INSTALLATION, SERVICE AND MAINTENANCE INSTRUCTIONS FOR A1-5020 CONTROL

This manual assigned to:
Serial #__________Control
Serial #__________Generator

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325V GENERATOR SYSTEM

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1.0 Introduction and General Description.

The 325V generating system is composed of the A1-5020 x-ray control and the A2-5000 generator. It is a single phase x-ray generating system designed to operate one double focus rotating anode tube. The output of the unit is 300 ma at 125 kvp with the significant feature of very accurate exposure timing, particularly at the short exposure times.

The control and generator are manufactured in accordance with all applicable standards of the Department of HEW Performance Standard 21CFR sub chapter J. A brief discussion of the HEW Performance Standard is given in section 1.1 of this manual.

This manual contains the necessary information for the assembler to properly install and calibrate the A1-5020 control in conjunction with the A2-5000 generator. All necessary drawings required for permissible field service are included with this manual. The assembler is required by the HEW Performance Standard to turn this manual over to the purchaser at the completion of the installation and the manual must remain with the machine throughout its useful life.

In addition to installation instructions in this manual, a brief discussion is given on the operational theory of the circuits in the machine necessary for performing installation and field service.

Upon completion of the installation and calibration, the assembler is requested to fill out TWX QC E104 installation data sheet, and return it to the Transworld factory for permanent filing with the factory test records on the unit. A copy of the test sheet should also remain with this manual at all times. A preventive maintenance schedule, with trouble shooting tips is provided in the rear of the manual. It basically requires a repeat of the test procedures on the form E104. According to the requirements as outlined in the HEW Performance Standard, the purchaser is required to keep this machine in compliance, and the maintenance schedule is presented for this propose.

From time to time Transworld X-Ray will publish addendums to this manual which may require changes in test procedures and/or the maintenance schedule. These addendums must be placed with this manual and become a permanent part of the manual. Results of periodic maintenance must also be kept with this manual as evidence that the maintenance has been performed.

1.1 HEW PERFORMANCE STANDARDS

INTRODUCTION

This section presents a general overview of the HEW regulations. It is presented only to inform the reader of selected highlights that have been judged to be of importance. It is not the intent of this section to present all regulations; it is the responsibilit of each party involved in the electronic-product radiation industry to obtain current copies of the regulations and to thoroughly under stand the applicable provisions.

THE ACT

The Radiation Control for Health and Safety Act known as Public Law 90-602, was enacted by Congress, and was signed by the Presiden on October 18, 1968. It requires the Secretary of Health, Educatio and Welfare to prescribe performance standards to control man-made radiation from all domestic and imported electronic products if he determines that such standards are necessary for the protection of the public.

SCOPE

Any manufactured or assembled product is covered by this Act if it capable of emitting electronic product radiation, or any manufactur article intended as a component of such a device which can affect the emitted radiation.

The Secretary has delegated to the Bureau of Radiological Health (BRH) responsibility for day-to-day administration of the Act, and in fulfilling this responsibility, the BRH has issued specific rules regulations, and performance standards. Inquiries relative to the implementation or clarification of the regulations should be directe to the Director, Bureau of Radiological Health, 12720 Twinbrook Parkway, Rockville, Maryland 20852.

In fulfilling the requirements of the Act, performance standards for electronic products have been established with an effective date of August 1, 1974.

HIGHLIGHTS

The x-ray industry is a diversified one in which components are assembled on the user's site to form the completed system. The various components may be gathered from a variety of companies, so it is necessary to state that the manufacturing process is not complete until the system is ready to use.

With the many steps in this process, definitions are required to separate the various steps. The term MANUFACTURER applies to the person or company engaged in manufacturing, assembling, or importing electronic products. The term DEALER applies to the person or company engaged in the business of offering these products for sale, lease, or as gifts to purchasers. A DISTRIBUTOR is a person or company engaged in the business of offering the products to dealers while PURCHASERS are the first persons who acquire a product for purposes other than resale. An ASSEMBLER is any person engaged in the business of assembling, repairing, or replacing one or more products into a subsystem or system.

The assembler may also be a manufacturer, however all responsibilities are discharged by following the instructions of the original manufacturer of the product and by filing of reports. If the assembler modifies a circuit, component, etc. which will affect the radiation safety, or if he does not follow the instructions provided, he assumes some of the legal responsibilities of a manufacturer of that product, subsystem, or system and must perform all tasks as outlined by the Act and its regulations.

