-E391)

EHT is switched on by the kV ON (CONTROL) line being taken high (high=12V, low=0V). This signal does two things, it resets the trip latches in IC2 via C2 and takes the input to IC 3/9 low. The X-Ray ON state is shown by TP3 being high. A high signal is sent to the Power PCB via PL2 pin 5 to turn on the inverter gate drives and the switching regulator.

The X-Ray ON signal also turns off comparator IC11:A allowing the kV demand signal to ramp from a negative signal (-0.7V) to that determined by the level set in the interface controller. The kV demand is buffered by IC6:A to TP5 and then to the kV error amplifier, IC7:B , and then to the Power PCB via PL2 pin 4.

To obtain X-Ray ON the Interlock signal must be high in the interface at PL1 pin 15.

kV feedback is input at PL2 pin 8 from the Power PCB, buffered by IC8:A and inverted by IC8:B and named kV_MON (kV monitor). The kV monitor signal is fed to the kV error amplifier IC7:B and to the interface controller after buffering by IC5:A via PL1 pin 13. The kV monitor may be measured at TP2.
NB. The LKO components around IC8:B and IC9:B are to allow for different polarities of feedback signals in other types of generators. In the FC Series the following options are set:-

LKO3 is OUT
LKO2 is OUT
LKO5 is OUT
LK01 is IN
LKO4 is IN (17CE391 SHOWS THESE OPTIONS)

This makes IC8:B a unity gain inverter.
This makes IC9:B a unity gain buffer.

The mA feedback is input at PL2 pin 9 from the Power PCB, buffered by IC9:A and IC9:B named mA MON (mA monitor). This is connected to the mA error amplifier, IC7:A, and via buffer IC5:B to the interface controller at PL1 pin 12. The mA monitor may be measured at TP7.

IC11:B detects when the kV feedback exceeds a level corresponding to 5 kV. When kV MON is over 0.25V (=5kV) IC11:B turns off which allows the mA demand signal to ramp from a negative level (-0.7V) to that determined by the level set in the interface controller. The mA demand is buffered by IC6:B to TP4 and then to the mA error amplifier (IC7:A) and then to the Filament drive PCB via PL2 pin 15. This signal is labelled mA Error. A high level (10 V) at PL 1 pin 15 causes maximum filament drive voltage.

The Filament temperature is controlled by an input signal at PL1-1. This voltage is routed through to PL2-11 and then to the Filament drive PCB. The Filament PCB is adjusted to give maximum drive at 10V of signal level.

There is provision for two filament transformers in the FC Series of generators. Generators with a '-2' suffix eg. FC 160-2 have an extra PCB, the Relay PCB. A change over relay on this PCB redirects the output from the Filament Drive PCB to one of two transformers in the EHT tank. A select line is input to the Control PCB at PL1 pin 21 and labelled BROAD/FINE SELECT. This signal is inverted by IC4:B to turn on TR1 when BROAD/FINE SELECT is high. This signal is output at PL2 pin 13 to the Relay PCB. When the relay is not activated a high (15V) signal is input from the Relay PCB at PL2 pin 12 and labelled SPOT_SIZE. This signal is inverted by IC1 and output at PL1 pin 23 in the interface.
NB. With '-1' generators with one filament transformer and no Relay PCB a link LK06 is fitted to return the correct SPOT_SIZE signal to the interface.

Two analogue trips are provided by the dual comparator IC 10.

R36 and R37 set up the Over kV threshold.

R39 and R40 set up the Over mA threshold.

In addition two trip signals are input from the Power PCB:-

DC O/VOLTAGE at PL2 pin 4.
DC O/CURRENT at PL2 pin 7.

Both of these signals are double buffered by IC4.

Positive transitions of the IC10 comparator outputs or Power PCB trip signals cause one or more of the quad latches to be set in IC2 which in turn cause one of the 'Q' outputs to go low. Any low signal at one of the inputs to the 8 input NAND gate IC3 will cause the X-Ray ON state to be terminated and the exact cause to be indicated on the interface through IC1.

3.4 REGULATED FILAMENT DRIVE PCB (Dwg No. 17C - E390)

Unregulated power is input at P1-4 (+30V Nominal) and P1-1 (0V).

TR7, L1, D19 and C10, C11 and C20 comprise a boost regulator controlling an output voltage of 33V at TP8 for an input voltage range of 19V to 31V.

The control signal for TR7 is labelled PHASE_3. This signal is pulse width controlled and 15V in amplitude.

A feedback from TP8 (labelled V_REG) is divided down by R24 and R20 to 2,5V at IC2-2.

The +15V supply for IC2 is derived from the unregulated supply with R11, D8 and de-coupled by C7.

The period of the oscillator of IC2 is set to 8.3µS by R23 and C15. The output frequency is half the oscillator frequency ie 60kHz.

The oscillator ramp is output at IC2-4 and is buffered by TR2 and attenuated by R21 and R18 to the ramp input IC2-3 for the pulse width modulator.

The 15V output pulse at IC2-6 is inversely proportional in width to the input voltage.

IC1 is a pulse width modulator IC connected to the push-pull output stage connecting to the filament isolation transformer primary at P2.

The oscillator of IC2 is locked to the output frequency of IC1 (60KHZ) by the connection of R28 and C28.

The output pulse frequency of IC2 is half it's oscillator frequency ie.30kHz.

A sense of output current is derived across the resistor R14. This signal is smoothed by L2 and C25 to the external connection P1-5. In addition this signal is fed to the shutdown pin of IC1 via the filter R9 and C5 to provide a current limit function. P1-5 is not used in the FC interface.

The pulse width of the 15V output signal at IC1-14 and IC1-11 is proportional to the signal (V_CONTROL) at IC1-2.

Component options:
D15, LK1, TR6 & R7 are fitted. D6, TR1 & LK2 are omitted.

The voltage at P1-3 is sourced from the mA error signal on the control PCB. In X-Ray On, when the mA demand exceeds the mA feedback this signal is +10.5V DC at maximum and -0.7V DC at minimum.

The maximum filament drive (limit) is set by potentiometer RV2 when the mA error signal is set at +10.5V DC.

In X-ray off, the mA error signal will be -0.7V DC. In this condition a minimum duty cycle (standby) is set by RV1 to enhance filament life.

3.5 RELAY PCB (OPTIONAL) (Dwg No. 17C-E027)

The Relay is powered from the 30VDC supply from the Filament Drive PCB. The Filament drive is input via a flying lead.

The Filament drive is then output on PL2 and connected to either filament transformer depending on the status of relay RL1.

Relay RL1 is turned on when a high signal is present on the Select input at PL1 pin 5.

The 30VDC is zenered down to 15VDC by D4. This voltage is fed back to the Control PCB as the Status signal (TP3) when the relay is not energised. An open circuit wire or failure of the 15VDC or 30VDC will cause the Control PCB to indicate the selection of the alternate filament. This is configured this way for safety reasons in the belief that the alternate filament drive is connected to a focal spot size of much lower power dissipation.

3.6 PSU PCB (Dwg No. 17C-E019)

This PCB contains the rectifiers and smoothing circuits and fuses for the four 18VDC supplies.

As mentioned in the Chassis Interconnection description there are two supplies referred to earth, these are in the circuits fused by FS1 and FS2 and can be measured at TP2 and TP3 with respect to TP1.

Also there are two supplies isolated from earth. These are the circuits fused by FS3 and FS4 and can be measured at TP5 and TP6 with respect to TP4.

3.7 GENERATOR TANK SCHEMATIC

FL100-1 (Dwg No. 17G-E031)
FL160-2 (Dwg No. 17G-E032)
FL225-1 (Dwg No. 17G-E234)

The connector at the top left of the circuit represents the flying lead to the FL Power PCB. Connection to the internal circuitry of the generator tank is via feed-through terminals in the oil-tight tank casing.

The output of the FC Power PCB is first stepped up by a high frequency transformer and then multiplied by a cascaded doubler to the output terminal.

Direct measurement of output current and voltage is also fed back to the FC Power PCB.

The output of the Filament transformer is rectified and smoothed on the Filament Output PCB.

The output of the Filament circuit is connected with the EHT output in the high voltage receptacle.

On generators with a '-1' suffix the output is connected as follows (160kV for example) :-

-160kV	C	
-160kV	L	
FIL.	S	

On generators with a '-2' suffix the output is connected as follows (160kV for example):-

-160kV	C	
FIL #1	L	"BROAD"
FIL #2	S	"FINE"

4.0 Field Adjustments and Waveforms

Some adjustments are factory set and others are available to tailor the unit to meet varying X-Ray tube and interface requirements.

The potentiometers on the IGBT power and Sub PCB's are factory set and are not to be modified.

4.1 LOGICAL X RAYS ON CONDITION (LOGICAL KV ON CONDITION)

All the logic and auxiliary powered drive circuits on the FC Series of generators can be checked without producing E.H.T.

The main supply should be isolated (PLB pins D and E or 4 and 5) and only auxiliary power supplied. Under these conditions all of the interface logic can be checked together with the high frequency drive circuitry.

The sub pcb contains circuitry to detect the level of the main supply. This has been introduced as an improvement from the FL series of generators, where there was a risk of damaging an expensive semiconductor fuse, should the main supply be applied whilst in an X-RAY's on condition. Because of this extra circuitry, the fuse has been eliminated.

In order to check high frequency drive circuitry without applying the main supply, the level detection circuitry must be overridden. This can be done by applying a link on the sub pcb between TP33 and TP31. **THE MAIN SUPPLY MUST NOT BE APPLIED WHEN THIS LINK IS IN PLACE, OTHERWISE CONSIDERABLE DAMAGE WILL BE DONE TO THE POWER PCB.**

4.2 POWER PCB WAVEFORMS

DO NOT MEASURE THESE WAVEFORMS WITH THE MAIN SUPPLY CONNECTED. Because the sub pcb contains circuits to ensure that the unit is not activated until the main supply is established, a temporary override of this circuit is necessary. Ensure that PL1 on the power pcb is disconnected, and then link TP31 and TP33 on the sub pcb. BEFORE RECONNECTING PL1, THE LINK MUST BE REMOVED. FAILURE TO DO THIS WILL RESULT IN SEVERE DAMAGE TO THE POWER PCB.

Switching Regulator Drive signal

Fig. 4.0 shows the switching regulator drive signal at TP48 wrt TP36 on the sub pcb in the X-Ray ON state.

Inverter IGBT Gate Drive

Fig. 4.1 shows the gate waveform at either of the IGBT's gate wrt source.

4.3 FILAMENT PCB ADJUSTMENT

The filament limit adjusts the maximum open loop drive to the filament.

Too high a level will cause a reduction in filament life and excess dissipation in the FILAMENT PCB. Too low a level will cause the beam current to limit under the desired level.

To adjust the filament limit, first remove the Power and Interface connectors from the Converter Chassis and wait two minutes for the internal supplies to discharge. Remove the Converter Chassis cover then apply power.

RV2 adjusts the limit for the filament drive. There is only one limit adjustment even though the MP1 or external signal is switching between BROAD and FINE.

Adjustment of the Filament limit is likely to be required at the initial installation of all generators manufactured by Gulmay. This is because the maximum filament voltage required to operate the X-ray tube satisfactorily is dependent on several variables. These variables are:- the type of X-ray tube being used, the length of the H.T. cable connecting the X-ray tube to the generator and the supply voltage to the generator.

To determine the optimum settings for the Filament limit potentiometers for Broad and Fine focuses the following procedure should be followed;-

a. From the manufacturers' data determine the minimum value of kV at maximum mA for the tube/generator combination for the Broad and, where applicable, the Fine focal spots.

b. If the generator is operated with an MP1 controller confirm that the correct generator/tube table has been selected using engineering codes 906 and 907 (see MP1 technical manual) and switch SW1/8 on the CPU pcb in the MP1 to the ON position. This will prevent the system switching off with error E19 when the mA is less than the demanded value.

c. With the Broad focus selected, set the kV and mA to give the minimum value of kV for the maximum mA. Switch X-rays ON.

d. If the mA indication reaches the demanded value, it is necessary to adjust the Filament Limit potentiometer RV2 on the Filament PCB, inside the generator, in a CLOCKWISE direction until the indicated mA drops slightly below the demanded vale. Then adjust RV2 ANTI-CLOCKWISE ½ turn.

e. If the mA indication does not reach the demanded value when X-rays are switched on, RV2 must be adjusted in an ANTI-CLOCKWISE direction until the required mA

indication is obtained. RV2 should then be adjusted a further ½ turn in an ANTI-CLOCKWISE direction. Switch off X-rays.

The other potentiometer on the Filament PCB (RV1) sets the output level in the X-Ray Off state. This setting is set low to preserve filament life.

Waveforms from the Filament PCB are shown in Figs. 4.2, 4.3 and 4.4. They are all measured at TP6 or TP7 with respect to TP1.

Fig. 4.2 shows the "Filament Standby" waveform in X-Ray Off, this can be readjusted with RV1.(Clockwise to increase).

Fig. 4.3 shows a "Filament in Limit" waveform and can be readjusted with RV2. The need for readjustment comes about through tolerances in X-Ray tube characteristics and the differing lengths of E.H.T. cable.(Anti-clockwise to increase).

Fig. 4.4 shows the "Filament Open Circuit" waveform. It can be seen that the natural frequency of the waveform oscillation is lower.

5.0 TROUBLE SHOOTING

5.1 WARNINGS

Trouble shooting should only be attempted by qualified personnel who have been trained by the suppliers of the X-Ray System.

Dangerous voltages exist inside the converter chassis as well as the obvious dangers of the E.H.T. output and X-Radiation as warned of in sections 1.1 and 1.2.

Flow charts are given for the following conditions:-

Fig. 5.1	NO kV AT SWITCH ON
Fig. 5.2	NO BEAM CURRENT
Fig. 5.3	OVER kV
Fig. 5.4	OVER mA
Fig. 5.5	CONVERTER OVER CURRENT
Fig. 5.6	CONVERTER OVER VOLTAGE

5.2 DC LINE MEASUREMENTS

A useful check on the performance of the UC Generator is to measure the value of V-REG on the Power PCB. This is the regulated DC line which feeds the high frequency inverter. The voltage can be measured at TP11(+) wrt TP10(-). **THE VOLTAGE IS NOT REFERRED TO EARTH AND CAN BE AS HIGH AS 250VDC, OR 380VDC IN A FAULT.**

Some typical figures are given here. A 10% variation could be expected from unit to unit.

Type	kV	mA	V DC
FC100	100	0	190
FC100	100	6.0	212
FC160	160	0	196
FC160	160	4.0	230
FC225	225	0	185
FC225	225	2.8	220

These figures may be a useful guide in diagnosing problems with multipliers and feedback circuits.

6.0 Spare Parts

This section details sub assembly ordering information.

6.1 Converter Chassis

DESCRIPTION	PART No.	ASSY No.
FL CONTROL PCB ASSY	17C-A009[1]	
IGBT POWER PCB ASSY	17C-A278[1]	
IGBT SUB PCB ASSY	17C-A283	AS0905
IGBT DRIVE PCB ASSY	17C-A300	AS0908
FL RELAY PCB ASSY (FL160-2 ONLY)	17C-A028	AS0831
FL PSU PCB ASSY	17C-A020	AS0830
FC REGULATED FILAMENT PCB		AS0904

6.2 Generator Tank

DESCRIPTION	PART No.	ASSY No.
MULTIPLIER ASSY TYPE A	15G-B087	AS0567
MULTIPLIER ASSY TYPE B	15G-B088	AS0568
SURGE RESISTOR ASSY (100kV,160kV)	17GB039	AS0559
SURGE RESISTOR ASSY (225kV)	20GB020	AS0667
STEP UP TXFMR ASSY (100kV,160kV)	15G-A078	AS0550
STEP UP TXFMR ASSY (225kV)	22G-A008	AS0552

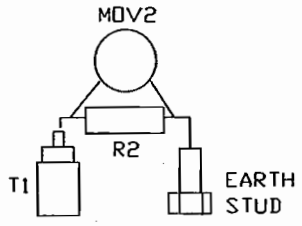
[1] Please specify unit type when ordering this PCB.

THIRD ANGLE PROJECTION

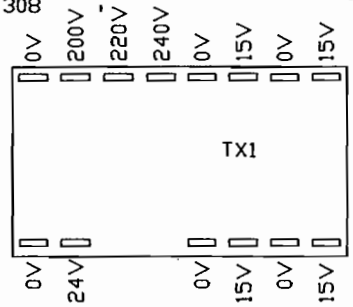
PREPARED IN ACCORDANCE WITH BS 308

0 50

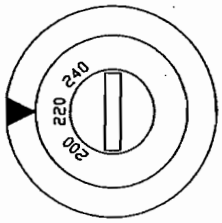
50 MILLIMETRES FULL SIZE



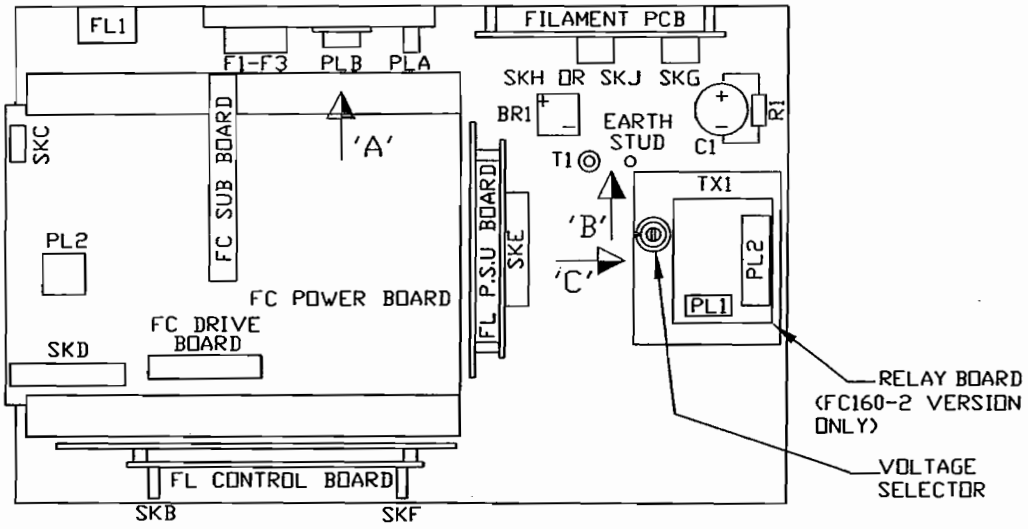
VIEW ON ARROW 'B'

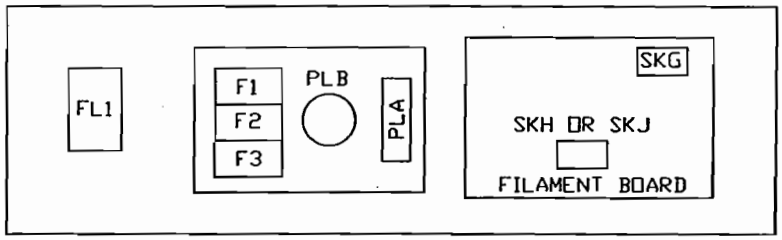


VIEW ON ARROW 'C'



VOLTAGE SELECTOR





VIEW ON ARROW 'A'

CAD PRODUCED DRAWING NO MANUAL ALTERATION							
SCALE N.T.S	MATERIAL NONE	FINISH NONE					
DIMS. IN MILLIMETRES	TOLERANCE - WHOLE No. ±0.5mm ONE DEC. PL. ±0.2mm ANGLE ±0° 30'				A	11-01-02	1st PROD. ISSUE
APPD. DES.			ISSUE	DATE	CHANGE REF.	ISSUE	DATE	CHANGE REF.
			© GULMAY LTD AS PER DATE OF ISSUE HEREOF					
CHECKED	SURFACE FINISH 3.2 UNLESS OTHERWISE STATED		TITLE FC CHASSIS COMPONENT LAYOUT				
DRAWN C.R. AUTON 11-01-02	GULMAY LIMITED CHERTSEY SURREY ENGLAND		DRAWING No. 17C-A344			SHEET No 1 OF 1	