The manufacturer of components subject to certification must provide to assemblers (and anyone who wishes to buy them) instructions for assembly, installation, adjustment, and testing of such components adequate to assure that the products will comply with applicable provisions of the standard when these instructions are followed. Furthermore, these instructions are to include the specifications of other components which would be compatible with the component when compliance depends on the compatibility. Therefore, if an assembler were to install a certified component into a system with other than compatible components which would affect the certification, the original manufacturer would not be liable. The original manufacturer may either list compatible components by model number, etc. or list the technical specifications required of other components.

The standard also requires a manufacturer to prescribe a schedule of maintenance which will keep the component in compliance. It is the purchasers' responsibility to provide this maintenance to insure that the equipment will stay in compliance.

The purchaser who redesigns or modifies certified components in, or removes certified components from, an x-ray system would also be considered an assembler in some cases and like an assembler could, by these changes, be deemed to be known as a manufacturer, and thus must be authorized by a formal variance, for these proposed changes. If he orders special non-conforming equipment from a component manufacturer, the component manufacturer must also petition for a variance before supplying the components.

Transworld X-Ray Corporation is a manufacturer of radiographic x-ray equipment and radiographic x-ray systems. Transworld's equipment line encompasses single phase x-ray generators, x-ray bucky tables, various types of tubestand assemblies, and special purpose equipment such as tomographs. Any x-ray system that can be assembled from Transworld components is a certified system. Components that are assembled into the system that are not manufactured by Transworld have to be components specified by Transworld as being compatible with their system. This is done either by actual catalog numbers as in the case of Machlett x-ray tubes and automatic collimation systems; or it is done by generic specifications or statements that spell out the compatibility requirements of other manufacturers' equipment that must be met in order to be compatible with Transworld equipment.

It is most important that the assembler be extremely careful in making decisions about installation of Transworld components with other manufacturers' components; furthermore, the assembler should be aware that if he makes any modifications during assembly not specifically covered in Transworld instructions, or any circuit changes in Transworld equipment without the prior written approval of Transworld for the installation involved, he will totally invalidate the certification and warranty on the machine if it affects the certification of the system. This would make the assembler liable for all reporting and testing criteria normally assigned to the original manufacturer.

It is the intent of Transworld X-Ray Corporation, that its equipment may be used with other manufacturers' equipment provided all compatibility requirements are met. As an example, Transworld X-Ray Corporation does not manufacture ceiling crane tubestands; however, this fact should not prevent installation of a Transworld generator and table with a ceiling crane tubestand manufactured by another manufacturer. Also, Transworld generators can be used with other manufacturers' bucky tables. If there is ever any question about compatibility of a Transworld component with another manufacturers' component, then the assembler should consult with the Transworld factory prior to his making a decision regarding mixing the two pieces of equipment.

1.2 APPLICATIONS AND COMPATIBILITY

APPLICATION.

The model A1-5020 control in conjunction with the model A2-5000 generator is intended to be used as a general purpose radiographic x-ray generating system and may also be used for the following specific applications: tomography, urology, chest, head and neck.

COMPATIBILITY.

The 325V control and generator, catalog #A1-5020 and #A2-5000 respectively are compatible with the following certified components, or with other certified components which meet the generic specifications outlined.

X-Ray Tubes:	Machlett	Dynamax	40
	"	"	42
	"	"	57

Any other certified tube housing assembly which has a minimum rating of 300 ma at 125 pkv; a large focus filament which does not require more than 5.5 amps at 12 volts for 300 ma operation; space charge characteristics that are linear with respect to kv in the 50 to 125 kv range; and will calibrate in accordance with instructions in this manual.

Beam Limiting Devices:

A. The 325V control and generator is compatible with any automatic collimation system which provides an isolated normally open switch which closes when the automatic collimation system presents an "exposure ready" mode to the x-ray control.

B. Other beam limiting devices. The 325V control and generator is compatible with any certified beam limiting device intended for use on radiographic equipment other than general purpose radiographic systems.

X-Ray Tables.

The 325V control and generator is compatible with any certified table which meets the performance standard requirements for x-ray table in general purpose radiographic rooms.

Cassette Holder.

The 325V generator is compatible with any certified cassette holder (non-bucky) and any certified bucky cassette holder that contains a Liebel-Flarsheim catalog #225059 or catalog #225058 bucky.

1.3 SPECIFICATIONS.

LINE FREQUENCY.

This control is designed for operation at 60 cycles AC.

LINE VOLTAGE.

The input line voltage may range from 220 VAC to 240 VAC for line regulations up to 8% (maximum tube current and maximum tube kvp).

The line voltage may range from 208 volts to 240 volts for line regulations up to 5.8% (maximum tube current and maxiumum tube kvp).