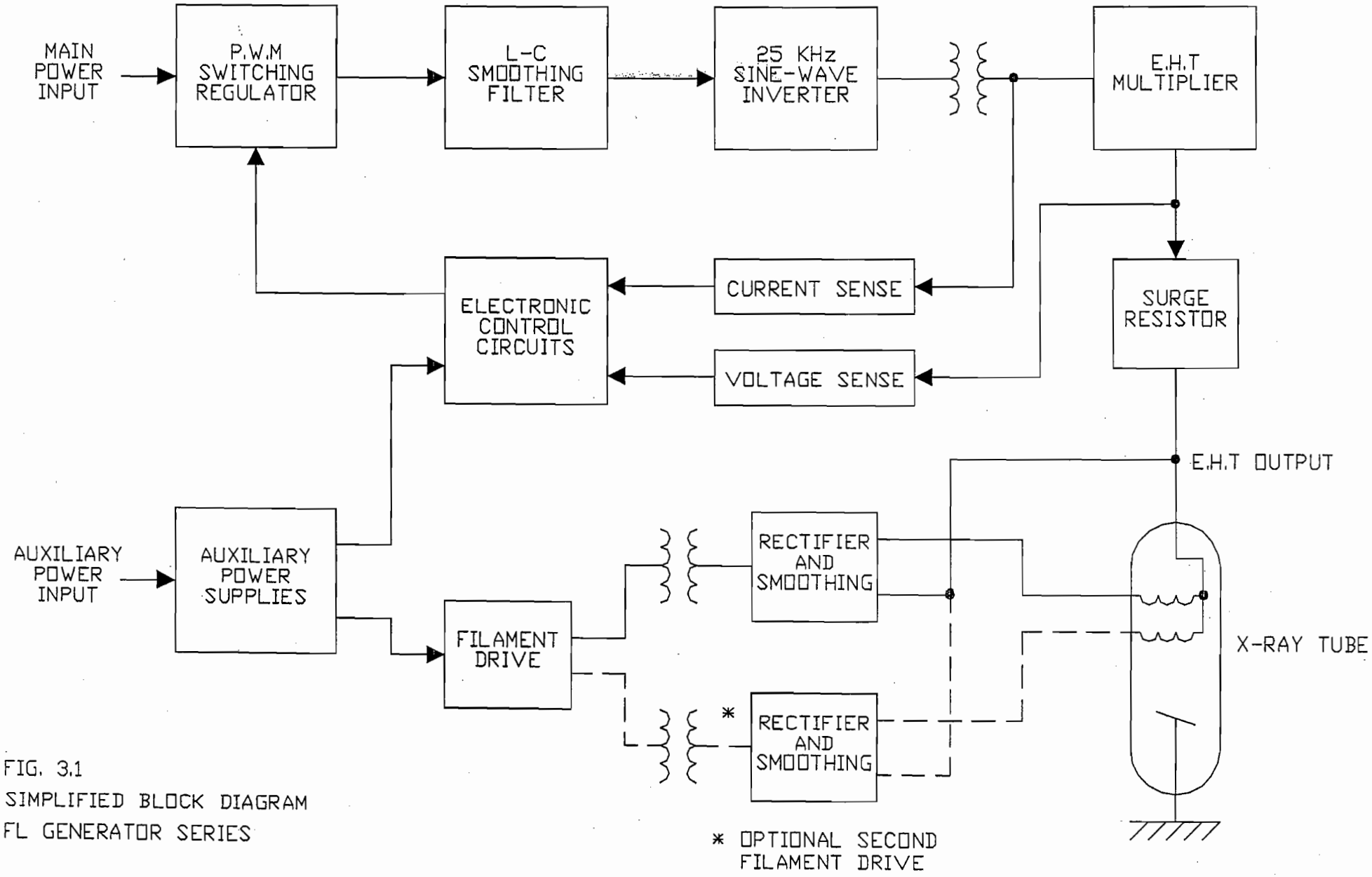
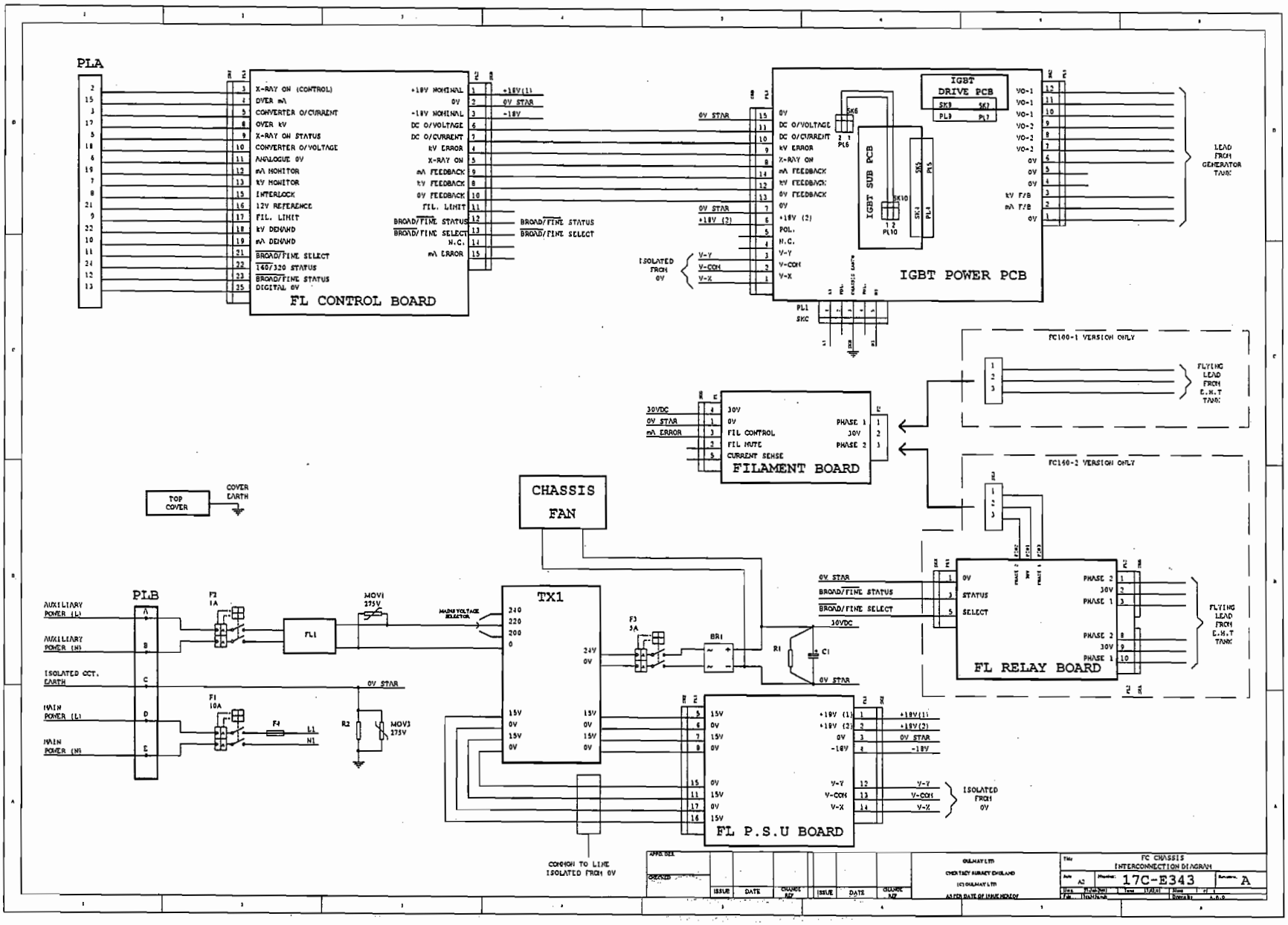
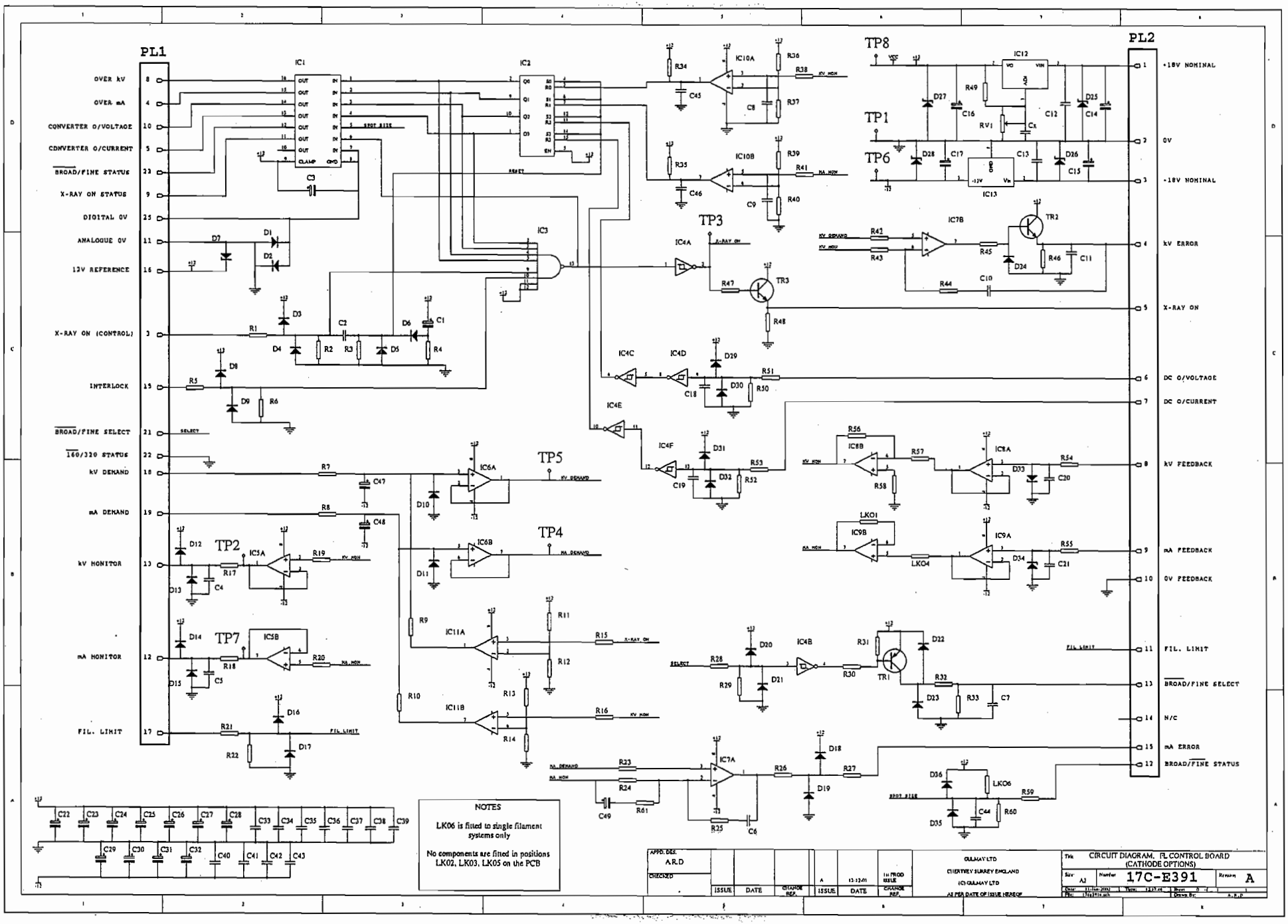
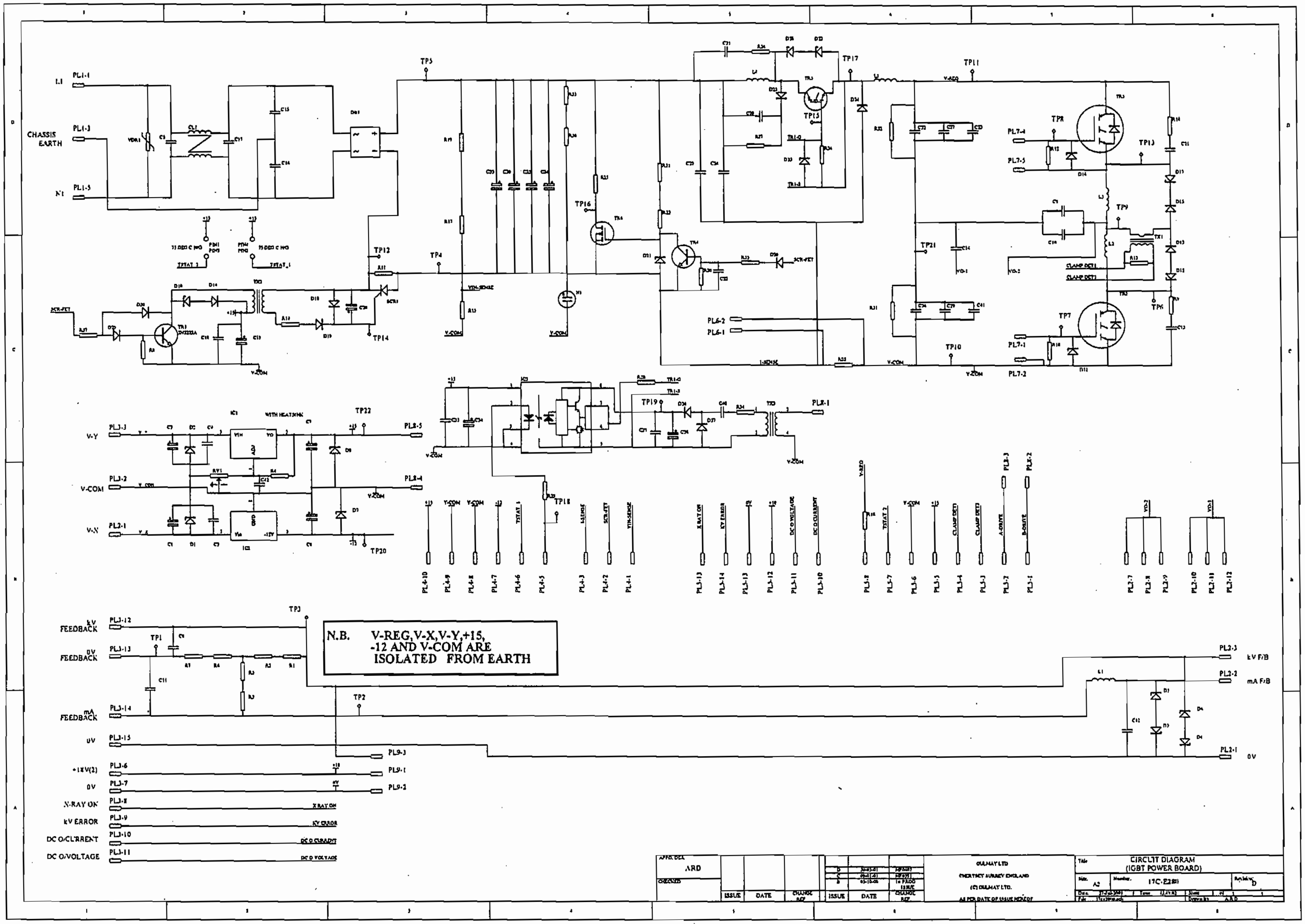


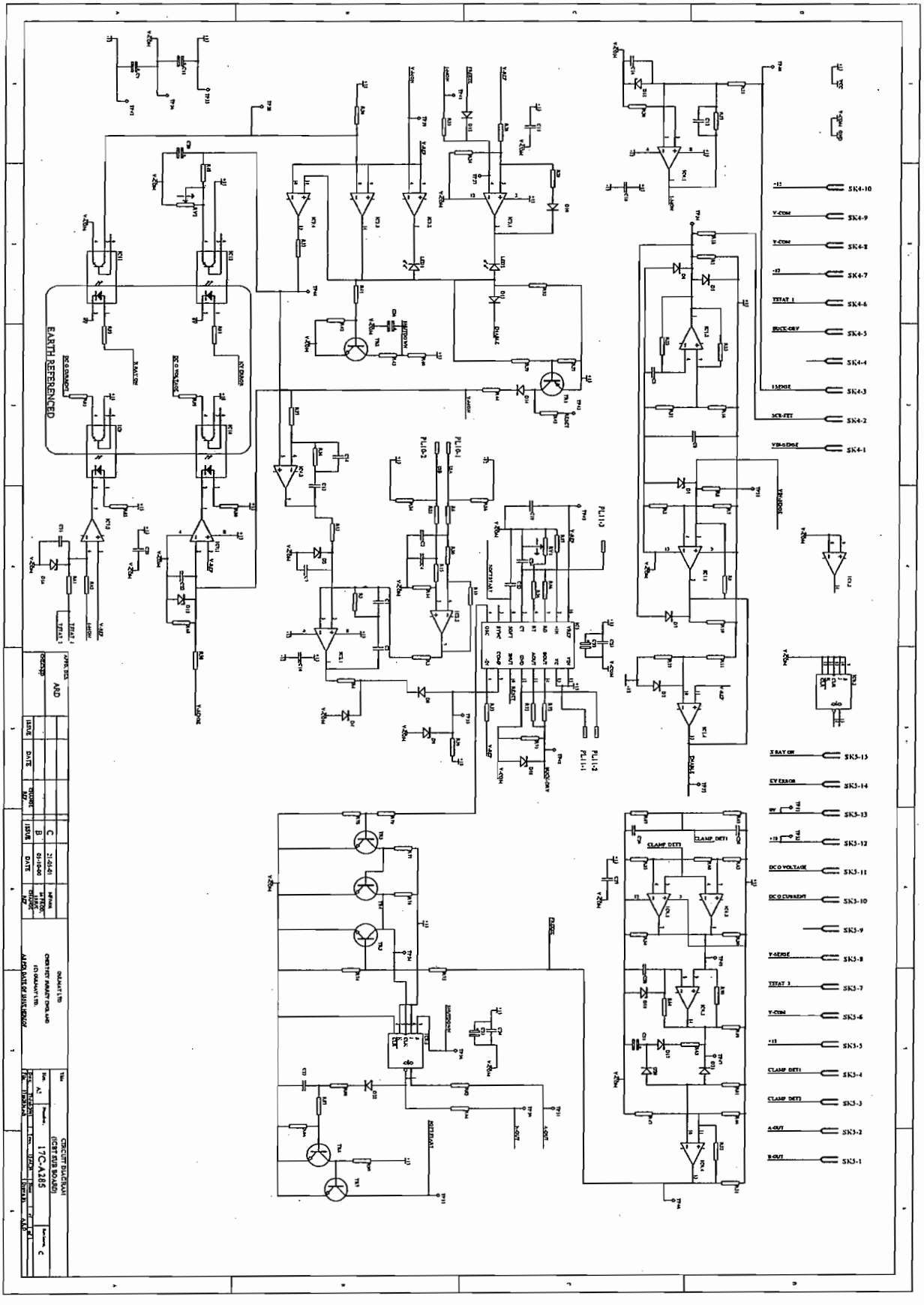
FIG. 3.1
SIMPLIFIED BLOCK DIAGRAM
FL GENERATOR SERIES

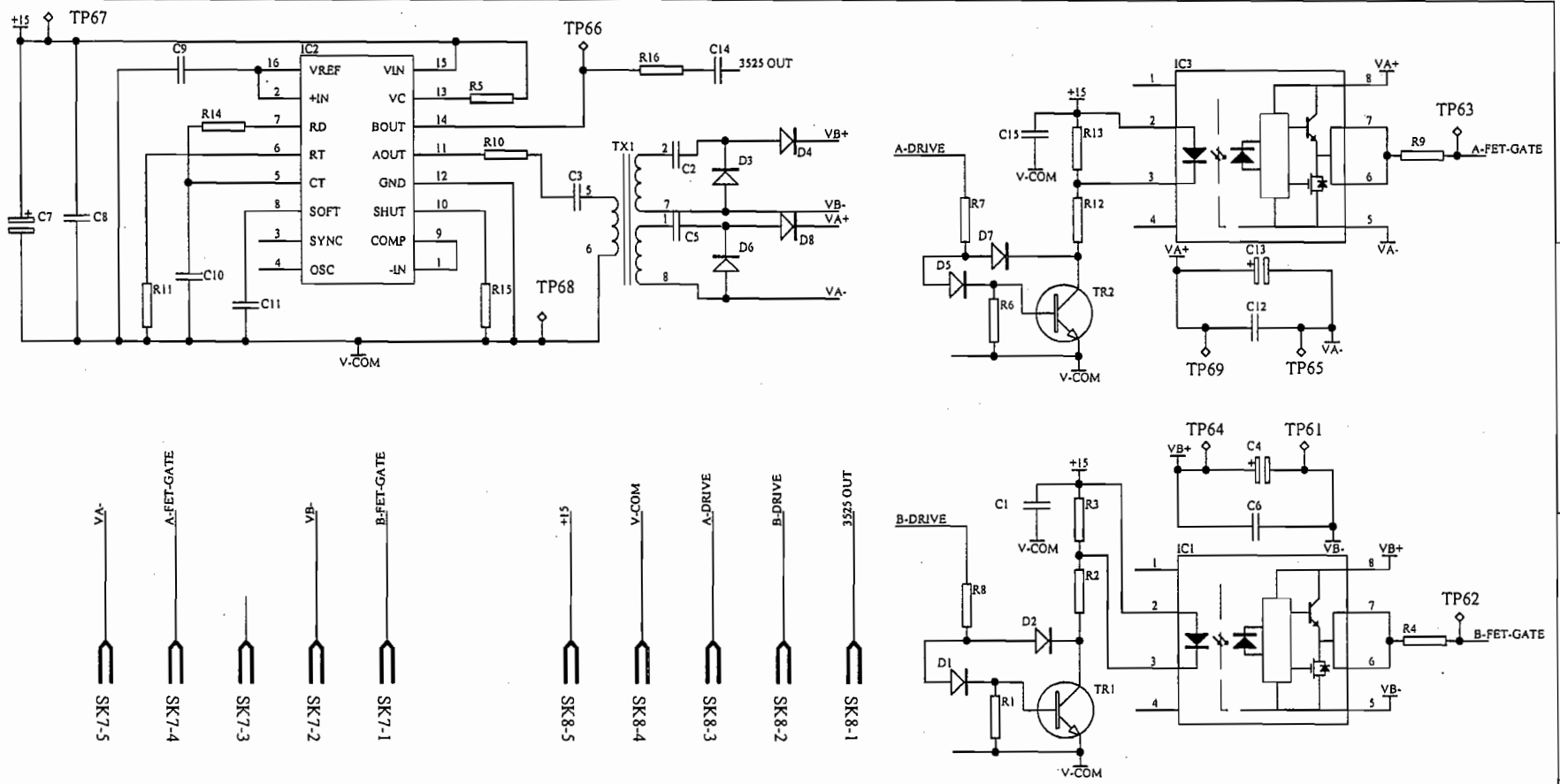
* OPTIONAL SECOND FILAMENT DRIVE


PLA
X-RAY ON (CONTROL)
OVER mA
CONVERTER O/CURRENT
OVER kV
X-RAY ON STATUS
CONVERTER O/VOLTAGE
ANALOGUE 0V
mA MONITOR
kV MONITOR
INTERLOCK
12V REFERENCE
FIL. LIMIT
kV DEMAND
mA DEMAND
BROAD/FINE SELECT
140/320 STATUS
BROAD/FINE STATUS
DIGITAL 0V
+18V NOMINAL
0V
-18V NOMINAL
DC O/VOLTAGE
DC O/CURRENT
kV ERROR
X-RAY ON
mA FEEDBACK
kV FEEDBACK
0V FEEDBACK
FIL. LIMIT
BROAD/FINE STATUS
BROAD/FINE SELECT
N.C.
mA ERROR
FL CONTROL BOARD
+18V(1)
0V STAR
-18V
BROAD/FINE STATUS
BROAD/FINE SELECT
IGBT DRIVE PCB
IGBT SUB PCB
IGBT POWER PCB
0V
DC O/VOLTAGE
DC O/CURRENT
kV ERROR
X-RAY ON
mA FEEDBACK
kV FEEDBACK
0V FEEDBACK
+18V (2)
POL.
N.C.
V-Y
V-COM
V-X
ISOLATED FROM 0V
VO-1
VO-2
VO-3
kV F/B
mA F/B
LEAD FROM GENERATOR TANK
FC100-1 VERSION ONLY
FLYING LEAD FROM E.H.T TANK
30VDC
0V STAR
mA ERROR
30V
0V
FIL CONTROL
FIL MUTE
CURRENT SENSE
PHASE 1
PHASE 2
FILAMENT BOARD
FC160-2 VERSION ONLY
TOP COVER
COVER EARTH
CHASSIS FAN
PLB
AUXILIARY POWER (L)
AUXILIARY POWER (N)
ISOLATED OCT. EARTH
MAIN POWER (L)
MAIN POWER (N)
F1 10A
F2 1A
F3 3A
F4
FL1
MOV1 275V
MOV2 275V
R1
R2
C1
BR1
L1
N1
MAINS VOLTAGE SELECTOR
240
220
200
0
TX1
24V
0V
15V
0V STAR
BROAD/FINE STATUS
BROAD/FINE SELECT
STATUS
SELECT
FL RELAY BOARD
FLYING LEAD FROM E.H.T TANK
+18V (1)
+18V (2)
-18V
FL P.S.U BOARD
COMMON TO LINE ISOLATED FROM 0V
GALWAY LTD
CHERTSEY SURREY ENGLAND
(C) GALWAY LTD
AS PER DATE OF ISSUE HEREOF
FC CHASSIS
INTERCONNECTION DIAGRAM
17C-E343
A
ISSUE
DATE
CHANGE REF

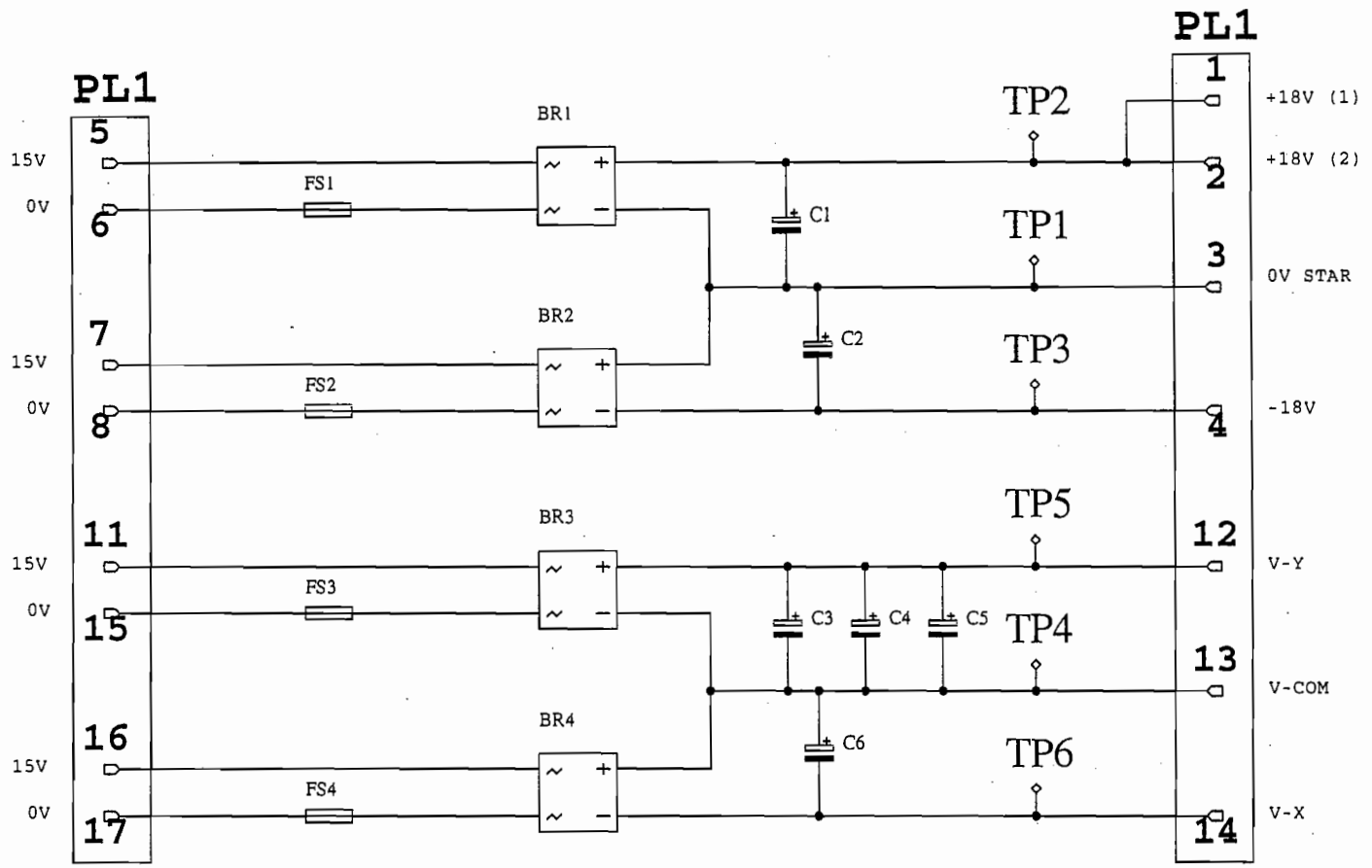

PL1
PL2
OVER kV
OVER mA
CONVERTER O/VOLTAGE
CONVERTER O/CURRENT
BROAD/FINE STATUS
X-RAY ON STATUS
DIGITAL 0V
ANALOGUE 0V
12V REFERENCE
X-RAY ON (CONTROL)
INTERLOCK
BROAD/FINE SELECT
160/320 STATUS
kV DEMAND
mA DEMAND
kV MONITOR
mA MONITOR
FIL. LIMIT
+18V NOMINAL
0V
-18V NOMINAL
kV ERROR
X-RAY ON
DC O/VOLTAGE
DC O/CURRENT
kV FEEDBACK
mA FEEDBACK
0V FEEDBACK
FIL. LIMIT
BROAD/FINE SELECT
N/C
mA ERROR
BROAD/FINE STATUS
TP1
TP2
TP3
TP4
TP5
TP6
TP7
TP8
IC1
IC2
IC3
IC4A
IC4B
IC4C
IC4D
IC4E
IC4F
IC5A
IC5B
IC6A
IC6B
IC7A
IC7B
IC8A
IC8B
IC9A
IC9B
IC10A
IC10B
IC11A
IC11B
IC12
IC13
TR1
TR2
TR3
NOTES
LK06 is fitted to single filament systems only
No components are fitted in positions LK02, LK03, LK05 on the PCB
GULMAY LTD
CHERTSEY SURREY ENGLAND
(C) GULMAY LTD
AS PER DATE OF ISSUE HEREOF
CIRCUIT DIAGRAM. PL CONTROL BOARD (CATHODE OPTIONS)
17C-E391
A


N.B. V-REG,V-X,V-Y,+15,
-12 AND V-COM ARE
ISOLATED FROM EARTH
L1
CHASSIS EARTH
N1
V-Y
V-COM
V-X
kV FEEDBACK
DV FEEDBACK
mA FEEDBACK
0V
+18V(2)
0V
X-RAY ON
kV ERROR
DC O/CURRENT
DC O/VOLTAGE
kV F/B
mA F/B
0V
ARD
ISSUE
DATE
CHANGE NO
GULMAY LTD
CHERTSEY SURREY ENGLAND
(C) GULMAY LTD.
CIRCUIT DIAGRAM
(IGBT POWER BOARD)
17C-E281


EARTH REFERENCED
SK4-10
SK4-9
SK4-8
SK4-7
SK4-6
SK4-5
SK4-4
SK4-3
SK4-2
SK4-1
SK3-15
SK3-14
SK3-13
SK3-12
SK3-11
SK3-10
SK3-9
SK3-8
SK3-7
SK3-6
SK3-5
SK3-4
SK3-3
SK3-2
SK3-1
17C-A185

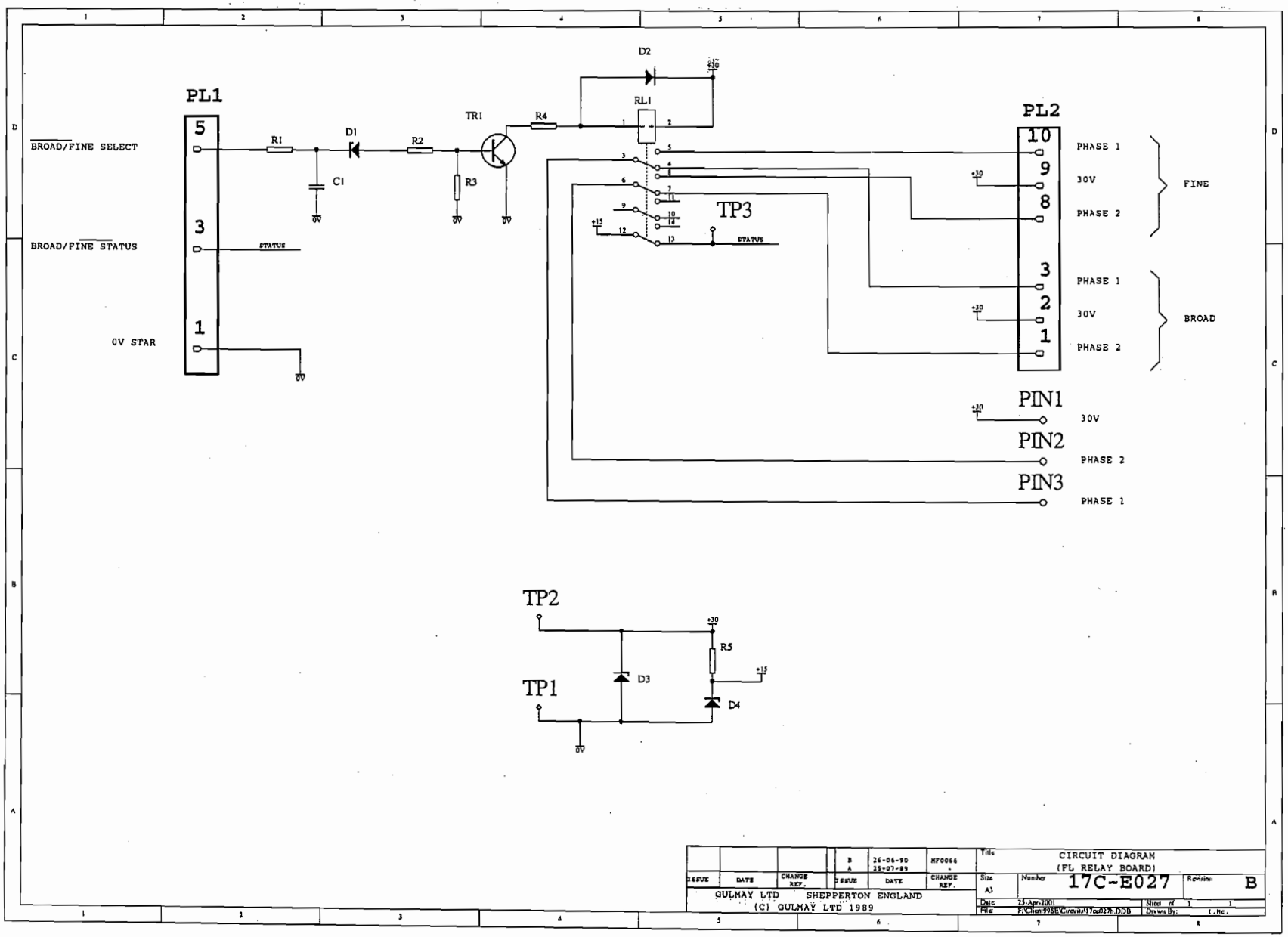


APPD. DES.								
ARD				C	21-02-01	MF0394	GULMAY LTD	Title: CIRCUIT DIAGRAM (IGBT DRIVE BOARD)
CHECKED				B	09-01-01	MF0389	CHERTSEY SURREY ENGLAND	Size: A4 — Number: 17C-E302 — Revision: C
				A	26-09-00	1st PROD ISSUE	(C) GULMAY LTD.	Date: 27-Jul-2001 — Time: 13:42:13 — Sheet 1 of 1 of 1
	ISSUE	DATE	CHANGE REF.	ISSUE	DATE	CHANGE REF.	AS PER DATE OF ISSUE HEREOF	File: 17CE302C.SCH — Drawn By: A.R.D



GULMAY LTD SHEPPERTON ENGLAND

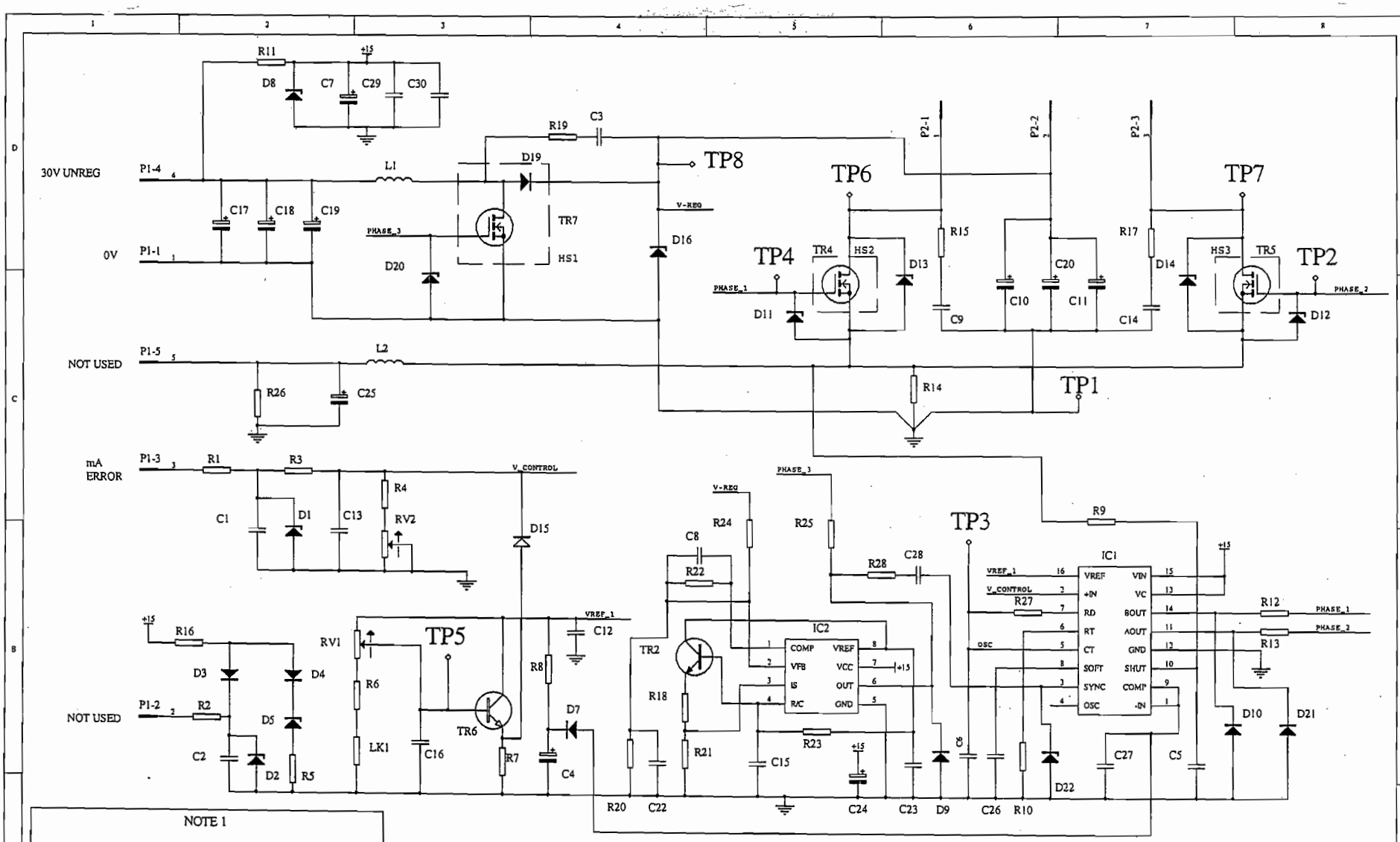
Title: CIRCUIT DIAGRAM (FL P.S.U. BOARD)		
Size: A4	Number: 17C-E019	Revision: A
Date: 25-Apr-2001		Sheet of 1
File: F:\Client99SE\Circuits\17ce019a.DDB		Drawn By: I.Mc.



ISSUE	DATE	CHANGE REF.	ISSUE	DATE	CHANGE REF.
			B	26-06-90	MF0066
			A	25-07-89	

GULMAY LTD SHEPPERTON ENGLAND

Title: CIRCUIT DIAGRAM (FL RELAY BOARD)
Size: A3
Number: 17C-E027
Revision: B
Date: 23-Apr-2001
File: F:\Client\93E\Circuits\17ce027h.DDB
Sheet of 1 1
Drawn By: I. Mc.



NOTE 1

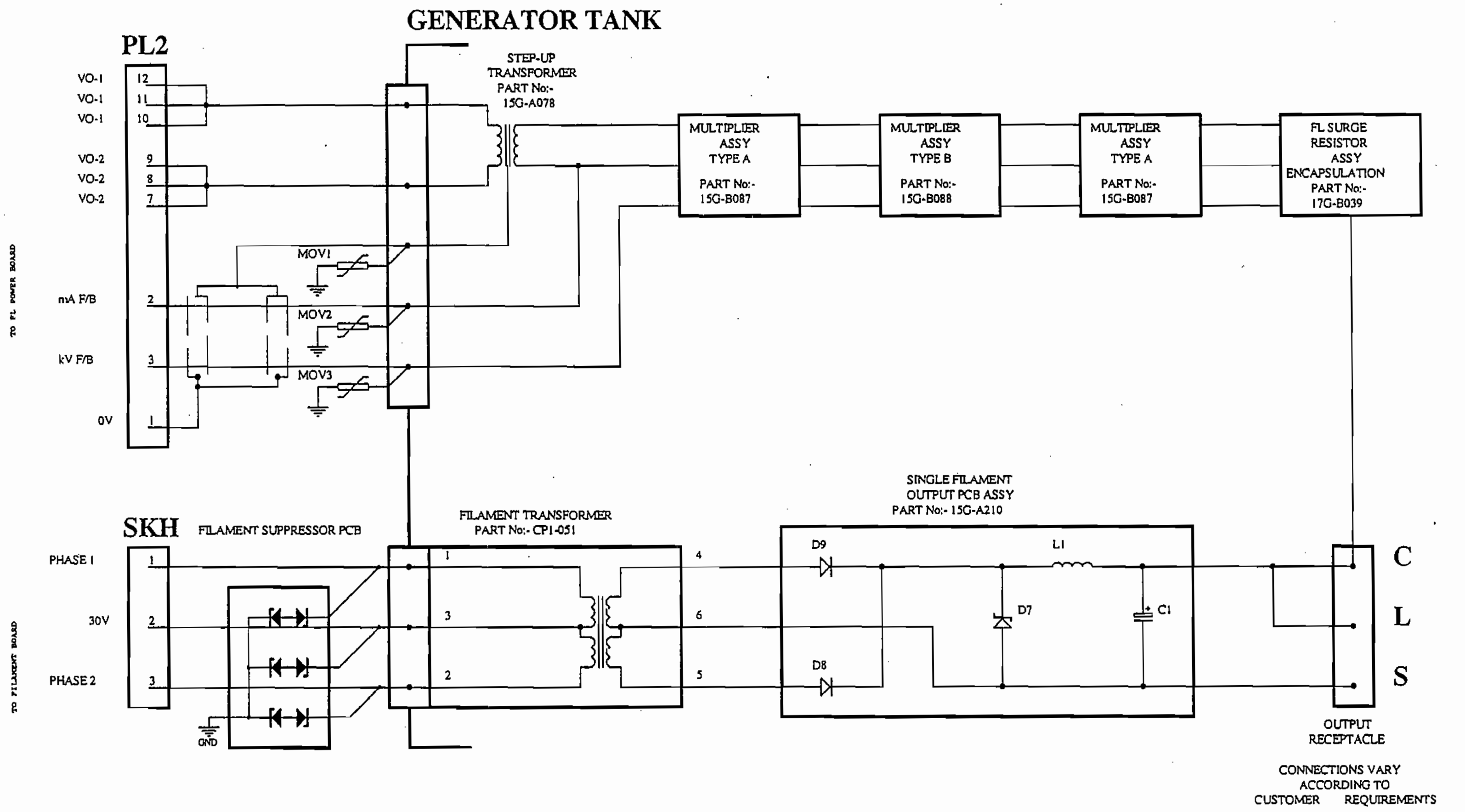
ADJUSTMENTS

RV1 :- Standby Adjust RV2 :- Limit Adjust
Clockwise reduces limit (RV2) and increases standby (RV1)

NOTE 2

No components are fitted in positions
D6, LK2, and TR1 on the PCB

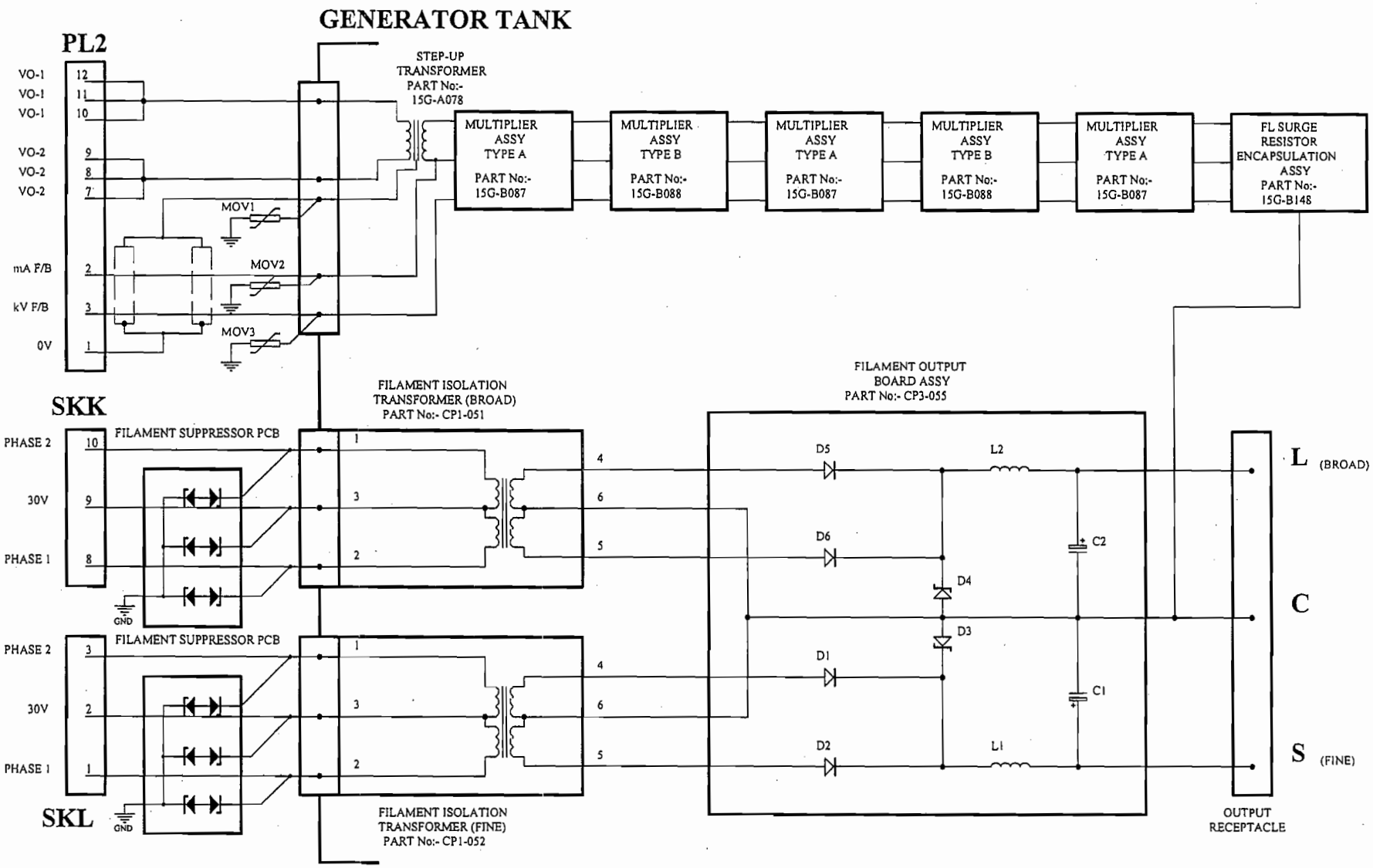
APPD. DES.							GULMAY LTD	Title: CIRCUIT DIAGRAM, REGULATED FILAMENT PCB (FC,FL OPTIONS)	
A.R.D							CHERTSEY SURREY ENGLAND	Size: A3	Number: 17CE390
CHECKED							(C) GULMAY LTD.		Revision: A
	ISSUE	DATE	CHANGE REF.	A ISSUE	23-11-01 DATE	1st PROD ISSUE CHANGE REF.	AS PER DATE OF ISSUE HEREOF	Date: 1-Jan-2002 Time: 12:14:39 Sheet 1 of 1	
								File: 17ce390a.sch	Drawn By: A.R.D



APPD. DES.				ISSUE	DATE	CHANGE REF.
CHECKED				C	13-10-95	MF0267
				B	08-10-91	MF0118
	ISSUE	DATE	CHANGE REF.	A	26-07-89	

GULMAY LIMITED
SHEPPERTON MIDDLESEX ENGLAND

Title: FL100-1 GENERATOR TANK SCHEMATIC
Size: A3 | Number: 17G-E031 | Revision: C
Date: 25-Apr-2001 | Sheet 1 of 1
File: F:\Client99SE\Circuits\17ge031c.DDB | Drawn By: I.MC.

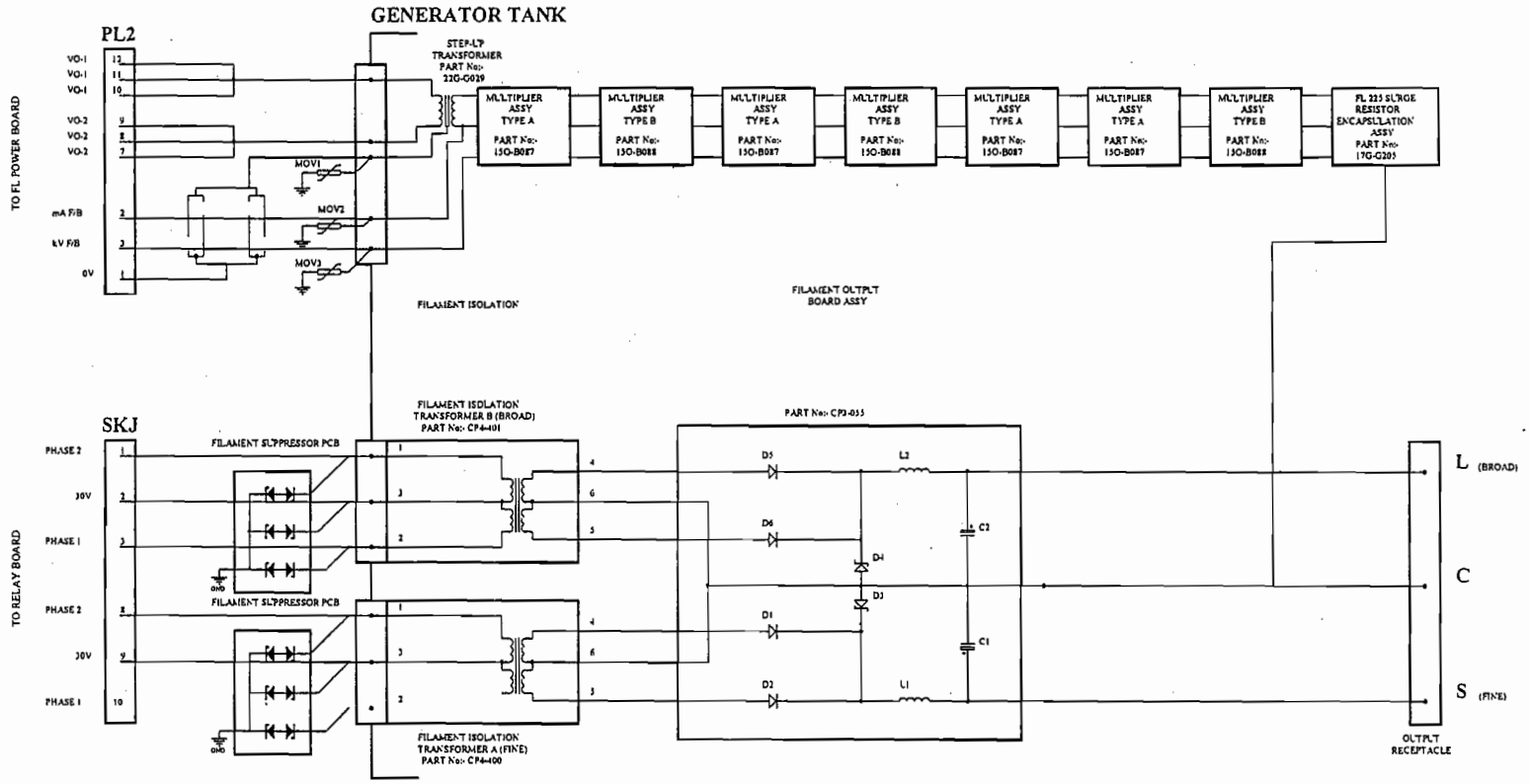


APPD. DES.							
CHECKED							
	ISSUE	DATE	CHANGE REF.		ISSUE	DATE	CHANGE REF.
				D	09-11-01	MF0423	
				C	25-10-95	MF0267	
				B	15-01-90	MF0028	
				A	25-07-89	-	

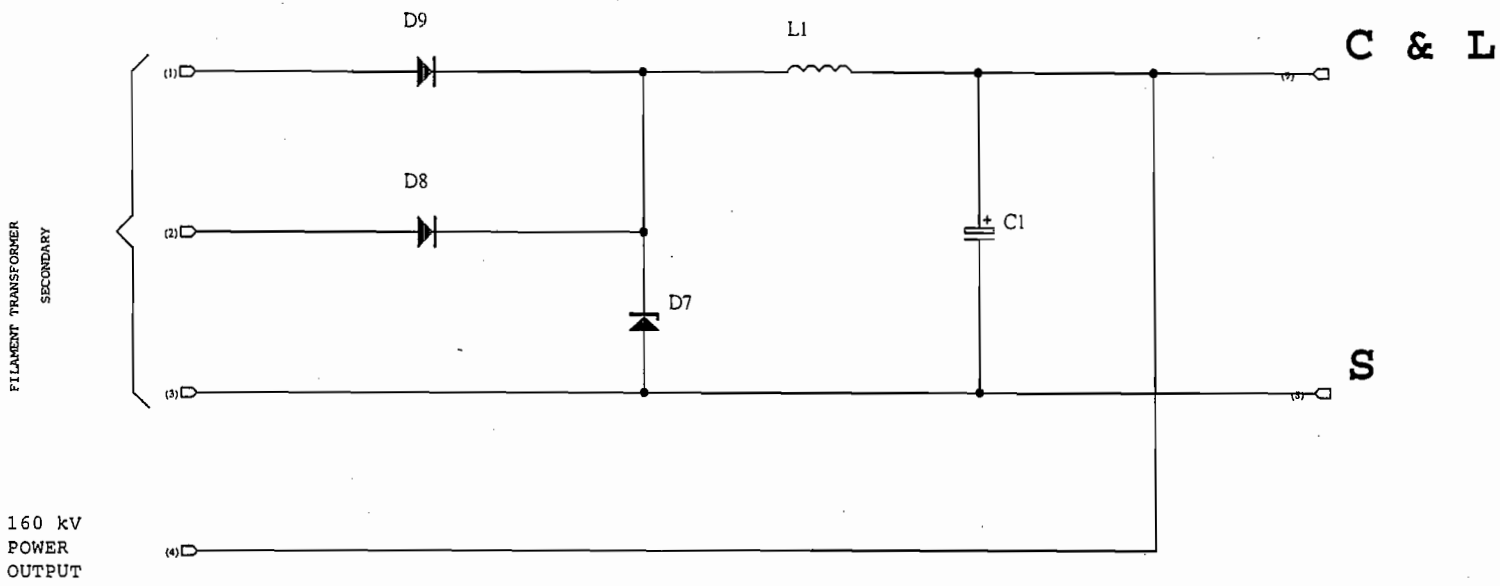
GULMAY LTD
CHERTSEY SURREY ENGLAND
(C) GULMAY LTD.
AS PER DATE OF ISSUE HEREOF

Title: FL160-2 GENERATOR TANK SCHEMATIC

Size: A3	Number: 17G-E032	Revision: D
Date: 12-Nov-2001	Time: 16:53:07	Sheet 0 of 1
File: 17ge032d.sch		Drawn By: I.MC.