LINE CURRENT.

The standby line current is1.25amps, AC RMS with no rotor running and/or exposure being made.

The momentary input line current to the x-ray control is 131 amps, AC RMS under the following conditions:

1. X-ray tube current of 300 ma and tube pkv of 125.
2. Load voltage of 221 VAC RMS.

GENERATOR RATING AND DUTY CYCLE.

Output rating: 300 ma at 125 pkv.

Duty cyle: 60 kilowatt seconds/5 minutes.

MAXIMUM DEVIATION FROM CONTROL PANEL LABELED OR METER SETTINGS.

EXPOSURE TIME: Zero deviation from 1/120 second to 6 seconds, measured by counting integral 1/2 electrical cycles applied to the generator.

X-RAY TUBE CURRENT.

The x-ray tube current shall not deviate more than 10% from the labeled nominal values of 100, 150, 200, and 300 ma. The x-ray tube current shall not deviate more than 15% from the labeled nominal value of 50 ma. Tube current indication by the panel ma meter may deviate one scale division (10 ma) plus the above deviations. In the calibration of the control, the deviation due to panel ma meter inaccuracy is to be corrected for so that this deviation does not significantly affect the linearity HEW requirement.

PEAK TUBE POTENTIAL.

The panel pkv meter of the A1-5020 control shall indicate the relative pkv output of the A2-5000 generator within 2 pkv over the range of 50 to 125 pkv for any indicated ma chosen when the input line regulation at maxiumu output is 1.5% or less. The relative pkv output of the generator may differ from the absolute pkv by ± 6 pkv due to the inaccuracy of pkv measuring techniques.

For line regulations greater than 1.5% the following chart is provided which shows maximum deviations in kv from the indicated panel pkv for different power line regulations and tube current load.

2% Line Regulation

Panel PKV / MA	40-60	60-70	70-80	80-90	90-100	100-110	110-120	120-125
300	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
200	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
150	2	2	2.0	2.0	2.5	2.5	2.5	2.5
100	2	2	2	2	2	2	2	2
50	2	2	2	2	2	2	2	2

Maximum deviation in PKV underload from no load panel PKV indication.

3% Line Regulation

Panel PKV / MA	40-60	60-70	70-80	80-90	90-100	100-110	110-120	120-125
300	3	3	3	3	3.5	3.5	3.5	3.5
200	2.5	2.5	3	3	3	3	3	3
150	2.5	2.5	2.5	2.5	2.5	2.5	3.0	3.0
100	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
50	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5

Maximum deviation in PKV underload from no load panel PKV indication.

4% Line Regulation

Panel PKV / MA	40-60	60-70	70-80	80-90	90-100	100-110	110-120	120-125
300	3.5	4	4	4	4.5	4.5	5	5
200	3	3	3.5	3.5	3.5	3.5	4	4
150	3.0	3.0	3.0	3.0	3.0	3.0	3.5	3.5
100	2.5	2.5	2.5	3	3	3	3	3
50	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5

Maximum deviation in PKV underload from no load panel PKV indication.

5% Line Regulation

Panel PKV / MA	40 - 60	60 - 70	70 - 80	80 - 90	90 - 100	100 - 110	110 - 120	120 - 125
300	4.5	4.5	5	5	5.5	5.5	6	6
200	3.5	3.5	4	4	4	4.5	4.5	4.5
150	3.5	3.5	3.5	3.5	3.5	4.0	4.0	4.0
100	3	3	3	3	3	3	3.5	3.5
50	2.5	2.5	2.5	2.5	2.5	3	3	3

Maximum deviation in PKV underload from no load panel PKV indication.

6% Line Regulation

Panel PKV / MA	40 - 60	60 - 70	70 - 80	80 - 90	90 - 100	100 - 110	110 - 120	120 - 125
300	5	5.5	5.5	6	6.5	7	7	7.5
200	4	4	4.5	4.5	5	5	5.5	5.5
150	3.5	3.5	4.0	4.0	4.5	3.5	3.5	4
100	3	3	3	3.5	3.5	3	3	3
50	2.5	2.5	2.5	2.5	3	2.5	2.5	2.5

Maximum deviation in PKV underload from no load panel PKV indication.

7% Line Regulation

Panel PKV / MA	40 - 60	60 - 70	70 - 80	80 - 90	90 - 100	100 - 110	110 - 120	120 - 125
300	5.5	6	6.5	7	7.5	8	8.5	8.5
200	4	4.5	5	5	5.5	5.5	6	6
150	3.5	4.0	4.5	4.5	5.0	5.0	5.5	5.5
100	3	3.5	3.5	3.5	3.5	3.5	4	4
50	2.5	3	3	3	3	3	3	3

Maximum deviation in PKV underload from no load panel PKV indication.