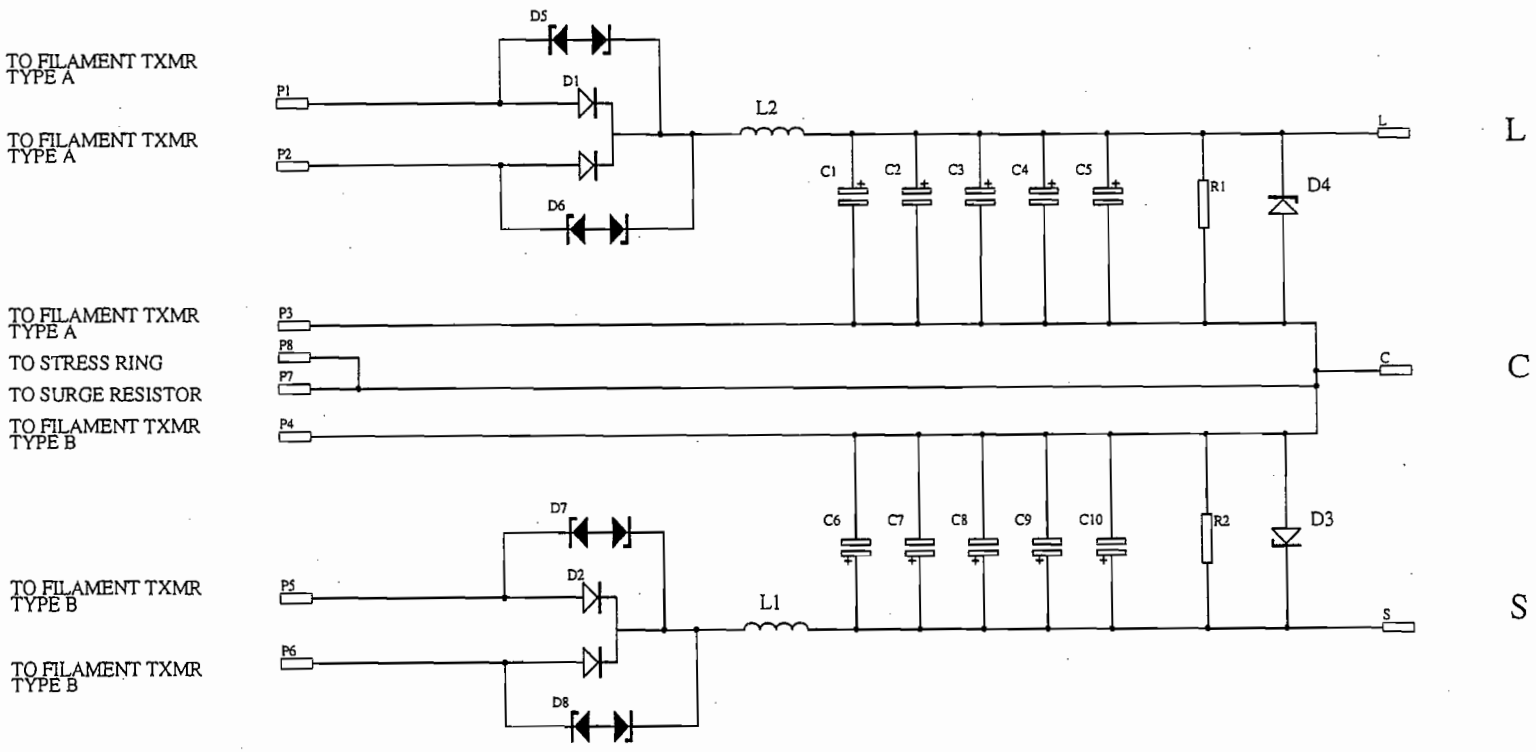


APPD. DCE							GULMAY LIMITED	TITLE	FL225-2 GENERATOR TANK SCHEMATIC
CHK'D							SHEPPERTON MIDDLESEX ENGLAND	No.	DRAWING 17G-E234	REVISION A
	ISSUE	DATE	CHANGE A/Z	A	MAKE	21-10-93 DATE	CHANGE A/Z	(C) GULMAY LTD. AS PER DATE OF ISSUE HEREOF	DWG	21-Feb-2001	SHEET 01



USED ON SINGLE FILAMENT FL GENERATORS ONLY

GULMAY LTD SHEPPERTON ENGLAND (C) GULMAY LTD 1989			
Title	CIRCUIT DIAGRAM (FL FILAMENT OUTPUT BOARD)		
Size A4	Number 17G-E033		Revision A
Date:	25-Apr-2001	Sheet of	1
File:	F:\Client99SE\Circuits\17ge033a.DDB	Drawn By: I.MC.	



APPD. DES.							
CHECKED							
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					E	22-07-99	CP0296
					D	01-02-94	CP0185
					C	16-07-92	CP0150
					B	15-01-90	CP0028
					1	25-11-88	-

GULMAY LIMITED

CHERTSEY SURREY ENGLAND

AS PER DATE OF ISSUE HEREOF

Title	FILAMENT OUTPUT PCBCIRCUIT DIAGRAM		
Size A4	Number **CP4-059**		Revision **E**
Date:	25-Apr-2001	Sheet 1of 1	
File:	F:\Client99SE\Circuits\Cp4059e.DDB	Drawn By:	J.S.Hall

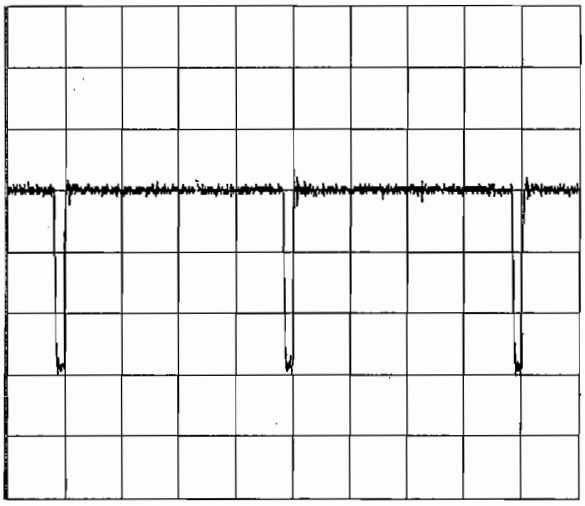


Fig 4.0 – Regulator Drive Waveform 0.5V/Div, 5μs/Div

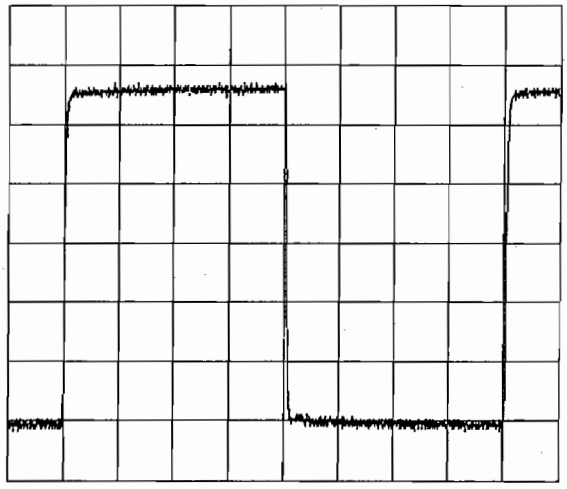


Fig 4.1 – Inverter IGBT Gate Drive Waveform 2V/Div, 5μs/Div

FCFIG40.PDW

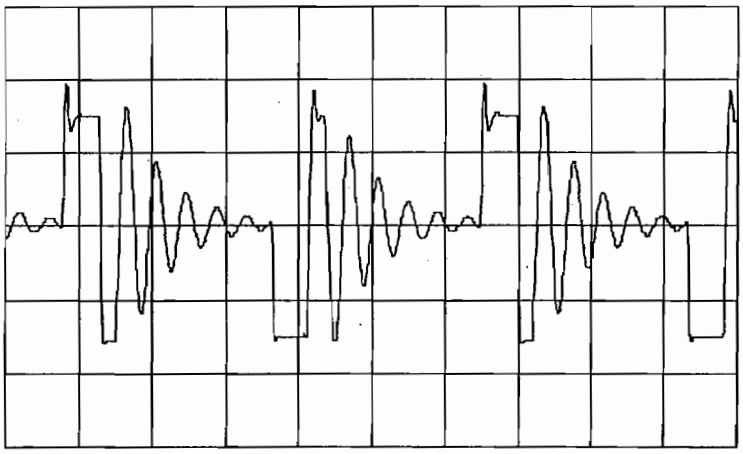


FIG 4.2

FILAMENT STANDBY

5.0 MICS

20.0 V

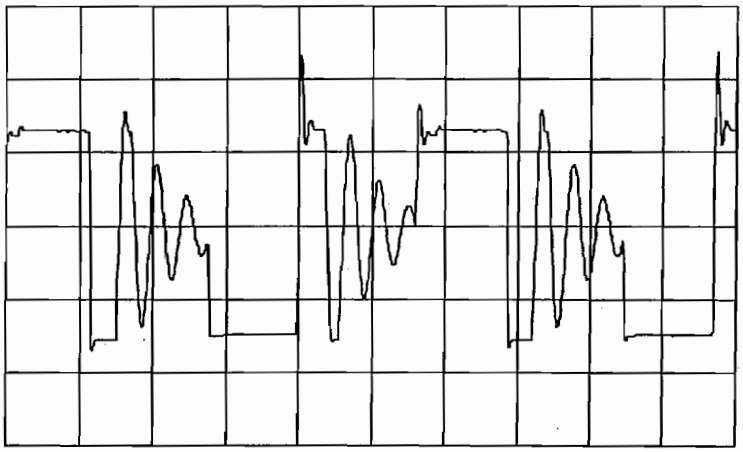


FIG 4.3

FILAMENT IN LIMIT

5.0 MICS

20.0 V

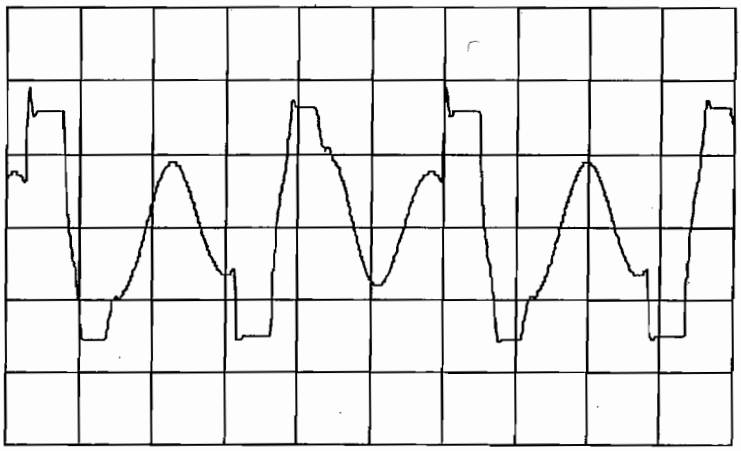
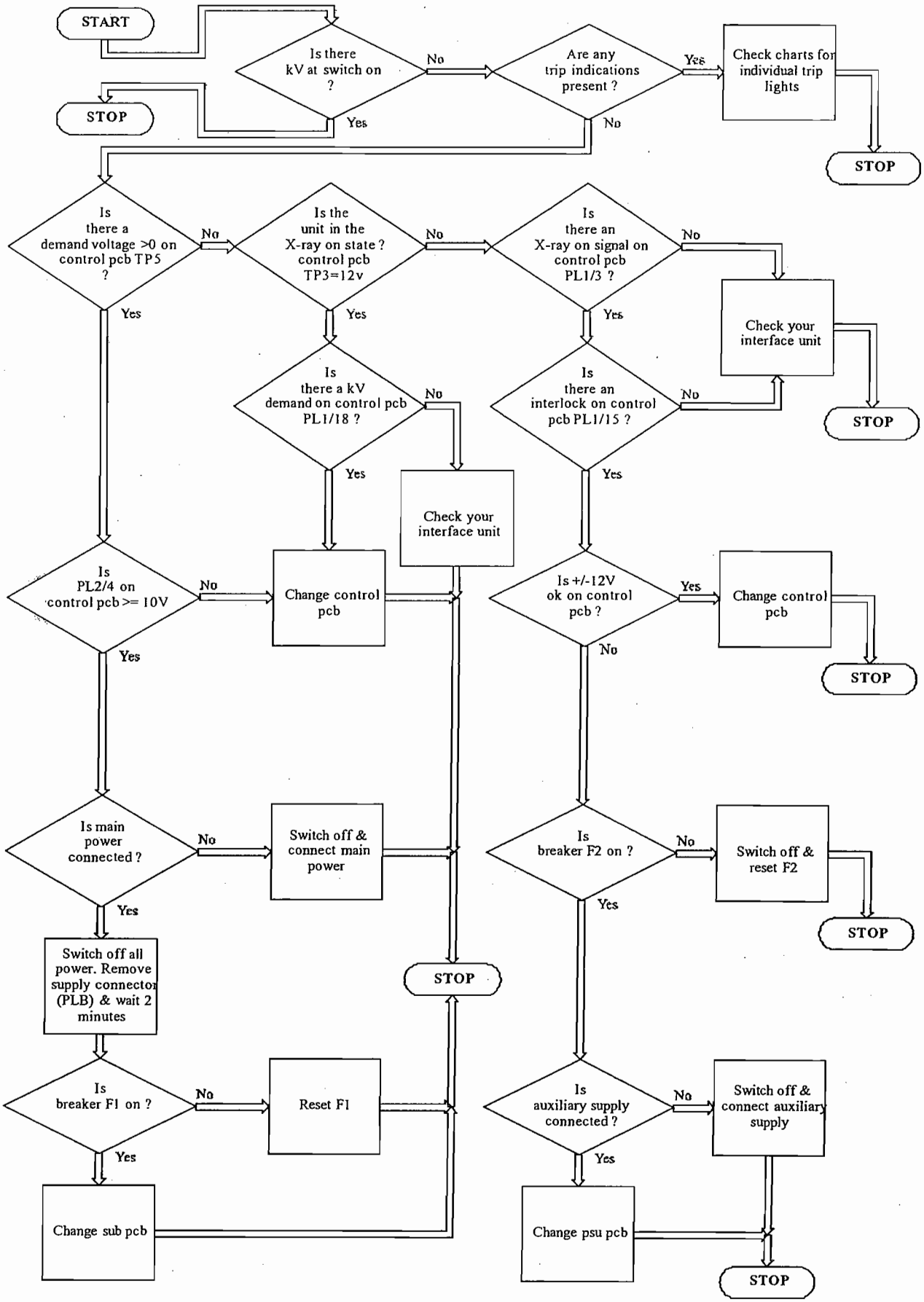