8% Line Regulation

Panel PKV / MA	40 - 60	60 - 70	70 - 80	80 - 90	90 - 100	100 - 110	110 - 120	120 - 125
300	6.5	7	7.5	8	8.5	9	9.5	10
200	4.5	5	5.5	5.5	6	6.5	7	7
150	4.0	4.5	5.0	5.0	5.5	6.0	6.0	6.0
100	3.5	3.5	3.5	4	4	4	4.5	4.5
50	2.5	3	3	3	3	3	3.5	3.5

Maximum deviation in PKV underload from no load panel PKV indication.

1.4 MEASUREMENT TECHNIQUES TO ATTAIN PUBLISHED SPECIFICATIONS.

EXPOSURE TIME.

For all times from 1/120 to 6 seconds, a Durgin and Browne, Inc. model DPC-303, digital pulse counter is utilized.

The counter is wired across the high tension primary through a full wave bridge rectifier in such a fashion that the pulse counter sees the rectified AC sine wave going to the high tension transformer.

Any similar pluse counter can be utilized. The accuracy of any device used for this purpose must be absolute 100% accurate as far as counting rectified pulses of the 60 cycle AC line.

TUBE CURRENT.

The x-ray tube current is measured in the low voltage side of the high tension circuit by placing an MAS meter or precision DC milliampere meter in series with the control panel milliampere meter.

A Weston ¼% DC ma meter, model 901, (or equivalent) is utilized for determining deviations from absolute ma value due to panel ma meter inaccuracies.

An MAS meter for 200 and 300 ma loads at exposure times of 1/10 second (± 0 deviation) calibrated against an ma standard of 300 ma as measured with ¼% Weston 901 (or equivalent) DC ma meter with "on" time of 1/10 second (± 0 deviation). Effective accuracy of the MAS meter for the measurement of ma is less than 2%. MAS meter is placed in series with control panel DC milliampere meter for this measurement.

PEAK TUBE POTENTIAL.

Measured with GE model #46-154966G1 high voltage bleeder in anode side. Result multiplied by 2. GE bleeder calibration checked and corrected against .05% Parke high voltage divider standard. Bleeder resistor temperature coefficients taken into account.

Output wave form read with Tektronix model 434 storage oscilliscope. Oscilliscope calibrated against 0.01% digital voltmeter, and voltage readings verified against corrected Weston 904 (½% moving iron meter). Under ideal conditions estimated accuracy of reading peak value of AC sinusoidal wave form less than 1%.

1.5 ASSEMBLER MEASUREMENTS AND REQUIRED TEST EQUIPMENT.

In these instructions the assembler is required to make certain measurements. The assembler is an extension of the manufacturing process when he is making the installation and the final test and calibration. As such his measurements and techniques must reflect a certain degree of care and accuracy.

The tests required of the assembler have been made as simple as possible, but it is necessary that accurate measurements using an accurate voltmeter be made. The voltages that will have to be measured are in the range of 175 VAC to 300 VAC.

The tests have been designed to keep the use of various test instruments to a minimum. At the time of this writing it is our impression that the John Fluke Company is manufacturing a special x-ray version of the model 8000A digital multimeter. The special feature being a time integrator on the ma range (MAS meter). It is possible that a single instrument like this can be used to make all final testing and calibration on the 325V generator, and not require the use of additional instruments as outlined below.

VOLTMETER.

We recommend the use of a moving iron voltmeter with an inaccuracy no greater than 0.75% of full scale. A DVM with an accuracy of ± (0.5% of reading + 2 digits) is also acceptable and is very close to the same accuracy of the moving iron voltmeter in the voltage ranges that have to be measured.

The moving iron meter such as the one referred to above is a Weston model 433. The DVM equal to the above specification is a Fluke model 8000A.

MAS METER.

An MAS meter which has an effective accuracy of 2% for determining x-ray tube current at 1/10 of a second is required. See paragraph 1.4 regarding the basis for this measurement technique.

DC MILLIAMPERE METER.

A DC milliampere as incorporated in the Fluke model 8000A digital multimeter is recommended, but not required. This instrument has an accuracy of ± (0.3% of reading + 1 digit) and would be helpful to the assembler in verifying panel ma meter readings.

OSCILLISCOPE.

An oscilliscope, single trace, with a storage mode would be helpful, but is not required, for the measurement of exposure time. The oscilliscope can further be used for line regulation tests that the assembler desires. If the assembler utilizes a high voltage bleeder for observing the high voltage output, then of course an oscilliscope is normally required.

HIGH VOLTAGE RESISTANCE DIVIDER.

This device provides a nice cross check for the assembler on the end result of his calibration, but is not required on initial installation, since the kvp was carefully checked at the factory before shipment. Nevertheless, it is often a tremendous advantage for the assembler to have such a kvp measuring device at his disposal both on installations and for routine periodic maintenance.

1.6 POWER REQUIREMENTS

The importance of an adequate power supply to insure maximum service, satisfactory performance, and compliance to the federal performance standard cannot be over-emphasized.

The enclosed electrical data will assist the assembler in determining the correct wire size to be fed to this x-ray machine.

In view of the importance of having an adequate power supply, the assembler may wish to enlist the services of qualified engineering personnel in the area familiar with the electrical services feeding the particular building where the installation is to be housed. In most cases this person or persons can be found in the architectural or engineering firm that originally did the internal electrical layout for the building. In some cases the local power company may be of help. Whatever the case may be, it is very important to determine what the line regulation will be under full load conditions of the x-ray machine.

In the final testing of the generator, the assembler is required to measure the line voltage regulation under full load, since the output of this x-ray machine is dependent upon the line regulation.

In determining adequate power line capacity, two cases generally arise.

(1) Those installations where the machine is to replace an existing machine, and therefore, there may be an existing power supply adequate to run the new machine. To determine whether an existing power supply is adequate, the assembler must satisfy himself that under full load conditions the 325V generator (149 amps RMS at 217 volts) will not cause the existing power line to exhibit more than 8% line regulation which is the limit at which the machine will perform at its maximum line current and still meet all applicable requirements of the federal performance standard.

(2) New installations where there is not an existing power line to the machine location. In this case the assembler can specify a power line adequate to insure good machine performance. At this point it is important that the purchaser of the equipment realize that there is very little dollars difference between providing an exceptionally good power line, and providing one of poor quality or even marginal quality. It is therefore recommended that careful

attention be paid to the engineering of the power line feeding the machine and that the lowest possible percent line regulation be sought after even though the machine will perform at greater line regulations.

For optimum machine performance, the line regulation at maximum line current should not exceed 3%.

EARTHING

It is extremely important that a good earth connection is established particularly where other than ground floor installations are made. In addition to the earth on the switch box, a good earth connection should be made to a cold water pipe. An electrical inspector should inspect the installation after completion to ascertain if proper grounding in accordance with local codes has been obtained.

POWER REQUIREMENTS - TECHNICAL DATA

Distribution transformer capacity: 35.5 KVA

Line switch: 100 amp, 250 volt

Line volts: 200-240 VAC

WIRING

Power transformer to line switch

0 to 50 ft. run	(2) No. 4	plus	(1)No. 8
51 to 100 ft. run	(2) No. 0	plus	(1)No. 6
101 to 150 ft. run	(2) No. 000	plus	(1)No. 4
151 to 200 ft. run	(2) No. 0000	plus	(1)No. 2

Line switch to control:

0 to a 8 ft. run # 6/3 SO cable
Supplied with control

Control to generator:

Primary Leads: 0-25 feet. A prelugged 6/3 type SO cable supplied by Transworld X-Ray may be used; otherwise, the standard 8' prelugged 6/3 Type SO cable must be cut and spliced as follows:

8' - 25'	#6 copper
25' - 35'	#4 copper
35' - 50'	#2 copper

Earth lead,	(1)	#8
Filament,	(3)	#16
MA Meter, M1, M2:	(2)	#16

Note: Local codes may require filament and meter interconnecting wiring to be larger.

MAXIMUM LINE CURRENT

The maximum line current of this machine is 149 amperes for nominal input voltage of 221 volts. For different input voltages, calculate a new maximum line current by use of the following formula.

$$\text{Line current} = \frac{(149)\quad(221)}{\text{nominal input voltage}}$$

1.7 WARRANTY.

Transworld X-Ray Corporation warrants its equipment to be free of defects in material and workmanship that would cause the equipment not to operate under its published specifications. Any parts proving defective will be repaired or replaced free of charge, f.o.b. factory, if the defective parts are returned to the factory for inspection, charges prepaid. This warranty does not apply to glass ware or high voltage cables or x-ray tubes or to damage caused by accident, misuse, neglect or normal wear and tear, and is void if service or maintenance is performed by persons other than authorized Transworld dealers or representatives. This warranty does not cover defects subject to performance requirements under 21 CFR 1020.30.