FIG 4.4

FILAMENT OPEN CIRCUIT

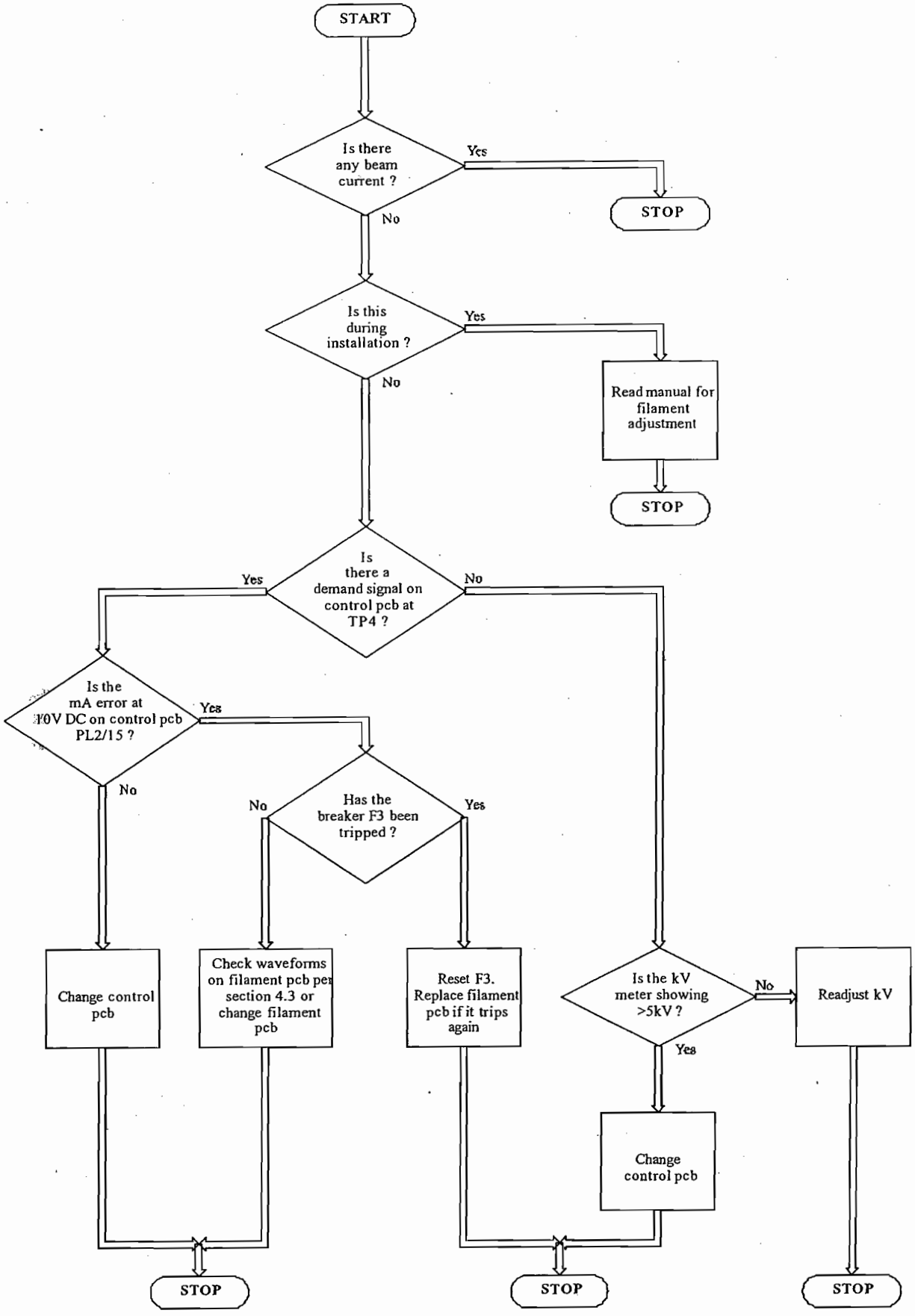
5.0 MICS

20.0 V



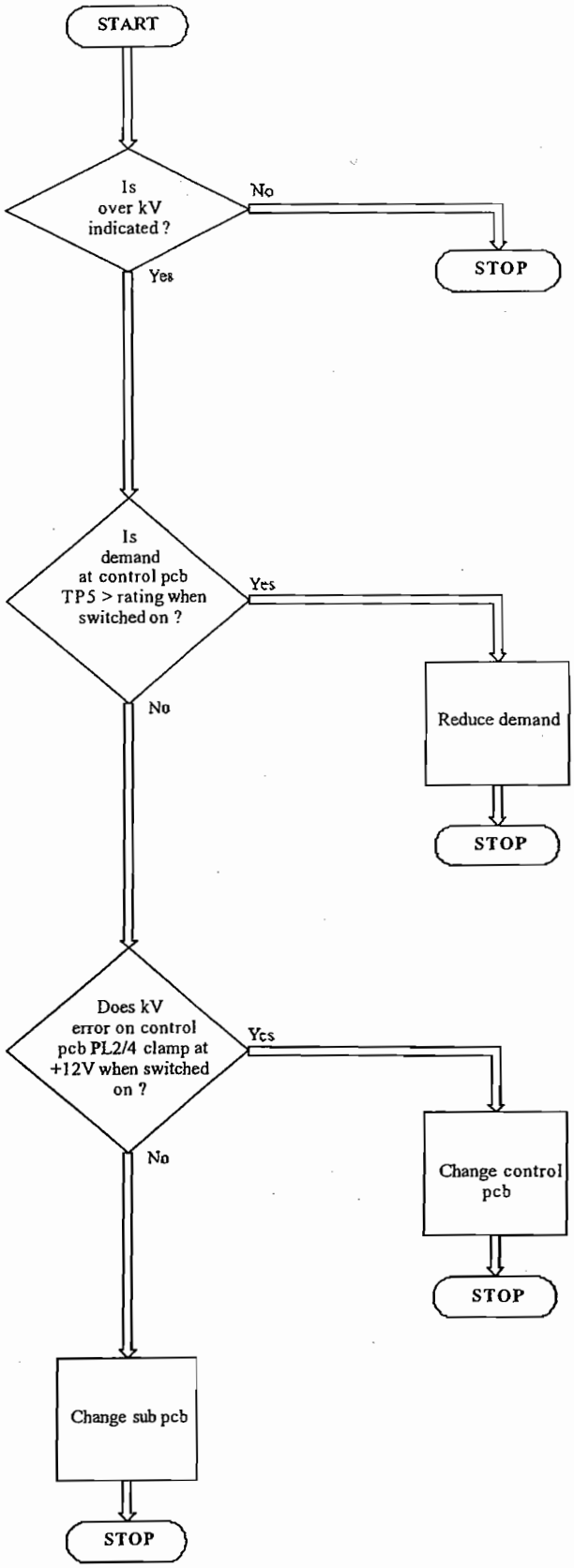
FLFIG51B.PDW

FIG. 5.1 NO kV



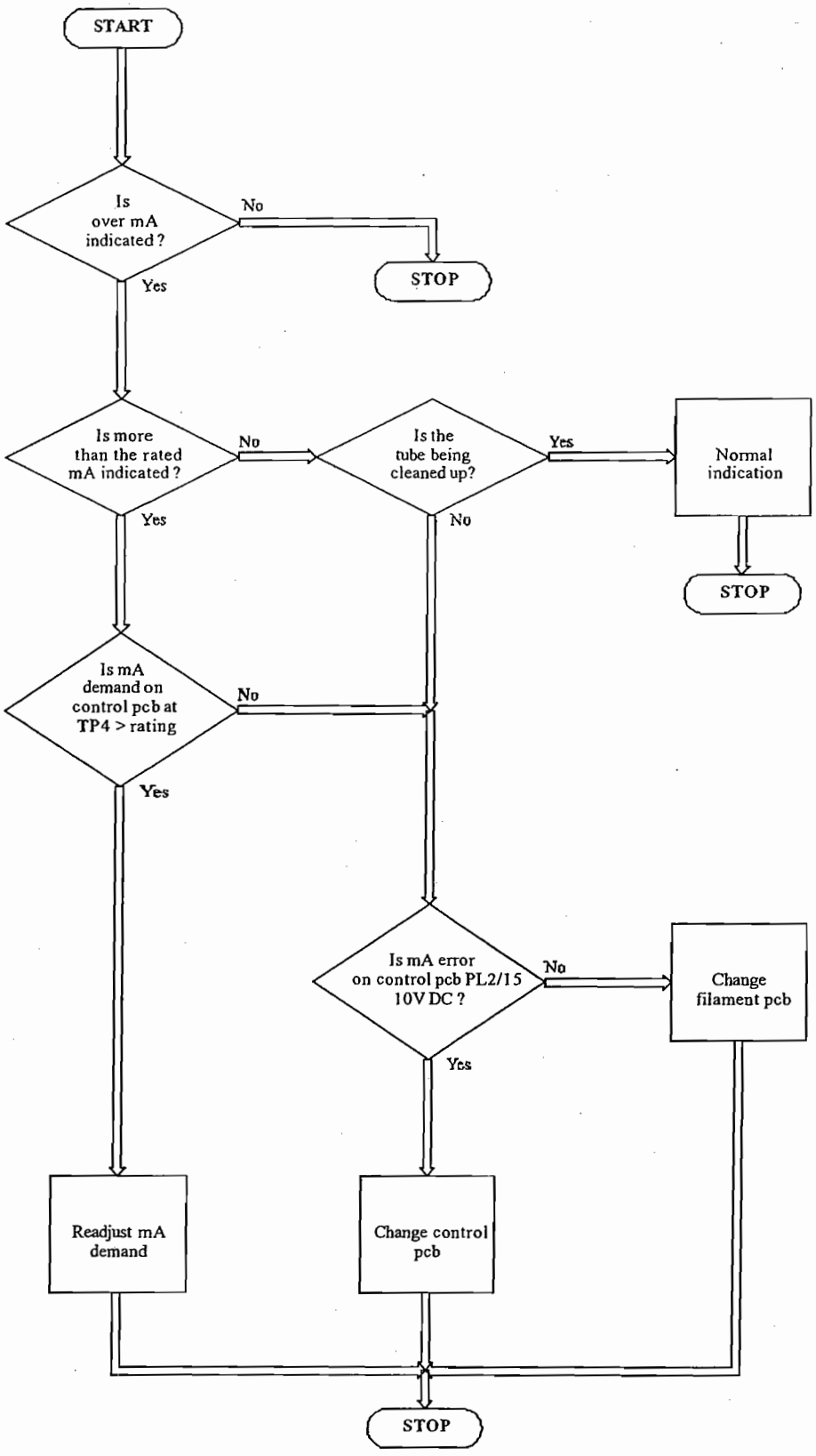
FLFIG52B.PDW

FIG. 5.2 NO BEAM CURRENT



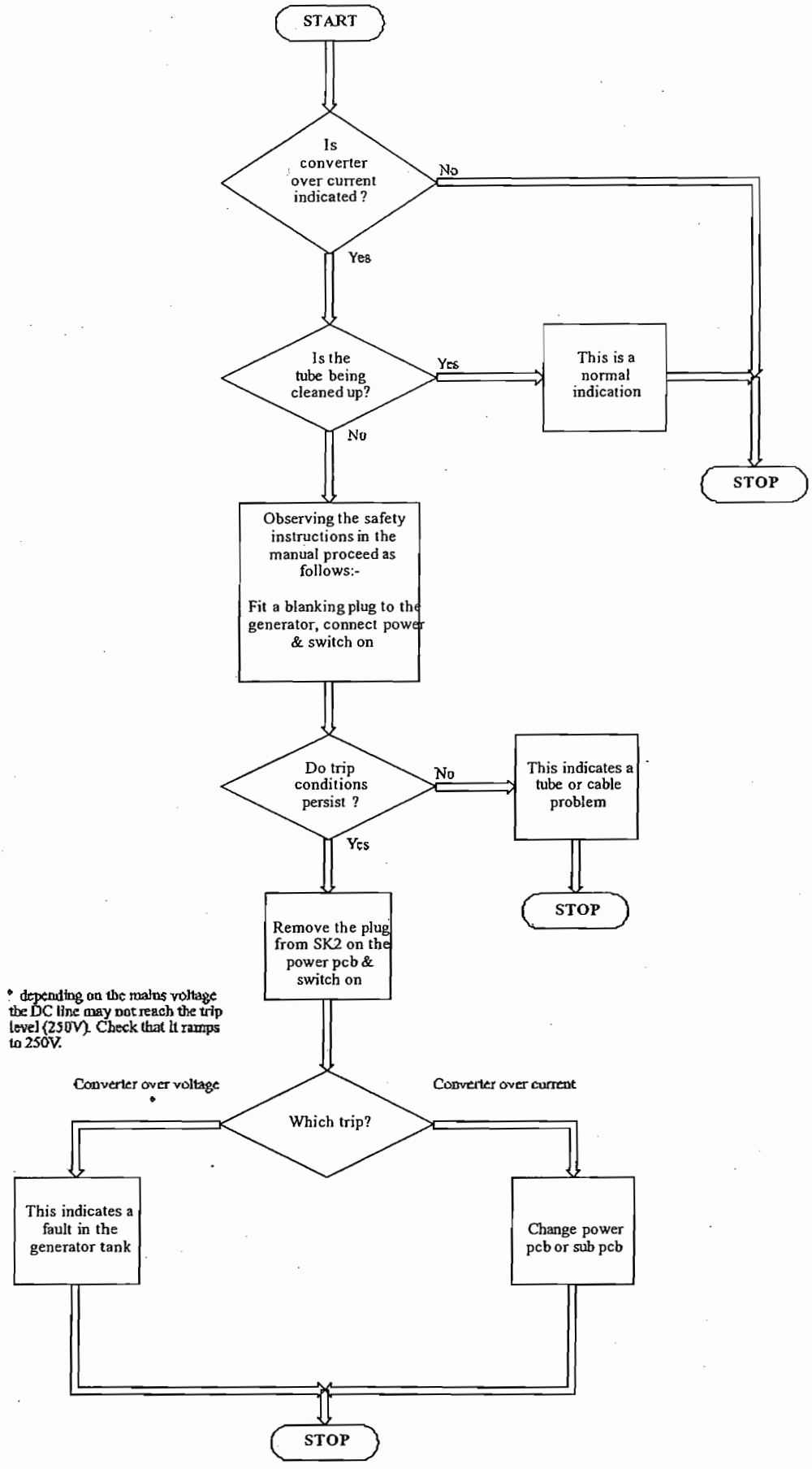
FLFIG53B.PDW

FIG. 5.3 OVER kV INDICATION



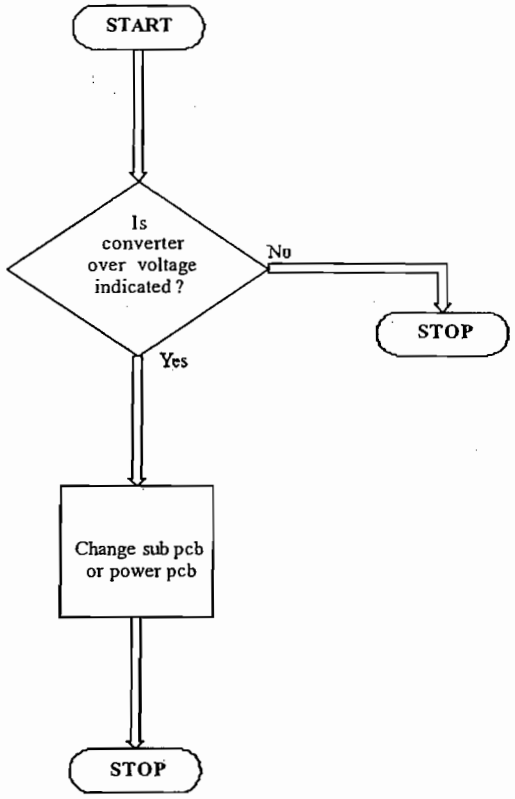
FLFIG54B.PDW

FIG. 5.4 OVER mA INDICATION



FLFIG55B.PDW

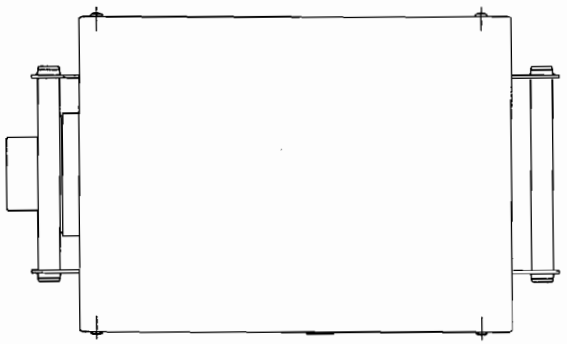
FIG. 5.5 CONVERTER OVER CURRENT

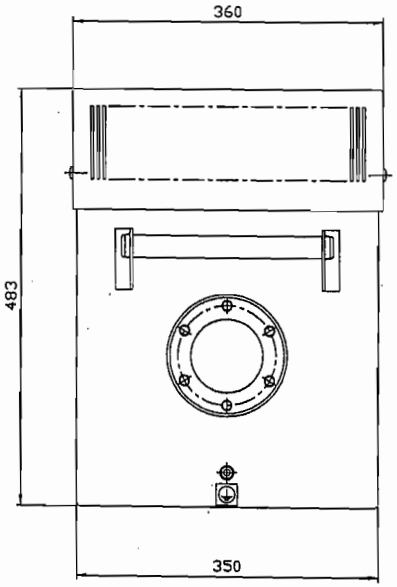


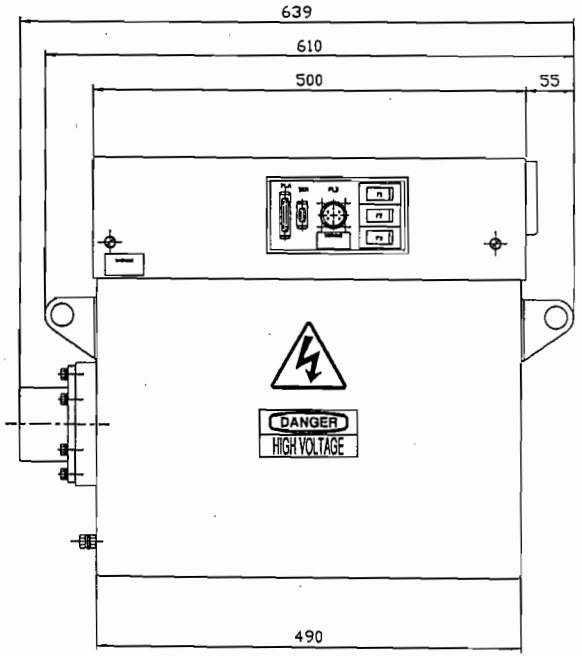
FLFIG56B.PDW

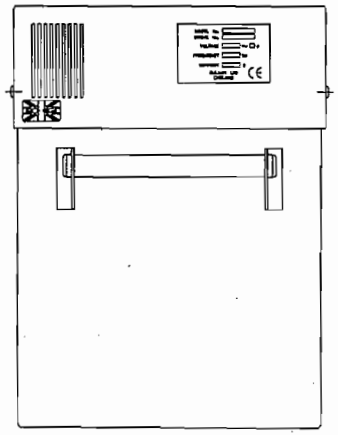
FIG. 5.6 CONVERTER OVER VOLTAGE

DRAWING No. 15G-A595









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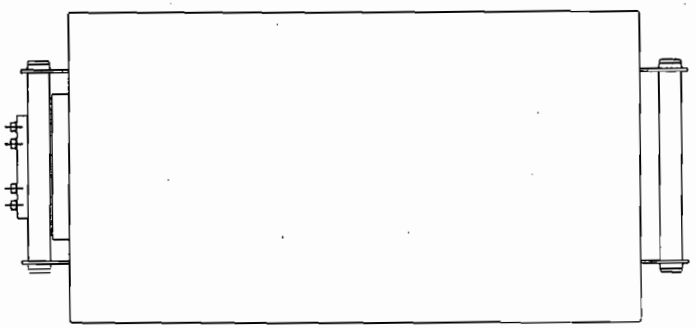
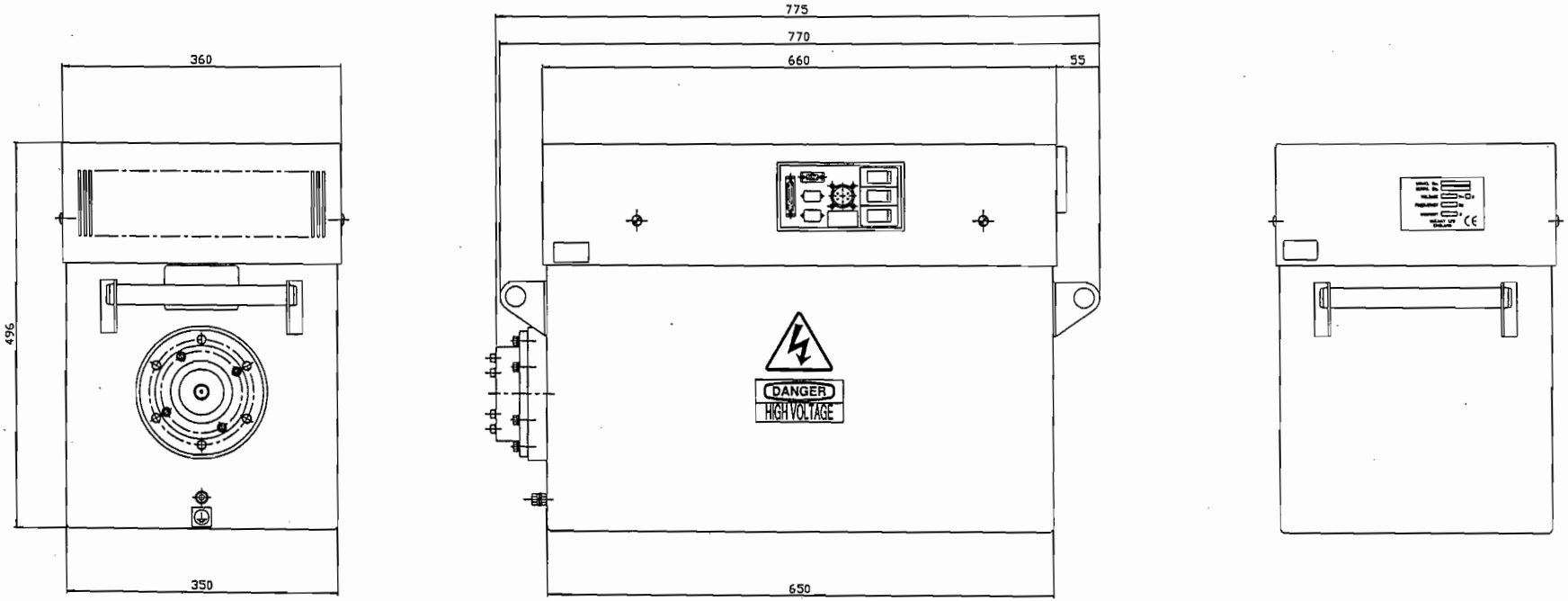
UC160 GENERATOR ASSEMBLY

DRAWING No. 15G-A595

DRAWING No. 20G-A063 SHEET NO. 1

THIRD ANGLE PROJECTION
PREPARED IN ACCORDANCE WITH BS 308





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GULWAY LIMITED

TITLE: GENERATOR OUTLINE (UCE80)

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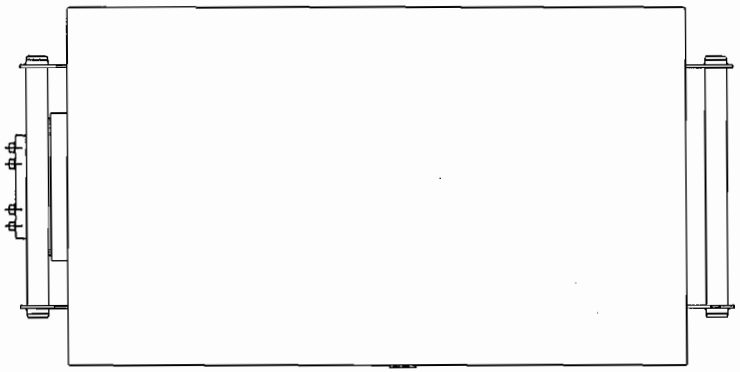

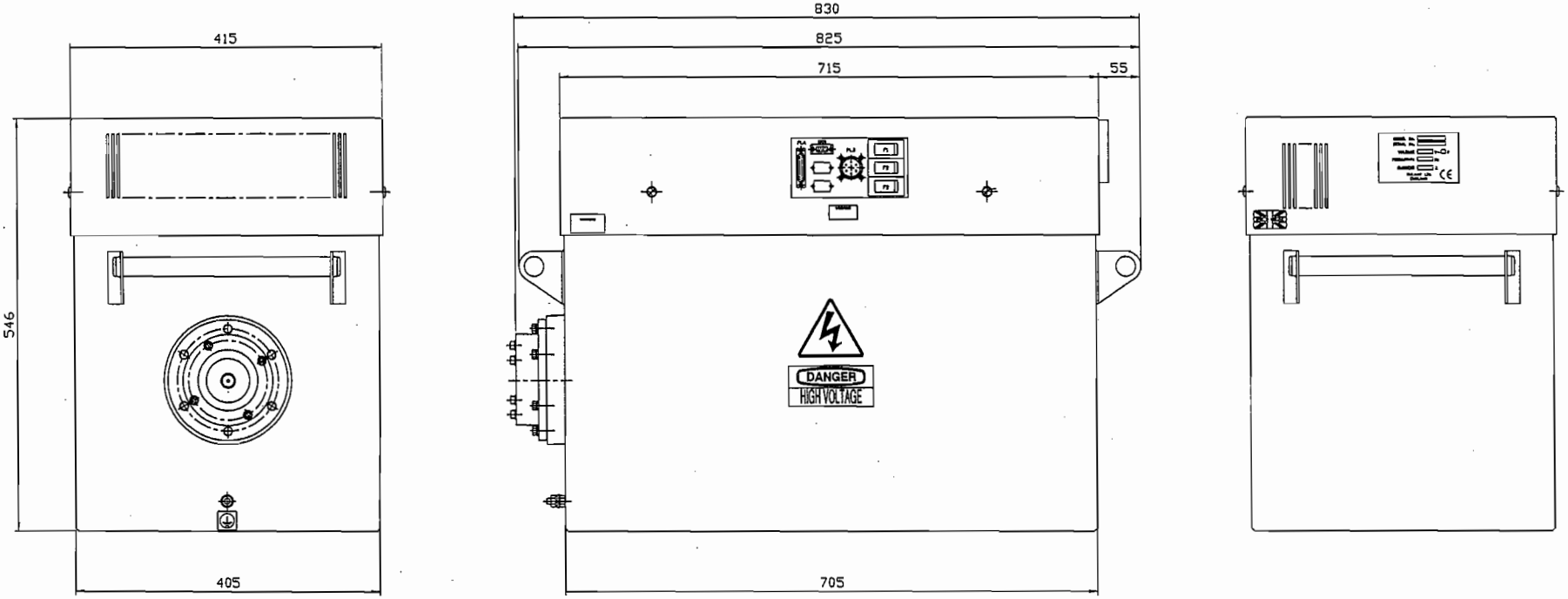

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GULWAY LIMITED

UC225 GENERATOR ASSEMBLY

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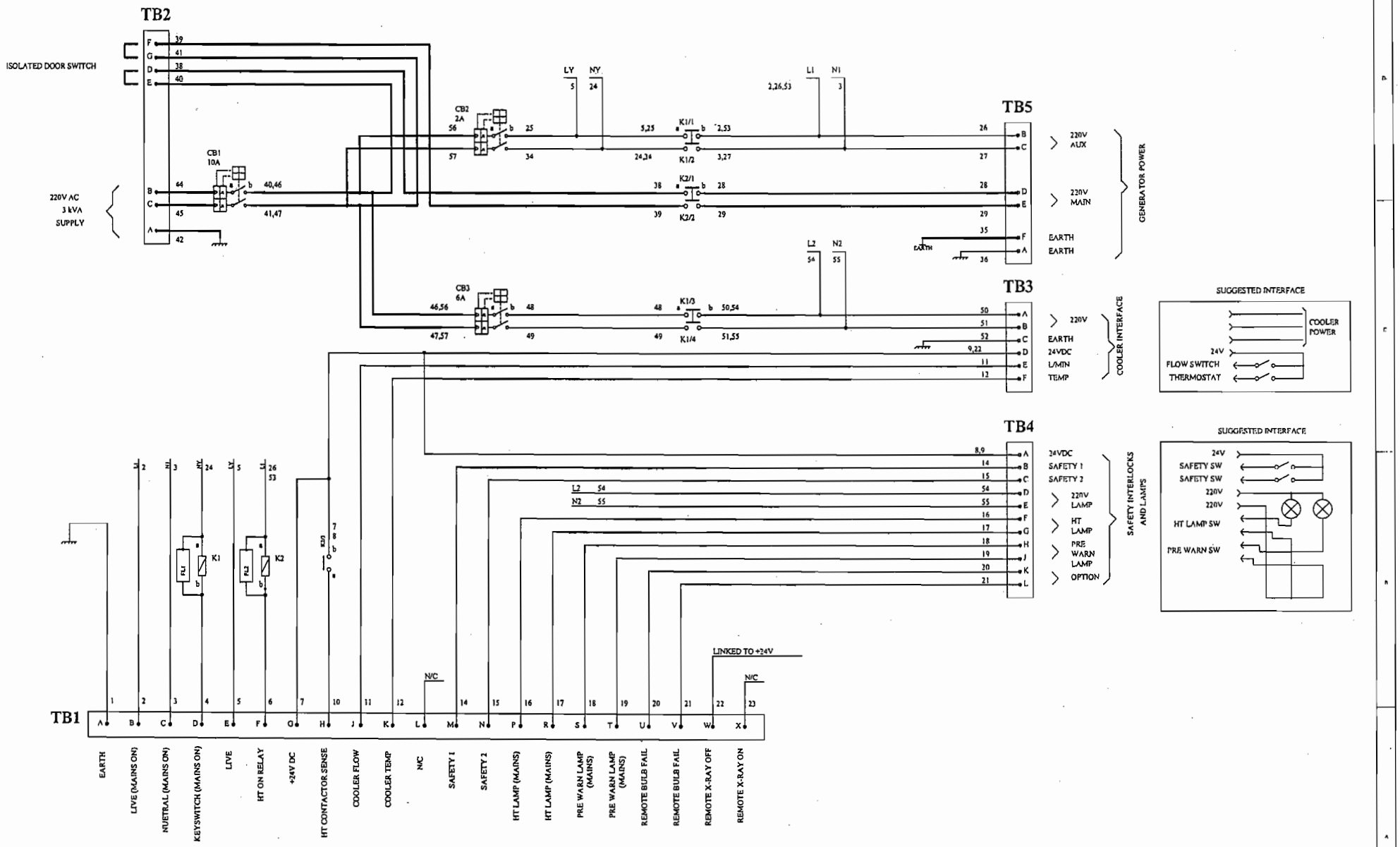

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Revision	B
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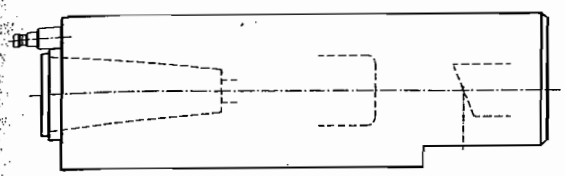


MXR-160/22

Strahlerdokumentation
Tube Assembly Documentation

Diese Dokumentation ist nur für die folgende Strahlernummer gültig
This documentation is valid only for the following tube assembly no.

Ohne Röhren- bzw. Strahlerschild an dieser Stelle ist die Dokumentation nur zur Orientierung. Änderung ohne Ankündigung möglich.

Without tube or tube assembly label here, the documentation is meant for information only. Modifications without notification possible.

Frühere Bezeichnung / *Former Designation*

MXR-160/0.4-3.0

Strahlerbezeichnung
Tube AssemblyType

MXR-160/22

Made in Switzerland

Bestellnummer
Reference No.
915301.51

COMET

MXR-160/22

Type No	915301.51	
Serial No	55-2653	
Nom. Voltage	160 kV	
Power	640 W	3000 W
Focal spot	d = 1.0 mm	d = 5.5 mm
Filament A (V)	4.1 (3.0)	4.2 (5.5)
Inh. Filtration	0.8 mm Be	
Manufactured	OCTOBER 2003	

COMET AG · CH-3175 Flamatt · Switzerland · Tel. +41 31 744 90 00

Der Inhalt dieser Dokumentation muss an den Betreiber der Röntgenröhre bzw. des Röntgenstrahlers weitergegeben werden.
The content of this documentation must be transmitted to the user of the X-ray tube or the X-ray tube assembly.

Inhaltsverzeichnis

Table of Contents

Allgemeine Beschreibung

Der Röntgenstrahler MXR-160/22 wurde für den Einsatz in der Industrie entwickelt.
Der Strahler besteht aus einer unipolaren Röntgenröhre mit gekühlter Anode auf Erdpotential und einer integrierten Hochspannungssteckdose. Das Strahlenschutzgehäuse ist mit Wasseranschlüssen ausgerüstet.
Die Hauptvorteile sind hohe Leistung, kleine Abmessungen, kleines Gewicht und robuste Konstruktion.

General Description

The X-ray tube assembly MXR-160/22 has been designed for industrial applications.
The tube assembly consists of a monopolar X-ray tube with cooled anode at ground potential and a high voltage receptacle socket. The tube housing has fittings for water hose connections.
The main advantages are high power, small dimensions, low weight and rugged mechanical design.

Sicherheit

WARNUNG

Die Informationen dieses Kapitels müssen vor Installation und Inbetriebnahme beachtet werden.
Der Gebrauch von Röntgenröhren und Röntgenstrahlern ist mit ernstzunehmenden Risiken verbunden.
Bei der Installation eines Röntgenstrahlers in eine Röntgeneinrichtung und beim Betrieb von Röntgeneinrichtungen sind die am Standort der Anlage gültigen Vorschriften zu beachten.

Einführung

Für den sicheren und zweckmässigen Gebrauch von Röntgenröhren und -strahlern sind Hersteller und Betreiber von Röntgenanlagen verantwortlich.
Röntgenröhren haben keine unbegrenzte Lebensdauer und können gelegentlich Störungen aufweisen, die eine Inspektion oder Reparatur nötig machen. Mehrfache Schutzmassnahmen und Sicherheitsvorkehrungen im Störfall zum Schutz von Personal und Material sind deshalb zu treffen.
Alle Personen, die mit Röntgenstrahlung oder röntgenstrahlenerzeugenden Systemen arbeiten (Inbetriebnahme, Bedienung, Wartung, Reparatur) und dabei der Röntgenstrahlung direkt oder indirekt ausgesetzt sein können, müssen die nötigen Vorkehrungen treffen, um sich und andere zu schützen.
Insbesondere ist die ganze Umgebung röntgenstrahlenerzeugender Systeme abzusichern.
Nur genügend qualifiziertes und erfahrenes Personal, welches mit den lokalen und nationalen Vorschriften über den Betrieb von röntgenstrahlenerzeugenden Systemen vertraut ist, darf für Betrieb, Wartung und Reparatur des Systems betraut werden.

Hochspannung

Röntgenröhren und -geräte arbeiten mit sehr hohen Spannungen, die lebensgefährlich sind. Röntgenanlagen müssen deshalb so konzipiert sein, dass das Personal nicht mit der Hochspannung in Berührung kommen kann.

Safety

WARNING

The information contained in this section must be read prior to installation and first operation.
Serious hazards exist in the operation of X-ray tubes and tube assemblies.
When installing an Xray tube assembly into an X-ray equipment and/or operating an X-ray equipment, compliance with local regulatory requirements must be assured.

Introduction

The safe and purposeful operation of X-ray tubes and tube assemblies is within the responsibility of both the X-ray equipment manufacturer and the user.
X-ray tubes do not have an indefinite life and can suffer from perturbations that may necessitate inspection and repair. Multiple protective measures and safeguards should thus be taken to ensure protection of personnel and material.

All personnel working with X-ray producing systems (installing, operating, maintaining, repairing), and those persons who may be exposed to X-ray either directly or indirectly, must take the necessary precautionary measures to protect themselves and others.

In particular the entire area of such X-ray production systems must be protected.
Only qualified and experienced personnel, who are fully conversant with local and national regulations concerning the operation of X-ray production systems should be permitted to operate, maintain or repair the system.

High Voltage

X-ray tubes and X-ray equipment operate at voltage levels which are potentially life threatening. X-ray equipment must therefore be designed to prevent personnel from coming into contact with high voltage.

Warntafeln betreffend Hochspannung müssen fest an der Anlage angebracht sein.
Wird ein direkter Zugang zum Röntgenstrahler nötig, ist zuerst die Stromzufuhr zum Primärkreis zu unterbrechen, dann sind Hochspannungskondensator und -kabel zu entladen.

Röntgenstrahlung

Allgemein

Röntgenröhren und -strahler produzieren Röntgenstrahlen, sobald Hochspannung angelegt ist. Betriebspersonal und Nichtbetriebspersonal müssen mit geeigneter Abschirmung von der Röntgenstrahlung und vor der Streustrahlung geschützt werden.

Strahlenschutz

Dieser Röntgenstrahler hat eine interne Strahlenschutzverkleidung. Vor der Auslieferung wird dieser Strahlenschutz auf Haubendurchlassstrahlung getestet.
Beim Einbau in ein Röntgengerät müssen lokale und nationale Strahlenschutznormen und Vorschriften eingehalten werden.

Röhrenwechsel / Änderungen

Nach jedem Röhrenwechsel, jeder Reparatur oder Änderung am Gerät ist die Wirksamkeit des Strahlenschutzes zu überprüfen.

Strahlenkollimatoren

Um nicht genutzte Röntgenstrahlung einzuschränken, müssen Strahlenkollimatoren unter Berücksichtigung der lokalen und nationalen Vorschriften eingesetzt werden.

Strahlenfilter

Die Röntgenröhren bzw. -strahler werden ohne Zusatzfilter geliefert. Beim Einbau in das Röntgengerät muss die Gesamtfilterung den am Standort gültigen Vorschriften angepasst werden.

Kühlung

Beim Betreiben des Strahlers ohne Kühlung kann der Strahlenschutz durch Überhitzung beschädigt werden. Dies kann zu erhöhter Haubendurchlassstrahlung führen. Wurde die Röhre ohne oder mit ungenügender Kühlung betrieben, muss deshalb die Überprüfung der Haubendurchlassstrahlung vor dem weiteren Gebrauch der Anlage wiederholt werden. Die Funktionstüchtigkeit der Kontrollelemente des Kühlflusses und der Sicherheitsschalter muss durch regelmässige Kontrollen sichergestellt werden.
Im Fall von Sicherheitsabschaltungen müssen die Gründe dafür sorgfältig ermittelt und entsprechende Korrekturen vorgenommen werden.