Components not manufactured by Transworld X-Ray Corporation are not covered by this warranty but only the warranty of the original manufacturer. Transworld X-Ray Corporation reserves the right to pass judgment on the cause of the defect or failure.

Claims under this warranty must be made within 24 months after installation or not later than 30 months after shipment from the Transworld factory.

1.8 SPACE REQUIREMENTS.

The control unit has overall measurements of 12" deep, 21" wide and 53" high. It is so constructed that it can be placed directly against a wall, and once installation is made, all normal service procedures can be performed without pulling the unit away from the wall.

From an operator's radiation protection point of view, the control unit should be installed in a separate shielded operator's booth in such a manner that the operator can observe the patient through a lead glass window, and at the same time be shielded from scatter radiation off the patient and any close wall upon which the primary beam may be directed.

The generator (transformer) occupies a floor area of 14" x 15" and stands 22 1/2" off the floor, not taking into account the bend area required for the high voltage cables. The transformer can be installed underneath the TRIMLINE table, and it can be installed in other reasonably inaccessible areas. It should be remembered however, that on a rare occasion, it may be necessary to lift the transformer up out of the oil for servicing, and therefore the transformer should not be placed in a location where it is impossible to either lift the unit vertically up out of the oil or shift it around in such a fashion that there is room vertically to lift the main unit from its oil filled tank.

It is not recommended that the transformer be installed in a high humidity and high heat location. Although we cannot predict any detrimental effects on the unit from such an environment, it is best that the transformer be installed in the same or equivilent environment of the x-ray room.

1.9 BOLTING THE X-RAY CONTROL TO THE WALL.

The x-ray control must be bolted to the wall in order to prevent tipping. This is accomplished by a flat metal plate anchored on top of the rear cover of the machine using the top two mounting holes for the rear cover and their mounting screws. The plate protrudes 3/4" above the top of the control and you are to use two #10 screws to anchor the control to the wall. Refer to drawing #B301.313 to see specifically how the plate is to be anchored and mounted to the wall.

2.0 UNPACKING AND INSPECTION.

It is important that immediately upon receipt of the equipment from the motor freight carrier or other carrier, that the packages involved be carefully examined for external damage to the pallets, and the shipping cartons. If there is evidence of abuse such as torn cartons, crushed tops, etc. the bill of laden should be signed indicating that the packing showed evidence of damage upon receipt.

If the above is the case, the carrier's representative should be notified and given the opportunity to be present when the equipment is unpacked. In the event of internal damage, this is the simplest method for an assembler to assure himself of minimum problems with the freight carrier in making a claim.

Regardless of the condition of the external carton and packing, the contents should be carefully inspected both on the outside and inside where possible for damage that may be the result of too rough a handling during shipment. Evidence of such damage could be loose components inside the x-ray control, slightly dented sides of the control or other evidence that the machine is not in the condition that you assumed it should have been when it left the factory. A warped metal cabinet, or excessive oil leakage from the high voltage transformer would be evidence that the equipment had been rather severely handled, perhaps dropped during the transportation.

Many times such damage is not serious; however, the assembler should protect himself and the purchaser by immediately notifying the carrier's representative, getting him over to the location and letting him inspect the damage and make a report. For this reason it is very important that the packing material never to thrown away, until the assembler is assured that there is no visible evidence of damage to the equipment either external or internal.

2.1 X-RAY TUBES.

VERY IMPORTANT. All x-ray tubes should be inspected immediately upon receipt from the carrier for breakage or concealed damage. No x-ray tube should be warehoused or otherwise stored after receipt without first being inspected and if at all possible thoroughly tested. The minimum action required is to remove the x-ray tube from the housing and observe the port of the tube, making sure the glass inse is intact and that no oil bubbles appear within the tube.

2.2 CONTROL.

The control is shipped strapped down to a single pallet and completed wrapped in furniture shipping pads. The external carton is heavy corragation, and it is so placed over the control that there is an approximate 3" gap between the sides of the carton and the control unit. Immediately remove the front panel and the back panel and inspect the inside of the control for any evidence which would indicate rough handling during shipment.

2.3 GENERATOR.

The transformer is shipped strapped down to a single pallet and covered with a single heavy corragated box. The transformer should be inspected for excess oil leakage. Normally there will be a minor amount of oil leakage due to vibration during shipment. If there is an excessive amount of oil leakage carefully inspect the transformer tank itself for evidence of a rough blow during shipment or possibly a warped tank, etc. In the event of suspected damage, the carrier's representative should be contacted and shown what the assembler feels is evidence of rough handling, and informed that there may be internal damage, and that such internal damage cannot be confirmed until the transformer is put under electrical tests.