Beryllium-Fenster der Röhre

Die Röhre ist mit einem Berylliumfenster im Strahlengang ausgerüstet. Das Einatmen von Berylliumdämpfen oder -staub ist gefährlich. Es wird deshalb empfohlen
- das Fenster vor Flüssigkeiten und Dämpfen so gut wie möglich zu schützen, um so dessen Korrosion zu reduzieren,
- vorhandene Korrosionssalze auf dem Beryllium-Fenster weder wegzukratzen noch anders zu entfernen.

Am Ende der Röhrennutzungsdauer muss das Beryllium-Fenster gemäss lokalen und nationalen Vorschriften entsorgt werden. Die Röhre kann zur Entsorgung an den Hersteller zurückgeschickt werden (Preis für Entsorgung auf Anfrage).

Prominently displayed high voltage warning signs must also be firmly attached to the equipment.
When direct access to the X-ray tube assembly is necessary, first interrupt the primary circuits of the power supply, then discharge the high voltage capacitors and cable.

X-Radiation

General

X-ray tubes and tube assemblies produce X-rays when high voltage is applied. Operating personnel and non-operating personnel must be protected by appropriate shielding against radiation from both the main X-ray beam and scattered radiation.

X-Ray Protection

This X-ray tube assembly contains an internal radiation protective lining. Before delivery this X-ray protection has been tested for leakage.
Local and National Radiation Protection Standards must be adhered to as regards to X-ray protection of the system and its environment.

Tube Exchange / Alterations

A reconfirmation of the radiation protection integrity should be performed after each tube exchange, repair, modification, or upgrade of the unit.

X-ray Beam Collimators

In order to reduce unnecessary X-rays, a beam collimator must be used in accordance with local and national regulations.

X-Ray Filter

Tubes are delivered without additional filters on the output window. On mounting tubes into the X-ray equipment, the total filtration values must be in compliance with the local requirements and regulations.

Cooling

If the tube assembly is used without cooling, excessive heat can damage the lead shield which can lead to an increase in the leakage radiation. Therefore, if the tube has been operated without cooling or the cooling has been insufficient, the radiation leakage test should be repeated before further use. In this respect, regular checks and maintenance work should be undertaken on cooling flow control elements and safety cut-out switches.

In case of the occurrence of safety related cut-outs, the reasons for cut-outs should be carefully determined and corrected accordingly.

Beryllium Window of the Tube Insert

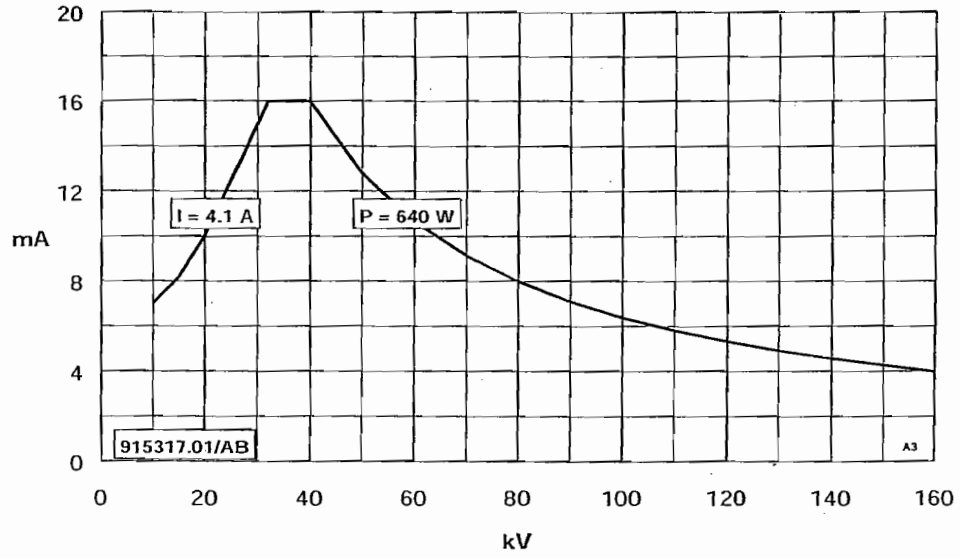
The X-ray tube is equipped with a beryllium window. Fumes of beryllium metal (or its compounds) or particles can be hazardous if inhaled. It is therefore advised that
- the window be protected as much as possible from fluids and vapours in order to prevent corrosion of the window
- if there are corrosion salts on the Beryllium window they should not be scraped or machined off.
At the end of the tube's life, the Beryllium window must be disposed off in accordance with local and national regulations or the tube may be returned to the tube manufacturer (price for disposal on request).

Spezifikationen *Specifications*

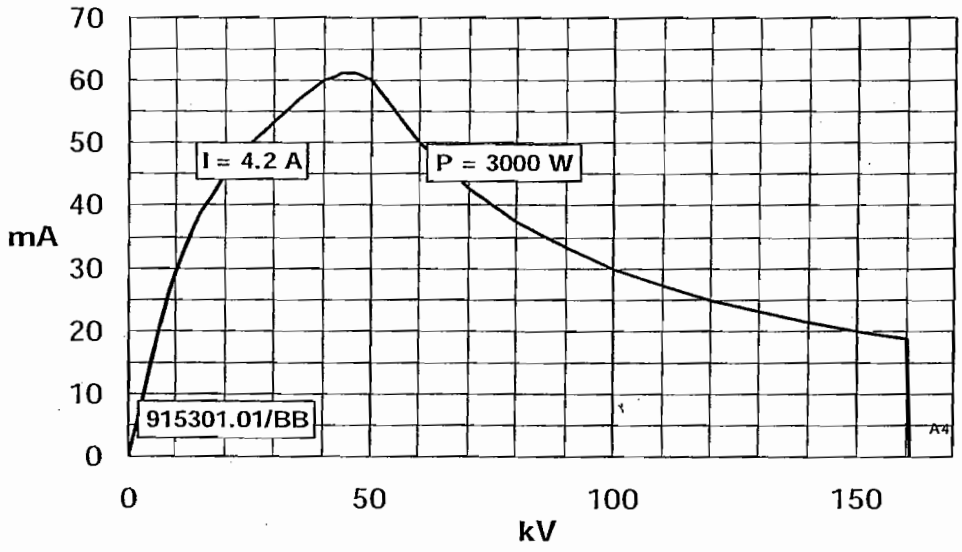
Strahlertyp Tube Assembly Type	MXR-160/22
Röhrentyp Tube Insert Type	MIR-160/22
Haubentyp Tube Housing Type	MOR-160
Röntgenröhren-Nennspannung Nominal X-ray tube voltage	160 kV
Dauerleistung Continuous rating	640 W | 3000 W
Röhrenstrom bei Nennspannung, max. Tube current at nominal voltage, max.	4 mA | 19 mA
Optischer Brennfleck nach EN 12543 Focal spot acc. EN 12543	d = 1.0 mm | d = 5.5 mm
(frühere Brennfleckbezeichnung) (former focal spot designation)	(0.4 | 3.0)
Heizstrom, max. Filament current, max.	4.1 A | 4.2 A
Heizspannung bei max. Heizstrom, typisch Filament voltage at max. filament current, typical	3.0 V | 5.5 V
Eigenfilterwert Inherent filtration	0.8 ± 0.1 mm Be
Targetmaterial Target material	W
Targetneigungswinkel Target angle	20°
Strahlenbündel Radiation coverage	40°
Haubendurchlassstrahlung in 1 m Abstand zum Brennfleck, max. Leakage radiation at 1 m distance to focal spot, max.	2.5 mSv/h
Daten zur Bestimmung der Haubendurchlassstrahlung Parameters for leakage radiation determination	160 kV; 19 mA
Kühlmittel Cooling medium	Wasser Water
Kühlmitteldurchfluss, min. Cooling medium flow, min.	4 l/min
zulässiger Druck am Kühlmitteleingang, max. Pressure at cooling medium inlet, max.	6 bar
zulässige Temperatur am Kühlmittel-Eingang, max. Cooling medium temperature at cooling medium inlet, max.	35°C
Masse ca. Mass app.	8 kg
Steckertyp Terminal type	R24

Leistungskurven — *Rating Charts*

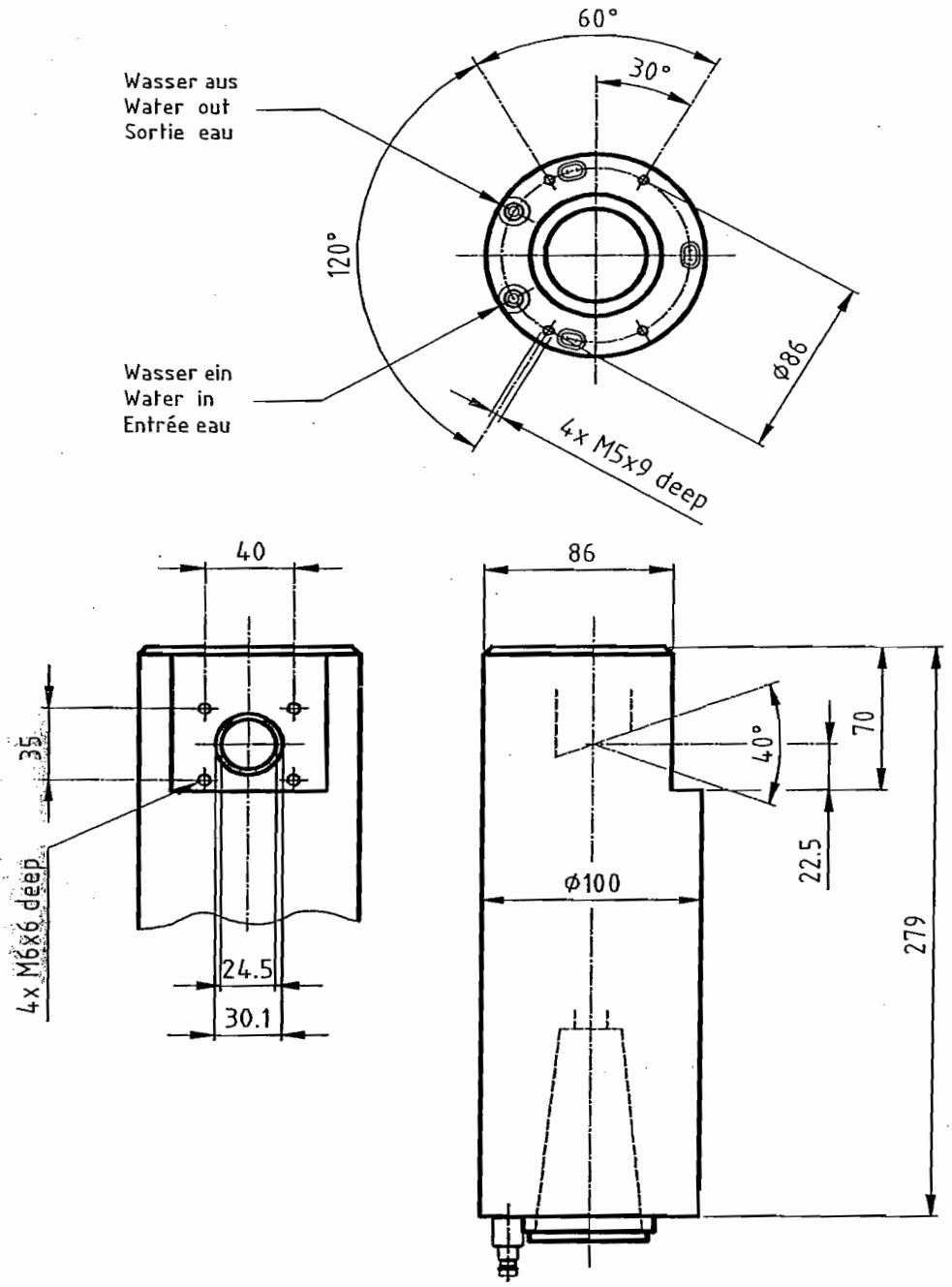
Brennfleckgrösse / Focal Spot Size d = 1.0 mm



Brennfleckgrösse / Focal Spot Size d = 5.5 mm

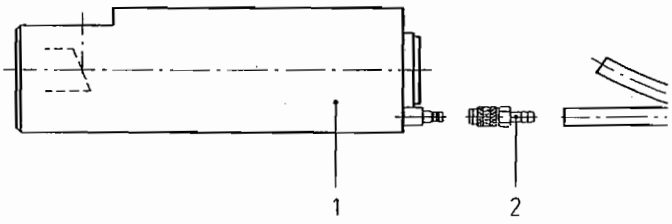


Abmessungen *Dimensions*

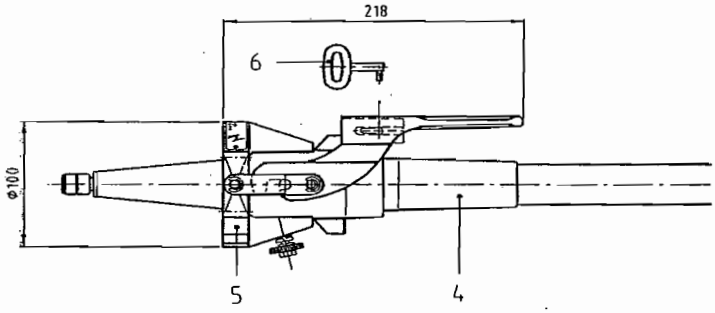


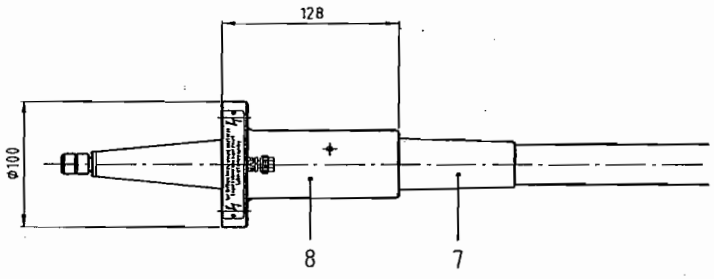
Zubehör / *Accessories*

	Bestellnummer *Reference No.*	
Wasseranschlusskupplung d=8mm	633117	*Fitting for water hose connections d=8mm*
Wasseranschlusskupplung d=12 mm	633142	*Fitting for water hose connections d=12mm*
Hochspannungskabel R24/R24 (x = Länge in m)	938605-x	*High voltage cable R24/R24 (x = length in m)*
Kniehebelverschluss mit	941002	*Locking device*
Führungshülse	651053	*Clamping sleeve*
Schlüssel	621057	*Key*
Kabelflansch	654013	*Mounting flange*



Pos. 2: 633117
633142
Pos. 4,7: 938605
Pos. 5: 941002
Pos. 6: 621057
Pos. 8: 654013





Allgemeine Betriebshinweise / *Operation*

Allgemeines / *General*

Die Steuerung der Hochspannung und des Heizstroms sowie die Auslegung des Kühlsystems liegen in der Verantwortung des Geräteherstellers.

The control of the high voltage and the filament current as well as the design of the cooling system are the responsibility of the equipment manufacturer.

Aus Sicherheitsgründen sind folgende Abschaltarten vorzusehen:

For safety reasons the power must be switched off under the following circumstances:

- Standardabschaltung am Ende der Aufnahme bzw. des Gebrauchs der Anlage
- Notabschaltung aus betrieblichen Gründen
- Notabschaltung wegen mangelnder Kühlung oder aus anderen technischen Gründen.

- standard cut-out at the end of an exposure or at the end of the use of the equipment
- emergency cut-out for operational reasons
- emergency cut-out due to insufficient cooling or due to other technical reasons.

Hochspannungsanschluss / *High Voltage Connection*

Hochspannung und Heizfadenstrom werden durch ein Hochspannungskabel mit folgenden Spezifikationen zugeführt:

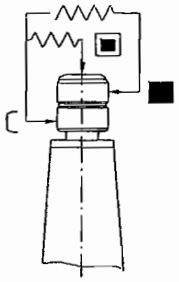
High voltage and filament current are supplied by the high voltage cable with the following specifications:

Steckertyp: R24

Terminal type: R24

Anschlüsse der Heizwendel: (C=Masse)

Connection of filament: (C=Common)



Es gibt 2 Möglichkeiten, das Hochspannungskabel am Strahler anzuschliessen.
- mit Kabelflansch
- mit Kniehebelverschluss

Der sachgerechte Anschluss von Hochspannungskabeln ist im Kapitel "Anleitung zur Montage und Inbetriebnahme" beschrieben.

Two different methods of mounting the high voltage cables are available:
- with locking device
- with mounting flange

The appropriate mounting of the high voltage cables is described in the chapter " Installation and Operation Instructions".

Überspannung, Überstrom

Auf keinen Fall dürfen die maximalen Betriebsdaten der Röhre (d.h. Filamentstrom, Röhrenstrom und Röhrenspannung) überschritten werden, da sonst die Röhre Schaden nehmen kann.
Dämpfungswiderstände im Hochspannungskreis von wenigstens 100 kOhm sowie Abschaltelemente bei Überstrom und Überspannung sind ein notwendiger Schutz der Röhre.

Overvoltage, Overcurrent

Under no circumstances should the maximum operating parameters of the tube (i.e. filament current, tube current and voltage) be exceeded, otherwise the tube may be damaged.
Therefore a damping resistor of at least 100 kOhm in the high tension circuit and trip devices for overcurrent and overvoltage in the control circuit must be provided.

Heizstrom während Betriebspausen

Während Betriebspausen sollte der Heizstrom reduziert oder abgeschaltet werden. Hohe Heizströme können zur Verkürzung der Lebensdauer des Heizfadens führen.
Entsprechende Vorkehrungen in der Steuereinheit werden empfohlen.

Filament Current during Standby Periods

During standby periods the filament current should be reduced or switched off. High filament currents can result in the reduction of the filament lifetime.
The appropriate design of the control unit to achieve this is recommended.

Kühlung der Anode

Generell

Das Kühlsystem ist nicht Bestandteil des Lieferumfangs. Es ist sicherzustellen, dass der Kühlmittelfluss die Anforderungen an die Anodenkühlung erfüllt.
Mangelnde Kühlung kann zur Zerstörung der Anode führen. Deshalb muss die Kühlung unbedingt vor dem Anlegen der Hochspannung eingeschaltet werden.

Cooling of the Anode

General

The cooling system is not supplied by COMET. The customer should ensure that the cooling medium flow meets the required cooling conditions.
Insufficient cooling can lead to the destruction of the anode. Therefore cooling must be switched on prior to the application of the high voltage.

Kühlmittelüberwachung

Druck, Durchflussmenge und Temperatur beim Kühlmitteleingang in den Strahler müssen mit geeigneten Mitteln überwacht werden.
Bei Unterschreitung des minimalen Drucks, der minimalen Durchflussmenge bzw. beim Überschreiten der maximalen Temperatur ist die Hochspannung sofort zu unterbrechen.
Ein sicherer Betrieb der Röhre bzw. des Strahlers kann nur dann garantiert werden, wenn die spezifizierten Werte für die Kühlung eingehalten werden

Das Kühlsystem sollte mit Sicherheitsschaltern für Druck, Durchfluss und Temperatur des Kühlmittels ausgerüstet sein.
Wir empfehlen, die Überwachungssysteme bei der Inbetriebnahme auf ihre Funktionstüchtigkeit hin zu überprüfen.

Zum Schutz des Strahlers sollte die Kühlung nach Abschaltung der Anlage noch mindestens 2 Minuten weiter betrieben werden.
Das gilt auch bei Notabschaltungen der Anlage wegen Überspannung, Überstrom oder Überhitzung.

Control of Cooling medium

Pressure, flow, and temperature of the cooling medium at the inlet to the tube or the tube assembly must be appropriately monitored.
High voltage must be interrupted when the pressure or flow rate fall fall below the minimum level or when the temperature exceeds the maximum level allowed.

Safe operation of the tube or the tube assembly can only be guaranteed if it is used in accordance with the cooling specifications given in this documentation.

The cooling system should be equipped with safety switches for pressure, flow, and temperature of the cooling medium.
We recommend strongly to test these control devices before starting the operation of the equipment.

When the tube is switched off, the coolant flow must continue for at least 2 minutes in order to protect the anode and the lead protection from overheating.
This is also the case after emergeny shut down after overvoltage, overcurrent or overheating.

Im Falle von Überhitzung im Anodenbereich muss der Strahlenschutz auf seine Wirksamkeit hin überprüft werden.

After such a cut-out, the X-ray protection of the tube assembly must be carefully checked.

Röhre und Strahler sind vor dem Service bzw. der Wartung abzukühlen. Bevor das Kühlmittel Raumtemperatur erreicht hat, sollten keine Wartungsarbeiten ausgeführt werden.

Allow the tube or tube assembly to cool before service or maintenance. No maintenance should be attempted until the cooling medium is at ambient temperature.

Betrieb in besonderen Umgebungsbedingungen

Beim Betrieb in einer Umgebung mit aggressiven Medien und/ oder starken Vibrationen sind Massnahmen zum Schutz der Röhre bzw. des Strahlers zu treffen. Die Rücksprache mit dem Hersteller wird empfohlen.

Aggressive Environmental Conditions

Operation in an environment with aggressive media and/or strong vibrations requires appropriate measures. Consultation with the manufacturer of the tube assembly is recommended.

Reinigung

Für generelle Reinigungszwecke des Strahlenschutzgehäuses sind möglichst lösungsmittelfreie Produkte zu verwenden. Auf jeden Fall muss vermieden werden, dass Lösungsmittel auf das Strahlerfenster oder in die Hochspannungssteckdose gelangt.

Auch zur Reinigung der konischen Teile der Hochspannungsstecker dürfen keine Lösungsmittel verwendet werden. Diese Teile sind mit trockenem, saugfähigem und nicht faserndem Papier von Fettresten zu befreien. Auf keinem Fall darf der Strahler zur Reinigung der Röhre zerlegt werden.

Cleaning

For the general cleaning of tube housing, non-solvent based products are perfectly adequate. Avoid using solvents on the tube assembly window and do not use solvents to clean the conical section of the high voltage cable termination plug.

Detergents should be used very sparingly in the region of the high voltage cable termination plug to avoid damaging the grease between the receptacle and the cable terminal. In no case should the tube assembly be disassembled to clean the X-ray tube insert.

Anleitung zur Montage und Inbetriebnahme

Instructions for Installation and Operation

Anschluss des Strahlers

Bei Verwendung von COMET Kabeln ist wie unten beschrieben vorzugehen, bei Fremdkabeln sinngemäss. Grundsätzlich sind die Angaben der Kabelhersteller zu beachten.

Zunächst wird die Hochspannungssteckdose mit einem trockenen, nicht faserndem Papier gereinigt. Lösungsmittel sind zu vermeiden, da sie die konische Oberfläche der Hochspannungssteckdose angreifen können.

Auch die metallischen Kontakte des Kabels sind sorgfältig zu reinigen und zu prüfen. Schlechte Kontaktierung kann die Röhre beschädigen.

Es ist wichtig, dass der Kabelanschluss sorgfältig vorgenommen wird.

Der Kabelanschluss muss innerhalb der Hochspannungssteckdose unter festem Druck stehen. Um diesen Druck zu justieren, wird das trockene, ungefettete Kabel zuerst vorsichtig und parallel zur Achse der Hochspannungssteckdose bis zum Anschlag eingeführt.

Der definitive Druck wird wie folgt eingestellt:

Kabelanschluss mit Kniehebelverschluss:

(Siehe Skizze unten)

Führungshülse drehen bis der Kniehebelarm 45° von der Kabelrichtung absteht.

Kabelanschluss mit Kabelflansch:

(Siehe Skizze unten)

Kabelflansch drehen bis zwischen ihm und der Röhre ein Spalt von 3 bis 4mm besteht.

Der Stecker wird nun wieder herausgezogen. Die Steckdose und der Stecker werden mit dem mitgelieferten Hochspannungsisolierfett vorsichtig eingefettet.

Der gefetteten Kabelstecker wird nun parallel zur Achse der Hochspannungssteckdose bis zum Anschlag eingeführt.

Kniehebelverschluss:

Den Kniehebelarm ganz schliessen. Dabei ist sicherzustellen, dass die Führungshülse nicht aus ihrer vorgegebenen Position gedreht wird.

Connection of the Tube Assembly

The instructions below refer to cables supplied by COMET. For foreign cables the procedure will be similar. In any case the recommendations of the cable supplier should be observed.

At first the socket of the receptacle has to be carefully cleaned with lintfree paper. Don't use solvents, they may attack the surface of the socket.

The metal contacts have to be cleaned carefully and their alignement to be checked. Bad contacts may damage the tube.

It is important that the connection of the cable is made very carefully.

The cable terminal plug must be under firm compression within the high voltage receptacle socket. To adjust this compression, first introduce the dry, non-greased cable carefully and parallely to the axis of the receptacle socket, advancing it until it stops.

The definitive compression is set up as follows:

Cable terminal with locking device:

(See the following drawing)

Rotate the clamping sleeve until the locking device arm stands 45° off the cable direction.

Cable terminal with mounting flange:

(See the following drawing)

Rotate the mounting flange until there is a gap of 3 to 4 mm between the mounting flange and the tube.

Remove the cable plug. The cable plug should be carefully greased using the supplied high voltage insulating grease.

Introduce the greased terminal plug again parallel to the axis of the high voltage receptacle socket and advance until it stops.

Locking device:

Close the locking device arm completely making sure not to rotate the clamping sleeve from its setup position.

Kabelflansch:
Der Kabelflansch ist mit den entsprechenden Befestigungsschrauben an dem Strahlenschutzgehäuse zu fixieren. Dabei ist sicherzustellen, dass der Kabelflansch nicht aus seiner voreingestellten Position gedreht wird.

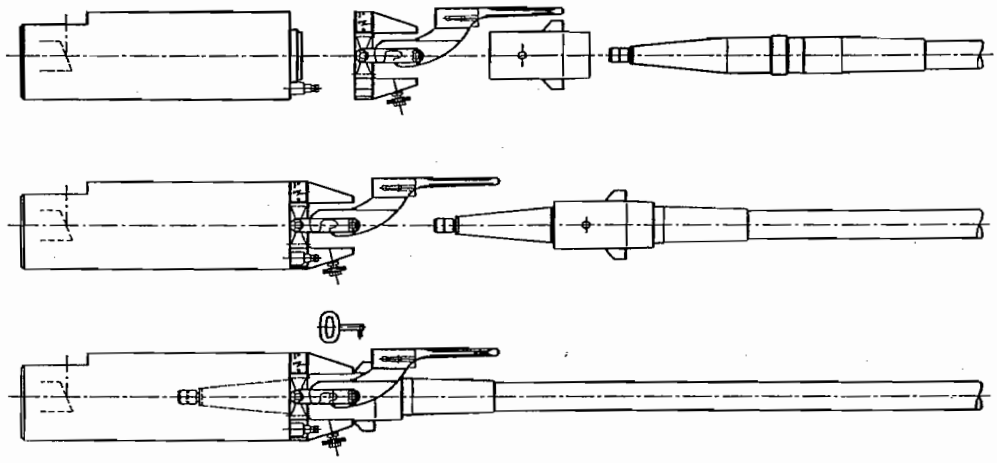
Beim Anschliessen des Kühlsystems ist auf die durch Pfeile angegebene Fliessrichtung zu achten.

Mounting flange:
Fasten the mounting flange to the tube housing using the flange fastening screws. Make sure not to rotate the mounting flange from its setup position.

Connecting the cooling system make sure the coolant flow is in the direction indicated by the arrows.

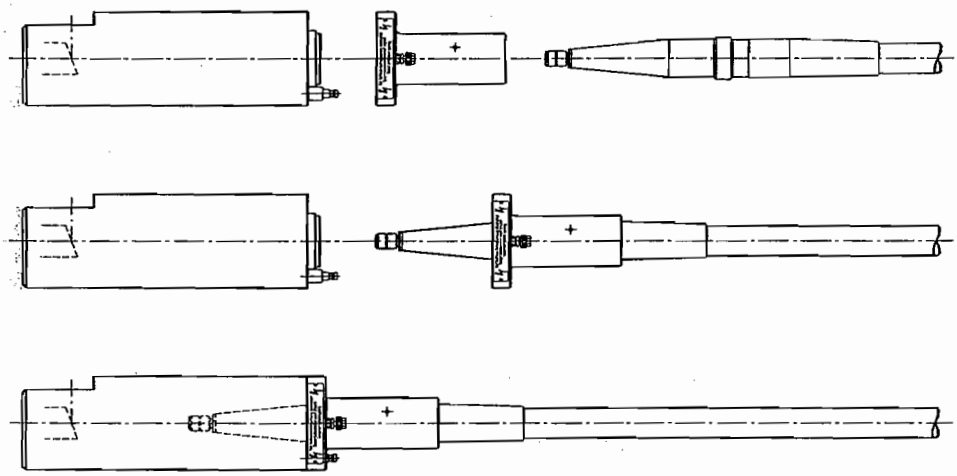
Hochspannungsanschluss mit Kniehebelverschluss

High voltage connection with locking device



Hochspannungsanschluss mit Kabelflansch

High voltage connection with mounting flange



Inbetriebnahme des Strahlers

Kühlung

Vor jeder Inbetriebnahme der Röhre muss die Kühlung eingeschaltet werden. Es muss sichergestellt sein, dass Kühlmittelfluss und Kühlmitteltemperatur den Vorgaben entsprechen.

Einfahren der Röhre

Vor der ersten Inbetriebnahme und nach längeren Betriebsunterbrüchen (mehr als 4 Wochen) muss die Röhre eingefahren werden.

Es wird empfohlen, dafür die Hochspannung von 100 kV in Stufen von 10 kV alle 5 min zu erhöhen, bis die gewünschte Betriebsspannung erreicht ist.
Beim täglichen Einschalten sollte die Spannung von 100 kV in Stufen von 10 kV pro 1 min bis zur gewünschten Betriebsspannung hochgefahren werden.
Dabei sollten Strom und Spannung nicht über die vorgesehenen Betriebswerte hinaus eingestellt werden.
Die Einfahrprogramme dürfen nicht bei voller Leistung gefahren werden. Auf keinen Fall dürfen dabei die maximalen Betriebsparameter überschritten werden.

Initial Operation of the Tube

Cooling

Prior to operating the tube the coolant should be turned on. Make sure that the coolant flow meets the required cooling conditions.

Seasoning and Daily Warm-Up

The tube should be seasoned before placing it into operation for the first time as well as after long down time periond (more than 4 weeks).
We recommend that the high voltage is switched on at 100 kV and increased in steps of 10 kV every 5 min until the anticipated operating voltage is reached.
For daily warm-up the voltage should be increased from 100 kV in steps of 10 kV per 1 min up to the desired operating voltage.
Do not to season or warm-up the tube beyond the voltage and current required for the application.
The seasoning and warm-up should not be done at full power, and under no circumstances should the maximum operating parameters of the tube be exceeded.

Nach Abschaltung der Anlage muss die Kühlung noch ca. 2 Minuten nachlaufen, bis die Röhre abgeküht ist.

The cooling system must remain in operation for at least 2 minutes after the termination of the last exposure.

Eine Strahlenschutzüberprüfung gehört zur Inbetriebnahme nach der Montage.

A confirmation of the X-ray protection is part of the initial operation after mounting.

Wartung / *Maintenance*

Ueberprüfung und Nachjustierung der Hochspannungskabelanschlüsse / *Checking and Readjustment of the High Voltage Cable Connections*

Da das Gummikonusmaterial des Hochspannungskabels fliesst und somit durch die Warm-Kalt-Zyklen die Vorspannung verlieren kann, ist die Hochspannungsverbindung periodisch (Empfehlung ca. 6 Monate) zu kontrollieren. Dazu muss das Kabel demontiert, neu eingestellt und gefettet werden.

As the rubber cone material of the high voltage cable is deformable and may therefore lose the tension due to the warm/cold cycles, the high voltage connection must be checked periodically (recommendation: 6 months). This is accomplished by disassembling, adjusting, and greasing the cable terminal again.

Neue Kabel sind bei der ersten Inbetriebnahme bereits nach 1-2 Tagen nachzustellen. Grundsätzlich sind die Angaben der Kabellieferanten zu beachten.

New cables have to be readjusted already after 1-2 days of their operation. Please refer to the recommendations of the cable supplier.

Reparatur des Strahlers / *Repair of the Tube Assembly*

Reparaturen des Strahlers bedürfen spezieller Ausrüstungen und Prüfgeräte und sollten nur durch den Hersteller des Strahlers durchgeführt werden.

Repair of the tube assembly needs special tools and test equipment; it should therefore be executed only by the manufacturer of the tube assembly.

Lagerung und Transport / *Storage and Transportation*

Allgemein / *General*

Nach Abschaltung der Hochspannung sind die Kabel und damit auch die Hochspannungskondensatoren des Generators durch Verbinden der Leiter mit Erdpotential zu entladen, damit die Kabel ohne Gefahr berührt werden können.

After switching off the high voltage discharge the cables and the high voltage capacitors of the generator by connecting the conductors with ground potential to ensure that the cables can be touched without danger.

Für Lagerung und Transport von Röntgenröhren und Röntgenstrahlern ist vorzugsweise die mitgelieferte Originalverpackung zu verwenden.

Use original or an equivalent packaging for storage and transport of tubes and tube assemblies.

Dabei sind die Hochspannungssteckdosen mit den in der Lieferung enthaltenen Plastikdeckeln abzudecken. Dadurch wird die Sauberkeit der Hochspannungssteckdosen gewährleistet.

For transportion cover the high voltage receptacle sockets with the two plastic covers included at delivery. This is to ensure cleanliness of the high voltage receptacle sockets.

Wird das Gerät während längerer Zeit nicht benützt, ist das restliche Kühlmittel aus dem Kühlungssystem zu entfernen. Dazu wird während einiger Sekunden Pressluft mit niedrigem Druck durch beide Kühlmittelanschlüsse geblasen.

If the unit is not in use for a long period of time, residual coolant should be removed from the cooling system. For this purpose blow compressed air through both inlet fittings for a few seconds.

Lagerbedingungen: / *Storage Conditions*

Temperatur: -10 bis +40 °C
Luftfeuchtigkeit: max. 95 %

Temperature: -10 to +40 °C at max. 95 % humidity

Transportbedingungen / *Transportation Conditions*

Temperatur: -10 bis +70 °C
Luftfeuchtigkeit: max. 95 %

Temperature: -10 to +70 °C at max. 95 % humidity

Rücksendung an COMET / *Return of Goods to COMET*

Vor der Rücksendung an COMET ist eine Rücksendungsnummer (RGA-Nummer) zu verlangen. Benützen Sie dazu das mitgelieferte RGA-Formular oder kontaktieren Sie COMET.

Prior to shipment to COMET a Returned Goods Authorisation No. will be required. Please use the RGA form supplied at delivery or contact COMET.

Das RGA-Formular und der ausgefüllte Feldausfallrapport (Field Failure Report) sind den Versanddokumenten beizulegen.

The RGA form and the completed Field Failure Report should be added to the shipping documents.

Bei Rücksendung zur Entsorgung ist auf den Versanddokumenten der Vermerk "ZUR ENTSORGUNG" anzubringen.

In case of shipment to COMET for disposal, the shipping documents must be marked with "FOR DISPOSAL".

Waldeggstrasse 72 • CH-3097 Liebefeld-Bern
Telefon +41 31 970 40 40 • Telefax +41 31 970 45 51

Field Failure Report - Industrial Products

RGA NUMBER: _____

In order that all incoming goods to COMET AG are directed quickly and efficiently to the appropriate party, the information you give us below is of the greatest importance.
Please complete the RGA form (Returned Goods Authorisation) and fax it to COMET AG (+41 31 970 45 81) before sending any goods. We shall allocate you an RGA number by return fax.

ATTENTION: Any returned material without an RGA number will not be accepted.

1. CUSTOMER IDENTIFICATION

DEALER / OEM / INSTITUTION name _____

contact person _____ phone _____

2. RETURNED TUBE IDENTIFICATION

X-ray tube-assembly _____ Serial No. _____

Delivery date _____ Installation date _____ Failure date _____

3. OPERATING CONDITIONS

Operating voltage _____kV Operating current _____ mA Operating time _____ h total

Maximal voltage _____kV Operating time _____ h / day

4. REASON FOR RETURN

☐ **IN-WARRANTY CLAIM**
(for warranty claim complete entire report and check here)

☐ Reload ☐ Repair ☐ Return for stock

☐ Analysis ☐ Other _____

☐ **NOT FOR WARRANTY CLAIM**
(for non warranty claim complete section 1, 2 and 3 and check here)

☐ Housing credit ☐ Reload ☐ Analysis

☐ Repair ☐ Other _____

5. ASSOCIATED EQUIPMENT

High voltage generator: Manufacturer _____ Type _____

High voltage cable: Manufacturer _____ Length _____

Cooling system: Manufacturer _____ Fluid _____

6. PROBLEM DESCRIPTION / OBSERVATIONS

_____

_____

_____

Transportation damage: If transport insurance has been covered by COMET, a report from the insurance broker, carrier or postal service has to be returned immediately.

Date _____ Signature _____

Name (please print) _____

COMET AG

Waldeggstrasse 72 • CH-3097 Liebefeld-Bern
Telefon +41 31 970 40 40 • Telefax +41 31 970 45 51

Returned Goods Authorisation RGA

In order that all incoming goods to COMET AG are directed quickly and efficiently to the appropriate party, the information you give us below is of the greatest importance.

Please complete this form and fax it to COMET AG (+41 31 970 45 81) before sending any goods. We shall return it with an allocated RGA number. This RGA number is valid for one return only.

ATTENTION: Warranty claims without a completely filled in Field Failure Report in addition to this form will not be accepted.

CUSTOMER IDENTIFICATION

DEALER / OEM	END USER
Name _____	Name of contact person _____
Address _____	Address _____
_____	_____
Zip code _____	Zip code _____
Phone _____ Fax _____	Phone _____ Fax _____

RETURNED MATERIAL IDENTIFICATION

X-RAY TUBES / X-RAY UNITS:

Tube type _____ Serial no. _____

Housing type _____ Serial no. _____

Delivery date _____ **Installation date** _____ **Date of failure** _____

Number of exposures/scans/filament hours _____ **Invoice value** _____

ACCESSORIES / OTHER MATERIAL:

Description: _____

_____

REASON FOR RETURN

❒ **IN-WARRANTY CLAIM**
(for warranty claim complete Field Failure Report and tick options here)

❒ Reload ❒ Repair ❒ Hold housing in stock

❒ Analysis ❒ Other _____

❒ **NOT FOR WARRANTY CLAIM**

❒ Housing credit ❒ Reload ❒ Repair

❒ Analysis ❒ Material for disposal

❒ Samples ❒ Return of consignment material

❒ Goods for delivery to Mr/Mrs _____

❒ Other _____

COMMENTS _____

_____

Date _____ Signature _____

Name (please print) _____

For the return of the material use original packaging.
Please mark the box with the allocated RGA number given below.

To be filled in by COMET AG: **YOUR RGA NUMBER IS:** ☐

released by _____ date _____

IWAKI WALCHEM Corporation

IWAKI WALCHEM MAGNETIC DRIVE PUMPS
OPERATING INSTRUCTIONS

INSTALLATION:

1. Secure the pump to floor or platform by bolting down the baseplate using all four bolt holes provided.

2. Check power source for proper voltage and phase. Plug the pump powercord into a switched, grounded outlet or hardwire into a properly grounded circuit. Use appropriate wiring materials and abide by all local and national standards for electrical codes.

3. Connect the inlet and outlet fittings of the pump with the appropriate size tubing or pipe connections.

   A. For tubing connections, use standard hose clamps to secure tubing. *DO NOT OVER TIGHTEN.*

   B. For pipe thread connections, use pipe tape to insure a good seal. *DO NOT OVER TIGHTEN.*

   C. For convenient disconnection of pumps installed with rigid pipe, install unions near both inlet and outlet connections.

4. *DO NOT OPERATE PUMP DRY!*

   A. All centrifugal pumps, when put in operation, must be primed with liquid unless the pump is installed below the level of the liquid and is provided with true flooded suction.

   B. To prime, pour liquid into the outlet tubing or piping and allow it to fill the pumping chamber. The pump will normally prime with less effort when a foot valve is installed at the end of the suction line; this will also eliminate the need to reprime each time the pump is turned off.

5. With inlet and outlet valves open, the pump can be started. The pump flow rate can be regulated by a valve on the discharge side. If flexible tubing is used, a simple tubing clamp can be employed to restrict flow. *DO NOT RESTRICT SUCTION.*

OPERATING TIPS:

A. If the pump is to be left idle for extended periods, flush the pump with water to prevent crystallization of the fluid inside the pump chamber.

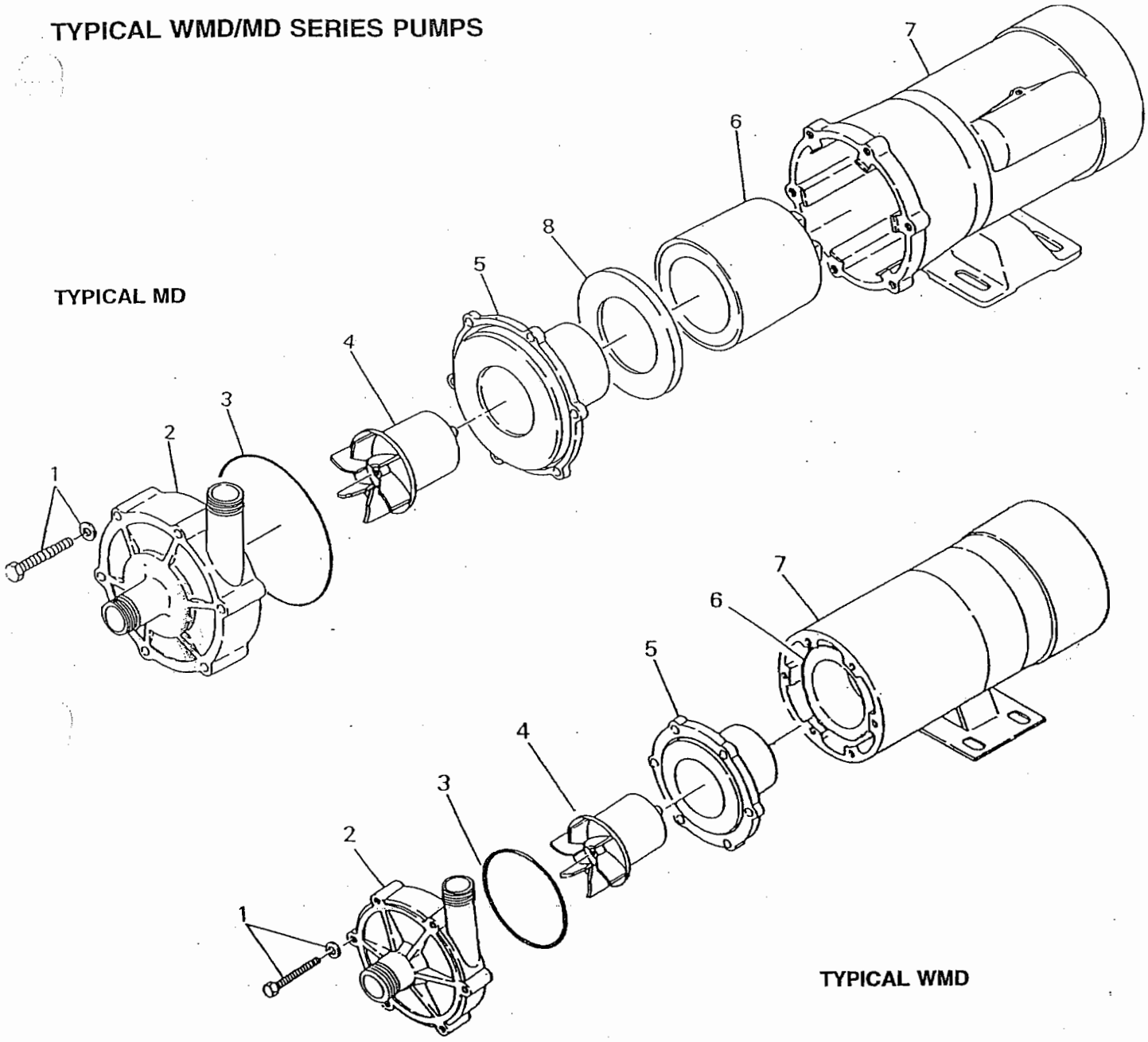
B. If the fluid to be pumped contains suspended solids, install a strainer in the suction plumbing, periodically inspect the suction strainer and remove any built-up debris.

C. Fluids of high specific gravity CAN NOT be pumped. See pump specifications for more information.

D. The impeller may decouple from the drive magnet for several reasons; e.g. temperature, viscosity or specific gravity are too high. This is usually indicated by initial pumping, then a complete cut off of flow. Turn off power to the motor, allow it to stop rotating, then start it again. If the problem recurs, check for excess temperature, viscosity, or specific gravity.

FIVE BOYNTON ROAD HOPPING BROOK PARK HOLLISTON, MA 01746-1446 USA
TEL: 508-429-1440 FAX: 508-429-1386
ON THE INTERNET: WWW.IWAKIWALCHEM.COM

TYPICAL WMD/MD SERIES PUMPS



Item No.	Description	Item No.	Description
1	Screw	5	Rear Casing
2	Front Casing	6	Drive Magnet
3	O-Ring	7	Motor Assembly
4	Impeller	8	Retainer (MD-100R, -100F, -55F only)

P/N 72949
Rev. M

Gems Sensors

Gems Sensors Inc.
One Cowles Road
Plainville, CT
06062.1198

tel 860.747.3000
fax 860.747.4244

Gems Sensors

Piston-Type Flow Switches
Series FS-925/926 & FS-927/930

Instruction Bulletin No. 72949

Installation . . .

Unless otherwise specified at time of purchase, units are calibrated in a vertical position, with lead wires up. Install unit in piping system, using standard pipe fitting procedures. Be sure to keep thread sealing compound out of unit. Make sure that flow is in proper direction - marked "IN" and "OUT" on housing. See wiring diagrams for electrical connections. CAUTION: See "Switch Ratings" before connecting power.

CAUTION: Flow settings for FS-920 series switches are normally calibrated using water** @ +70°F on increasing flow. If unit will be used to monitor liquids other than water, gas or air, Factory should have been consulted at time of purchase for special calibration. All air/gas units are factory-calibrated using a special piston. Water-calibrated units are not recommended for air/gas applications.

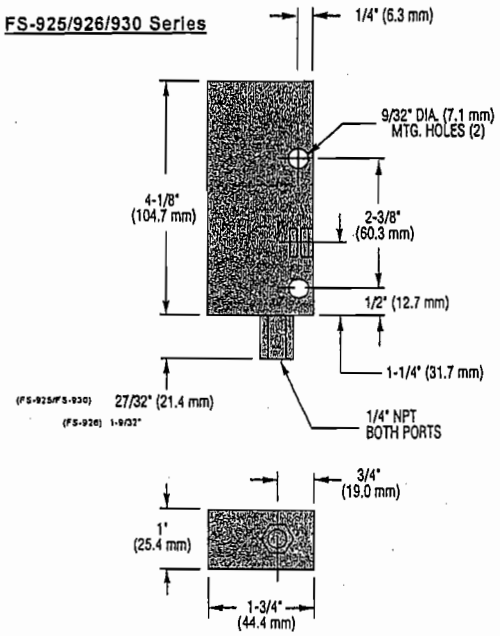
**Note: Flow settings for FS-930 Viscosity Compensating type switches are calibrated in a vertical position (lead wires up) with 300 SSU oil. Set points will be maintained within 20% of settings in a liquid viscosity range of 40 to 2,000 SSU.

Specifications . . .

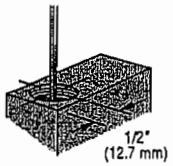
	FS-925/FS-926	FS-930	FS-927
Wetted Materials			
Housing	Brass or 316 SS	Brass	Brass
Piston		Brass	Brass
Brass Housing	Polysulfone/Water - Brass/Oil or Air		N/A
Stainless Steel Housing	316 SS		N/A
Spring	316 SS		
O-Ring	Viton®		N/A
Other Wetted Parts	Epoxy		SS
Pressure Rating			
Operating	1000 PSIG		1000 PSIG,Max.
Proof	2500 PSIG		
Burst	5000 PSIG		
Operating Temperature			
Brass or SS Piston	-20°F to +300°F	-20°F to +300°F	-20°F to +200°F
Polysulfone Piston	-20°F to +225°F		N/A
Repeatability	1% Maximum Deviation	15%, Max.	N/A
Set Point Accuracy	±10%		±15%
Set Point Differential	15% Max.(FS-925) - 20% (FS-926)		20% Max.
Switch*	SPDT, 20 VA		SPST, 20 VA
Inlet/Outlet Ports	1/4" NPT		1/4" NPT
Electrical Termination	No. 18 AWG, 24" L., Polymeric Lead Wires		No. 18 AWG, 24" L., PVC Lead Wires

Dimensions . . .

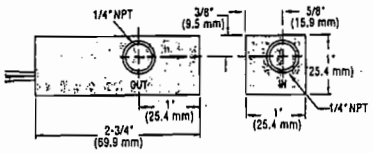
FS-925/926/930 Series



Electrical Connection (1/2" NPT Conduit)



FS-927 Series

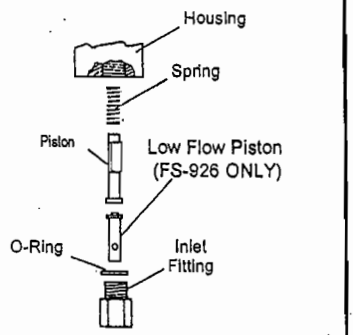


Maintenance . . .

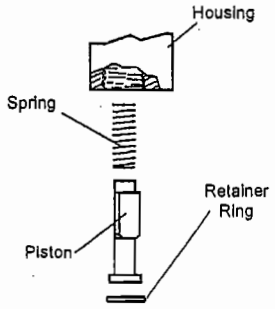
Accumulation of foreign debris should periodically be removed from these switches. Occasional "wipe-down" cleaning when excessive contamination is present is all that is normally required. To clean: Remove unit from system and disassemble as shown below. Clean all parts, reassemble and reinstall unit.

Note: 50 micron filtration is recommended.

FS-925/926/930 Series

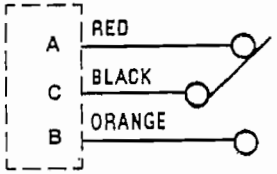


FS-927 Series



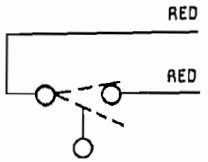
Typical Wiring Diagrams

FS-925, FS-926, FS-930 Series



Pin Connections for Units with MS Receptacle

FS-927 Series



Switch Ratings
Max. Resistive Load

VA	Volts	Amps AC	Amps DC
20	0-30	.4	.3
	120	.17	.13
	240	.08	.06

CE

This product is suitable for Class I and Class II applications only, per the requirements of standard EN60730 and any additional specific requirements for a particular application or medium being sensed. Class I compliance of metal bodied units requires a ground connection between the metal body and the earthing system of the installation. Class I compliance of plastic bodied units in contact with a conductive medium requires that the medium be effectively earthed so as to provide an earthed barrier between the unit and accessible areas. For Class III compliance, a supply at safety extra-low voltage (SELV) must be provided. Please consult the Factory for compliance information on specific part numbers.

Important Points!

Product must be maintained and installed in strict accordance with the National Electrical Code and Gems product catalog and instruction bulletin. Failure to observe this warning could result in serious injuries or damages.

An appropriate explosion-proof enclosure or intrinsically safe interface device must be used for hazardous area applications involving such things as *(but not limited to)* ignitable mixtures, combustible dust and flammable materials.

Pressure and temperature limitations shown on individual catalog pages and drawings for the specified flow switches must not be exceeded. These pressures and temperatures take into consideration possible system surge pressures/temperatures and their frequencies.

Selection of materials for compatibility with the media is critical to the life and operation of GEMS flow switches. Take care in the proper selection of materials of construction; particularly wetted materials.