3.0 ASSEMBLY AND WIRING OF THE A1-5020 CONTROL.

The following paragraphs in this section provide instructions for the interconnecting wiring between the control and the other various components which go to make up a complete x-ray system. Reference will be made to Transworld electrical drawings which are provided with this manual. Reference will also be made to instruction manuals as furnished by other manufacturers of components such as Machlett and Liebel-Flarsheim. Transworld drawing numbers referred to in this section are correct for the specific serial number control that this book is intended for. However, there could be model changes, modifications, etc. on other components supplied by other manufacturers; this requires the assembler to verify that he has the correct instruction manual for the particular component being supplied by another manufacturer.

3.1 PRINTED CIRCUIT BOARDS.

Inside the control there are three printed circuit boards. Two come mounted in the control and one is wrapped and packaged with the relays in the lower portion of the control.

One of the permanent boards mounted to the back of the time selector switch is the digital counter board and the other permanent board contains the timer power supply, kv limit sensing transformers, SCR short circuit test circuitry and relays RY-2, RY-3, RY-4 and RY-12.

Mount the timer logic board in the connector coming off the power supply board with the components facing out into the control.

3.2 RELAYS

The relays are packed loose in the bottom of the control to prevent their falling out during shipment. Refer to drawing #D301.134E point to point wiring diagram for the proper placement of the relays by coil voltage and number of poles.

3.3 INTERCONNECTING WIRING.

The assembler should be aware of all local codes that relate to the installation of this x-ray equipment. Some codes may require that the wiring from control and generator to their respective wall junction boxes be in flexible armored cable while other codes permit the use of STO, or SJTO rubber covered interconnecting cable from these units to the wall junction boxes.

Furnished with the A1-5020 control and the A2-5000 generator are one set each Romex electrical connectors for the cable entrance into the control or generator. In the event that armored cable connectors are required, it is the responsibility of the assembler to furnish these.

Refer to drawing C301.314E which is an interconnecting block diagram with minimum recommended wiring sizes for typical installation of the Transworld 325V control, generator, Liebel bucky, and automatic collimator.

The x-ray control comes furnished with 8 feet of number 6/3 SO cable for the main line cable; 8 feet of number 6/3 SO cable to go between the x-ray control and high voltage transformer primary; 8 feet of Belden number 8621 (or equivalent) 7 conductor cable to interconnect the x-ray control and high voltage transformer filament and ma connections. Additional lengths of the above cable are available from TWX, but must be ordered as options.

The assembler must furnish all interconnect cable between x-ray tables and the x-ray control, x-ray tube stands and the x-ray control, upright bucky stands, and the x-ray control.

The wire size of the two primary leads between control and high tension generator is important. The total resistance of both the primary leads should not exceed .01491 ohms which represents 60 feet of #4 wire. If the assembler has a special situation where the resistance of the wire has to be greater than this, the factory should be consulted for instructions on altering the reading of the kvp meter to allow for increased kv drop due to higher resistance primary wiring being used.

To wire up to this x-ray control of the Transworld products such as; x-ray tables, x-ray tube stand, vertical bucky stands, cassette holders, etc., refer to the appropriate product installation instructions for the hook up.

Where a particular cable is furnished by a manufacturer (such as Machlett), it is so indicated on this drawing.

Refer to drawing #B301.313E and #B301.122 to show the proper routing and installation of cabling into the x-ray control. Drawing #B301.122 also provides dimensional outlines of the control.

The A1-5020 control, A2-5000 generator may be interconnected to other components in the x-ray system by utilizing information furnished on the above drawing; however, the above drawing does not furnish interconnecting instructions for the Collimaster C(PBL II or III) system, nor for other components not specifically specified by catalog number as being compatible with Transworld equipment.

The assembler must refer to the Machlett Collimaster C(PBL II or III) installation manual for all installation instructions, final testing and check out instructions, etc. Only the connections to the Transworld equipment exposure circuit are shown in the above drawing. Additional information on Liebel-Flarsheim buckys and the Liebel cassette size sensing tray (which is part of the Machlett Collimaster C(PBL II or III) system) may be found in the appropriate Liebel-Flarsheim Operating and Service Instructions which are supposed to be furnished with the respective components.

If equipment not furnished by Transworld X-Ray is to be interconnected into the x-ray system with this x-ray control, then it is the responsibility of the assembler to determine the appropriate wiring connections, and if he cannot, contact the Transworld factory for assistance.