Life expectancy of switch contacts varies with applications. Contact GEMS if life cycle testing is required.

Ambient temperature changes do affect switch set points, since the specific gravity of a liquid can vary with temperature.

Flow switches have been designed to resist shock and vibration; however, shock and vibration should be minimized.

Liquid media containing particulate and/or debris should be filtered to ensure proper operation of GEMS products.

Electrical entries and mounting points may require liquid/vapor sealing if located in an enclosed tank.

Flow switches must not be field repaired.

Physical damage sustained by the product may render it unserviceable.

***Contact ... ...ing ratings:**

1/4" dia model
1.0 Amp @ 120 VAC
All 1/2" dia model
5 Amps @ 120 VAC 3 Amps @ 240 VAC 1 Amp @ 120 VDC
All 5/8" dia model
10 Amps @ 120 VAC 5 Amps @ 240 VAC 2 Amps @ 120 VDC

*** Material:**

Sheath material: 304 Stainless Steel.
Flange, Pipe & Coupling head options are 300 series Stainless Steel.
Consult factory for blockhead mounting option.

*** Lead wire termination: = 8" Long.**

All 1/2" dia model # 20 A.W.G. F/Glass insulation.
All 5/8" dia.model # 16 A.W.G. F/Glass insulation.
Stranded nickel clad copper wire.
1/4" dia. model # 26 A.W.G. Teflon insulation.
Stranded silver plated copper wire.
Tolerances on all models + / - 1/2"
Consult factory for optional type and lead lengths.

*** Sheath Diameters:**

1/4" dia. model .249" diameter.
1/2" dia. model .499" diameter.
5/8" dia. model .624" diameter.
Tolerances on all models +.000" - .004"

*** Caution:**

Excessive torque applied to pipe bushings or pipe couplings mounted on the CAL-STATS may change temperature settings.

Maximum torque values:

1/4" dia. 10 ft-lbs. (13.5 N-m) *
1/2"dia. 20 ft-lbs. (27.5 N-m) **
5/8"dia 35 ft-lbs. (47.5 N-m) ***
When teflon tape lubricant is used.
* 1.1ft-lbs. (1.5 N-m)
** 2.2 ft-lbs. (3.1 N-m)
*** 4 ft-lbs (5.4 N-m)

M14/0000/183000

TAKE TOTAL CONTROL
WITH THE
VULCAN CAL-STAT™
THERMOSTAT

"A proven simple, adjustable set point temperature controller".
This compact temperature control offers
design versatility in hundreds of applications including,

*** Packaging Machines *Marking Equipment *Livestock Waterers**
***Vending Machines *Laminating Equipment *Photographic Processing**
***Plastics Processing *Dryers *Shoe Machines**
***Commercial Food Service *Platens *Hot Stamping**

Manufacturing, Sales, and Accounting.
28 Endfield Street.
Porter, Maine 04068
(207) 625-3231 1-800-922-3027 Fax. (207) 625-8938

Definitions:

Normally Open CAL-STAT (N.O.): Contacts **close** on temperature rise at set point temperature.
Normally Closed CAL-STAT (N.C.): Contacts **open** on temperature rise at set point temperature.

TEMPERATURE SETTING INSTRUTIONS

Unless otherwise specified, the temperature setting of a CAL-STAT should be made in the following manner:

For all 1/2" and 5/8"dia. CAL-STATS TEMPERATURE ADJUSTMENTS:
Counterclockwise rotations of the adjusting screw **INCREASES** temperature set point.
Clockwise rotations of the adjusting screw **DECREASES** temperature set point.
For 1/4" dia. CAL-STATS TEMPERATURE ADJUSTMENTS:
Counterclockwise rotations of the adjusting screw **DECREASES** temperature set point.
Clockwise rotations of the adjusting screw **INCREASES** temperature set point.

1. Connect test light or other device suitable for determining contact position across heater leads.

2. **Procedure for setting all 1/2"dia. and 5/8"dia. CAL-STATS:**
   - 2.1 Install CAL-STAT in media to be controlled.
   - 2.2 Allow the temp. of media to increase 10 to 20 degrees above required temp. set point by turning the adjusting screw counter clockwise. Approx. 90 degrees Fahrenheit per revolution for the 5/8"dia. CAL-STAT. The adjusting rate for 1/2"dia. CAL-STAT is approx. 120 degrees Fahrenheit per revolution. Allow media to stabilize at this temp.
   - 2.3 Turn adjusting screw clockwise in small increments until desired control temp. (set point) is reached.
   - 2.4 CAL-STAT is now set.

3. If an over adjustment is made during step 2.3 or if a readjustment is required, restart at step 2.2 and repeat the procedure. Remember that all readjustments must be made by turning the adjusting screw clockwise to reach the desired set point.

4. **Procedure for setting 1/4" dia. CAL-STATS:**

   4.1 ... steps 1,and 2.1 on page 1.
   4.2 Allow the temp. of media to increase 10 to 20 degrees above required temp. set point by turning the adjusting screw clockwise. Do not turn adjusting screw more than 1/4 revolution in either direction from room temp. without checking set point. Adjusting rate is approx. 700 degrees Fahrenheit per revolution.
   4.3 Turn adjusting screw counterclockwise in small increments until desired control temp (set point) is reached.
   4.4 CAL-STAT is now set.

5. If an over adjustment is made during step 4. 3, or if a readjustment is required, restart at step 4. 2 and repeat the procedure. Remember, readjustments must be made by turning the adjusting screw counterclockwise to reach the desired set point.
6. Cal-Stats may be subject to a small amount of set point drift after a few cycles under load due to relaxation of stress and other factors. Check the set point and readjust if required after approximately 100 cycles under load to improve performance.

CAL-STAT Application Precautions

Please read carefully.

- **This unit is calibrated for _____degrees Fahrenheit.**

* Do not expose this unit to more than 100 degrees Fahrenheit (38 degrees Celsius) above set point.
* On 1/2"and 5/8"dia. CAL-STATS, do not turn adjusting screw more than 7 revolutions in either direction from room temp.
* On 1/4"dia CAL-STATS, do not turn screw more than 1/4 revolution in either direction from room temp without checking set point.
* Disassembly of adjusting screw may also render CAL-STAT inoperative.
* If necessary to reduce the temp setting in heated system, do not turn adjusting screw more than one revolution or 100 degrees Fahrenheit temperature drop at any one time.
* Do not exceed the rating shown on CAL-STAT shell.
* The maximum contact rating for the 1/4"dia, 1/2"dia. and the 5/8"dia CAL-STAT are listed under the engineering specifications. Optimum performance is achieved when the contact load is half the maximum rating. Improved performance will result when a contactor is used to control the load and the CAL-STAT is wired through the holding coil of the contactor.
* System vibration can cause contact bounce. Also, controlling systems where thermal rise over time is slow can result in overshooting the set point. The addition of a capacitor will reduce the bouncing and overshooting. The typical recommended capacitor is 0. I microfarad, rated at a minimum of 600 V DC. for 120 VAC. circuits and a minimum of 1000 VDC for 240 VAC circuits. The capacitor is wired in parallel across the leads of the CAL-STAT. Consult factory for application assistance, capacitor selection, and availability.
* Proper hole sizing for the CAL-STAT is extremely important to avoid restricting shell expansion during operation and at the same time maintaining proper fit for the best temperature control. For the best temperature control, the reamed hole sizes required are, (1/4"dia. models, .250 diameter hole), (1/2"dia. models, .500 diameter hole), (5/8"dia. models, .625 diameter hole),
* Do not seal lead end of CAL-STAT with silicone sealant materials such as oils, caulking or grease.
* Do not distort CAL-STAT shell.

Prepared by G.Kotsiroplos 10/31/99.

Vulcan Engineering Specifications:

*** Center adjust Cal-Stats:**
U.L. Recognized CAL-STATS.
1/2"and 5/8" dia. model
U.L. File # E36322
Canadian Standards Association Certified CAL STATS.
5/8"dia. model
C.S.A. File # LR23541

*** Off-Set adjust Cal-Stat:**
U.L Recognized CAL-STAT 5/8" dia. model.
U.L. File # E.36322
C.S.A. File # LR23541
1/2"dia. models U.L.reconized units are available only upon request.

*** CAL-STAT temperature range:**

Center adjust: 1/2" & 5/8" dia.	**Off-set adjust:** 1/2" & 5/8" dia.
- 100 to 600 deg. F	-100 to 700 deg. F.

1/4"dia. model
-100 to 500 deg. F

*** Set point definition:**
Temperature at which contacts open or close.

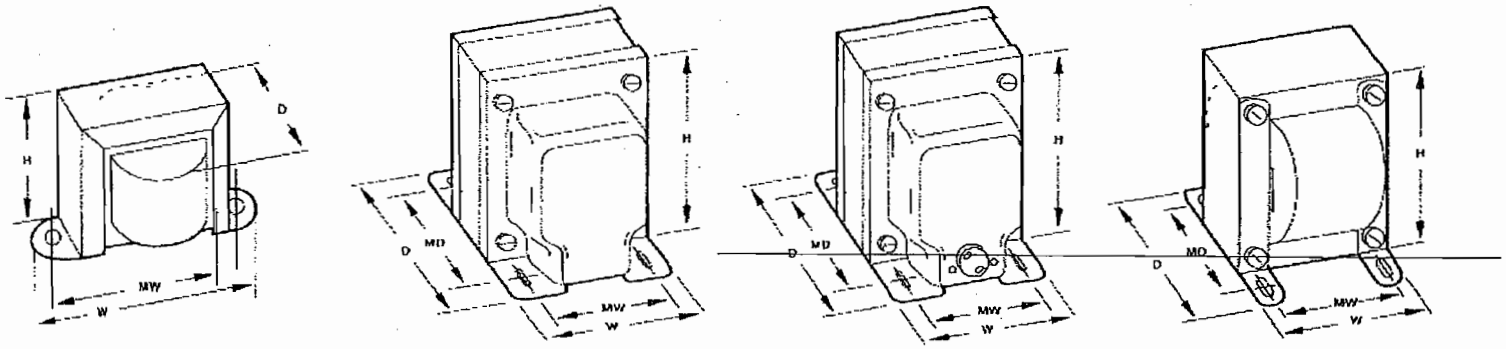
*** Standard factory set point:**
75 deg. +/- 15 deg. F (24 deg. +/- 8 deg. C.)
(optional factory setting available)

*** Temperature adjusting rate:**
1/4" dia. model Approximately 700 deg. F per revolution.
All 1/2" dia. model Approximately 120 deg. F per revolution.
All 5/8" dia. Model Approximately 90 deg. F per revolution.

*** Adjusting temperature set point:**
All 1/2" dia. & 5/8 dia. models
Turn adjusting screw **counterclockwise**, increases temperature set point.
1/4" dia. model
Turning adjusting screw **clockwise**, increases temperature set point.

POWER TRANSFORMERS Isolation/Medical 80040 REV B *MagneTek*

DESCRIPTION : TRIAD isolation transformers from MagneTek are power transformers for isolating equipment from direct connection to the power line. They are offered in a variety of voltages and case types. TRAID isolation transformers are also offered in a hospital type (designated with an MD suffix) which are designed and constructed to meet the low leakage current requirements for today's medical equipment. The transformers are constructed with nonconcentrically wound coils. The primary and secondary are wound on separate arbors, then assembled on a laminate core side-by-side separated by insulation. This prevents electrical connection, under normal or overload conditions, between the primary & secondary windings. These hospital type units are offered with a resettable circuit breaker, providing protection from overload and short circuit conditions.



CASE X CASE A CASE M CASE U

STANDARD APPLICATIONS Mounting Holes Sizes: (1) = 3/8" (2) = 13/64 x 3/8" (3) = 3/8 x 3/16" (4) = 21/32 x 9/32" (5) = 1/2" x 1/4"

TYPE NO.	CASE TYPE	PRIMARY VOLTAGE	VA	SECONDARY AC VOLTS +/- 5%	SECONDARY AC AMPS	Connec - tions	Lead Hole used	DIMENSIONS H	DIMENSIONS W	DIMENSIONS D	Mounting MW	Mounting MD	WT Lbs.
N-48X	X (1)	115	15	115	0.13	Leads	-	1 15/16	3 5/16	2	2 13/16	-	1.35
N-51X	X (1)	115	35	115	0.3	Leads	-	2 9/32	3 11/16	2 1/8	3 1/8	-	1.7
N-68X	X (1)	115/230 S	50	115	0.435	Leads	-	2 9/32	3 11/16	2 1/8	3 1/8	-	1.7
N-53M	M (3)	115	85	115	0.74	6' cord, Plug & Socket	-	3 19/32	2 31/32	3 3/4	2 1/4	2 3/8	4.7
N-53MG /	M (3)	115	85	115	0.74	6' cord, Plug & Socket	-	3 19/32	2 31/32	4 1/8	2 1/4	2 7/8	4.7
N-76U *	U (2)	115	100	115	0.86	Leads	-	3 7/16	2 13/16	3	2 1/4	2 1/2	4
N-77U *	U (2)	115/230	100	115	0.86	Leads	-	3 7/16	2 13/16	3	2 1/4	2 1/2	4
4M	M (3)	115	150	115	1.3	6' cord, Plug & Socket	-	3 7/8	3 9/32	4 1/4	2 1/2	3	7
MG /	M (3)	115	150	115	1.3	6' cord, Plug & Socket	-	3 7/8	3 9/32	5 13/16	2 1/2	3 1/2	7
N-73 A	A (3)	115	150	115/230 S	0.65	Leads	1	3 7/8	3 9/32	3 5/8	2 1/2	2 3/4	7
N-67A	A (3)	115/230 S	150	115	1.3	Leads	2	3 7/8	3 9/32	3 7/8	2 1/2	3	7
N-55M	M (3)	115	250	115	2.17	6' cord, Plug & Socket	-	4 5/8	3 15/16	5	3	3 13/16	11
N-55MG /	M (3)	115	250	115	2.17	6' cord, Plug & Socket	-	4 5/8	3 15/16	5	3	3 13/16	11
N-255MG /	M (3)	230	250	115	2.17	6' cord, Plug & Socket	-	4 5/8	3 15/16	5	3	3 13/16	11
N-66A	A (3)	115/230 S	250	115	2.17	Leads	2	4 5/8	3 15/16	4 5/8	3	3 5/8	11
N-57M	M (5)	115	500	115	4.35	6' cord, Plug & Socket	-	5 5/16	4 1/2	6 1/4	3 1/2	5 1/8	23.75
N-57MG /	M (5)	115	500	115	4.35	6' cord, Plug & Socket	-	5 5/16	4 1/2	6 1/4	3 1/2	5 1/8	23.75
N-257MG /	M (5)	230	500	115	4.35	6' cord, Plug & Socket	-	5 5/16	4 1/2	6 1/4	3 1/2	5 1/8	23.75
N-59M	M(5)	115	1000	115	8.7	6' cord, Plug & Socket	-	5 5/16	4 1/2	7 1/8	3 1/2	6	31
N-59MG /	M(5)	115	1000	115	8.7	6' cord, Plug & Socket	-	5 5/16	4 1/2	7 1/8	3 1/2	6	31
N-259MG /	M (5)	230	1000	115	8.7	6' cord, Plug & Socket	-	5 5/16	4 1/2	7 1/8	3 1/2	6	31

S = SPLIT WINDING * = UNIT DOES NOT INCLUDE STATIC SHIELD / = WITH GROUND WIRE

MEDICAL/DENTAL APPLICATIONS UL 544 FILE E102910

TYPE NO.	CASE TYPE	PRIMARY VOLTAGE	VA	SECONDARY AC VOLTS +/-5%	SECONDARY AC AMPS	Connec - tions	Lead Hole used	DIMENSIONS H	DIMENSIONS W	DIMENSIONS D	Mounting MW	Mounting ML	WT Lbs.
N-90MD	M (3)	115	250	115.0	2.17	6' cord, Plug & Socket Circuit Breaker	-	4-5/8	3-7/8	6-1/8	3	4-15/16	11.9
MD	M (4)	115	500	115.0	4.35	6' cord, Plug & Socket Circuit Breaker	-	5-11/32	4-1/2	7	3-1/2	5-3/8	17.6

Leakage current from primary to secondary is rated at less than 50 micro-amps and is typically measured at less than 10 micro-amps.

ECHNICAL NOTES:

1. Line cord, plug and receptacle are U.L. listed and verified to meet federal specifications.
2. Connections are by leads, plugs and sockets.
3. Hi-pot tested @ 1,500 VRMS
4. All units have static shields, except those marked with an asterisk.

SPECIFICATIONS:

PRIMARY: 115/230 VAC, 50/60 Hz

SECONDARY: 115/230 VAC

OUTPUT WATTS: 15 TO 1,000 VA

LEAD CONNECTION HOOK-UPS:

N-48X, 51X, 76U

HOOK UP						OUTPUT
115 VAC	-	-	APPLY TO	BLK - BLK	SEC	RED - RED

N-68X, 66A, 67A

HOOK UP						OUTPUT
115 VAC	TIE	BLK - RED/BLK	APPLY TO	BLK - YEL/BLK	SEC	RED - RED
		YEL/BLK - GRN/BLK				
230 VAC	TIE	YEL/BLK - RED/BLK	APPLY TO	BLK - GRN/BLK	SEC	RED - RED

N-77U

HOOK UP						OUTPUT
115 VAC	TIE	BLK - BLK/GRN	APPLY TO	BLK - YEL/BLK	SEC	RED - RED
		BLK/YEL - BLK/RED				
230 VAC	TIE	BLK/YEL - BLK/GRN	APPLY TO	BLK - GRN/BLK	SEC	RED - RED

N-73A

HOOK UP						OUTPUT
115 VAC	-	-	APPLY TO	BLK - YEL/BLK	SEC1	BLK/RED - BLK/YEL
					SEC2	BLK/GRN - BLK/WHT

5" SID, Shelf Position 9, Beam Center, 4" Beam Coverage, R/min at various technique factors (Max. Power) and depths of water.

Beam Filtration= 0.5 mm Cu

Technique Factors		1 cm. H2O	2 cm. H2O	3 cm. H2O	4 cm. H2O
kV	mA	R/min	R/min	R/min	R/min
100	10	215	193	168	148
110	9.1	265	236	207	179
120	8.3	314	276	246	214
130	7.7	360	315	281	245
140	7.1	404	364.5	317	281
150	6.7	445	413	354	311
160	6.2	484	447.5	388	340

13" SID, Shelf Position 7, Beam Center, 10.5" Beam Coverage, R/min at various technique factors (Max. Power) and depths of water.

Beam Filtration= 0.5 mm Cu

Technique Factors		1 cm. H2O	2 cm. H2O	3 cm. H2O	4 cm. H2O
kV	mA	R/min	R/min	R/min	R/min
100	10	28.6	25.9	22	21.2
110	9.1	35.3	31.9	26.8	25.6
120	8.3	41.5	37.8	32.5	29.9
130	7.7	48.1	43.7	37.2	34
140	7.1	54	48.9	42.5	39.2
150	6.7	60.5	55	47.2	43.1
160	6.2	65.2	60.1	50.8	47.9

13" SID, Shelf position 7, Beam Center, **No filtration**, values are in R/min.

kV	1 mA-R/min		2 mA-R/min.		4 mA-R/min.		Max. mA- R/min.		(mA)
10									7.9
20									16
30									16
40									16
50									16
60									16
70									14.3
80									12.5
90									11.1
100	215		470		978		2440		10
110	218		478		1000		2230		9.1
120	219		481		1019		2070		8.3
130	220		484		1030		1920		7.7
140	218		484		1035		1810		7.1
150	215		481		1037		1700		6.6
160	213		478		1032		1570		6.3

13" SID, Shelf position 7, Beam Center, **0.5 mm. Al filtration**, values are in R/min.

kV	1 mA-R/min		2 mA-R/min.		4 mA-R/min.		Max. mA- R/min.		(mA)
10									8
20									16
30									16
40									16
50									16
60									16
70									14.3
80									12.5
90									11.1
100	24.15		52.75		108.5		278		10
110	26.2		58		118.1		279		9.1
120	28.5		64.3		129.5		280		8.3
130	30.4		70.1		139.2		280		7.7
140	32.4		74.5		148		279		7.1
150	35.5		79.8		160		279		6.6
160	37.2		85		168.9		277		6.3

13" SID, Shelf position 7, Beam Center, **0.5 mm. Cu filtration**, values are in R/min.									
kV	1 mA-R/min		2 mA-R/min.		4 mA-R/min.		Max. mA- R/min.		(mA)
10									8
20									16
30									16
40									16
50									16
60									16
70									14.3
80									12.6
90									11.2
100	2.86		5.9		12.5		32.4		10
110	3.78		7.8		16.4		39.2		9.1
120	4.89		10.1		21.8		46		8.4
130	5.98		12.2		26		53.1		7.7
140	7.16		14.8		31.4		59.1		7.2
150	8.24		18.3		37		65.2		6.7
160	9.71		21.5		44.1		72		6.3
17" SID, Shelf position 6, Beam Center, **No filtration**, values are in R/min.									
kV	1 mA-R/min		2 mA-R/min.		4 mA-R/min.		Max. mA- R/min.		(mA)
10									8.3
20									16
30									16
40									16
50									16
60									16
70									14.3
80									12.4
90									11.1
100	112		249		510		1312		10
110	114.1		254		521		1225		9.1
120	115.3		256		530		1141		8.3
130	115.1		258		533		1063		7.7
140	114.5		258		536		990		7.1
150	113		257		534		922		6.7
160	112		256		532		815		6.2

5" SID, Shelf Position 9, Beam Center, 4" Beam Coverage, R/min at various technique factors (Max. Power) and depths of water.

Technique Factors			1 cm. H2O		2 cm. H2O		3 cm. H2O		4 cm. H2O
kV	mA		R/min		R/min		R/min		R/min
50	16								
60	16								
70	14.3								
80	12.4								
90	11.1								
100	10		1640		1140		766		580
110	9.1		1660		1175		813		626
120	8.3		1625		1210		850		665
130	7.7		1640		1240		882		700
140	7.1		1630		1268		924		734
150	6.7		1628		1308		964		768
160	6.2		1644		1330		1001		807

13" SID, Shelf Position 7, Beam Center, 10.5" Beam Coverage, R/min at various technique factors (Max. Power) and depths of water.

Technique Factors			1 cm. H2O		2 cm. H2O		3 cm. H2O		4 cm. H2O
kV	mA		R/min		R/min		R/min		R/min
50	16								
60	16								
70	14.3								
80	12.4								
90	11.1								
100	10		212		145		106.4		84
110	9.1		215		151		112.8		90
120	8.3		217		115.1		118.3		96
130	7.7		219		158.8		122.4		101.6
140	7.1		220		162		127		107
150	6.7		221		165		131.1		110.9
160	6.2		221		170.4		134		114

SECTION 8

RADIATION SURVEY

CONTENTS PAGE

SECTION 8

RADIATION SURVEY

8.1 RADIATION SAFETY STANDARD.

a. For systems delivered to all countries except UK:

Less than 0.5 mR/hr at 5 cm (2 in.) from exterior surface at maximum kVp.

b. For systems delivered to UK:

Less than 0.1 mR/hr at 10 cm (4 in.) from exterior surface at maximum kVp.

8.2 MEASURING INSTRUMENT CHECK - BEFORE SURVEY.

a. Type of instrument:

The Victoreen 450 P or equivalent with an accurate reading at 0.5 mR/hr is recommended.

b. Calibration date:

Make certain that the survey meter has been calibrated within the last three months.

c. Battery Check:

Check for proper battery condition. Replace batteries before survey if required.

d. Operational source check:

If the survey meter has a source check, check it as instructed in the operators manual for the meter.

e. All measurements should be made with the beta cap removed.

8.3 SURVEYING CABINET SYSTEM.

a. Place a shelf at the 18" SID level and a 4 liter (1 gallon) plastic jug of water on the center of the shelf. Make certain there is no filtration (filter is in the filter holder, etc.) in the direct beam.

b. Block or wedge the door open to a point just before the interlock actuates.

c. Set kVp to maximum and expose at 3 mA for standard and option A04 and A05 systems, 0.3 mA for options M110 and M55 systems.

d. Starting around the door slowly, scan the four sides and top of the system. Scan at about 4 cm/second (about 1.6"/second) across each side at about 2 to 2.5 cm (0.8 to 1") from face of survey meter to face of side or top of the system. Scans are made in horizontal movements from one edge of face to the other edge, moving down an average of 5 cm (2") each pass. Scan in a parallel line back and forth until the whole side is scanned.

Perimeter of sides are then scanned. If there is an increase while scanning, in meter reading, by leakage, or by background burst of radiation, the area of approximately 5 x 5 cm (2 x 2") shall be very slowly scanned. Go over the area two or three times until there is a stabilized reading on the meter. The highest stabilized reading (HR) is recorded for all four sides and for the top of the system.

e. Determine the lowest value of background radiation, by turning the X-ray system off and waiting for the meter to stabilize to its lowest level (BG). Record this value. Actual (net) leakage values are determined by the formula:

Actual Leakage = HR - BG

SURVEYING CABINET SYSTEM (cont'd)

NOTE: In order to obtain the reading for the top of the system, the meter was held vertically. Be certain to measure the corresponding background reading with the meter held vertically.

f. If the system is on a table, or if there is personnel on the floor below where the system is used, the bottom of the unit should also be surveyed. Before scanning the bottom of the cabinet, all attenuation in the direct beam, such as the water jug, metal shelf, filters, etc., shall be removed.

NOTE: In order to obtain the reading for the bottom of the system, the meter was held vertically. Be certain to measure the corresponding background reading with the meter held vertically.

g. When the system is placed against a wall and people occupy an area on the other side of the wall - be certain to survey the area immediately on the other side of the wall in a similar manner as specified in step d.

8.4 MEASURING INSTRUMENT CHECK - AFTER SURVEY.

a. Battery Check:

Check for proper battery condition. If battery condition is not correct, replace batteries and repeat the survey.

b. Operational source check:

If the survey meter has a source check, check it as instructed in the operators manual for the meter. If the reading is out of specification, all readings made during the survey could be incorrect. Recalibrate or replace the survey instrument and repeat the survey.