In making the interconnections between the x-ray control and high voltage generator, it is suggested that neither of the primary leads (P1, P2) be connected at the transformer, in order to prevent accidental energizing of the high voltage generator prior to final testing. It is also suggested that the common filament lead not be connected, in order to prevent accidental burnout of one of the tube filaments should there be a wiring error.

3.4 ACCESSORY EQUIPMENT.

Accessory electrical equipment requiring 117 volts AC may be connected across terminals TB3-4 and TB3-1 provided such apparatus does not draw more than 2 amperes.

3.5 HIGH VOLTAGE GENERATOR INSTALLATION.

A separate instruction manual is provided for installation of the high voltage generator. In this manual details concerning proper handling of the high voltage cables and installation of them is covered. Also covered in this manual are problems to look for should high voltage instability occur upon testing of the control, or during life of the machine.

The terminals on the high voltage generator are to be covered by a terminal cover which fastens to a strain relief bracket which the assembler must anchor at the top of the generator.

This strain relief bracket contains one-1¼" Romex connector and two-3/4" Romex connectors.

The strain relief bracket also contains an elongated slot through which a green ground wire must pass from a 10/32 stud welded on the underneath lip of the generator tank to the ground terminal on the terminal strip on top of the generator tank. The assembler should remove the ground strap from the 10/32 stud underneath the tank, pass it through the strain relief bracket and secure it again to the stud on the underside of the lip.

4.0 PRELIMINARY TESTS PRIOR TO MAKING X-RAY EXPOSURES.

The following paragraphs describe the various preliminary tests the assembler must perform prior to the final testing and calibration of the unit. Some of the tests are redundant, since they were performed at the factory prior to shipment, and some procedures are suggested solely for the purpose of preventing problems due to accidental wiring errors on the installation.

If these procedures are followed point by point, then the assembler should experience no difficulty, or certainly a minimal amount of final check out problems.

In making voltage measurements in the 325V control it is important for the assembler to understand that there is no voltage measurement that should be made from a particular point back to a chassis ground or machine ground. There is no measurement required for any purpose where reading a voltage from such a point back to ground has any meaning whatsoever. The DC power supply provides volts DC not only for the timer but also for the rotor circuit, the SCR safety circuit, the kv limit circuit and sonalert circuit. Although the schematic diagram may show a ground reference point for the output voltages of this power supply, it must be emphasized that this is not a chassis ground. It is merely a floating ground within the several circuits. There is no physical connection from ground designation shown on the various schematics and the actual chassis ground.

There is one exception, and that is the ground connection shown at the junction between circuit breaker coils. The center tap of the high voltage secondary circuit is tied directly to ground as has always been historically the case in single phase x-ray units.

Complete point to point wiring diagrams for all the chassis in the 325V control are furnished in this manual. Point to point wiring diagrams are most helpful in determining the most accessible voltage measuring point for the particular measurement concerned. Once the assembler is familiar with the control, many measurements and adjustments can be accomplished primarily with the aid of the main schematic diagram only.

Before turning the machine on make sure that both or at least one of the primary leads to the high tension transformer are not connected nor should the common of the filament lead F be connected.

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When making the adjustments and tests indicated in the following paragraphs of this section, as well as the final testing and calibration in section 6, the assembler is asked to record certain data on Transworld X-Ray form #TWX QC E104. At the completion of the installation, this form is to be returned to Transworld X-Ray Corporation and will be filed with the factory quality control test data on this particular x-ray control and generator. A copy of this test data must also become a permanent part of the maintenance section of this section, and must be delivered to the purchaser upon completion of installation.

4.1 AUTO MAJOR ADJUST SETTING. REFER TO DWG # B301.147E

Measure the incoming line voltage at TB1-1 and TB1-2. This represents the nominal input line voltage for the x-ray generator. The #10 black wire coming from T1 of RY10 down to terminal strip TB2 on top of the autotransformer is the auto major adjust lead. The lead is tagged and stamped with the words AUTO MAJOR ADJUST. Place this lead on the terminal whose voltage corresponds closest to the input line voltage.

The terminals on TB2 and their appropriate input voltages are as follows:

TB2-1	195 VAC
TB2-2	209 VAC
TB2-3	219 VAC
TB2-4	231 VAC
TB2-5	243 VAC
TB2-6	276 VAC

Adjust the Line Adjust switch until the meter reads on the LINE indication or as close to it as possible.

Do not alter the setting of potentiometer R15 which is the line adjust pot. This was carefully set at the factory and there is no reason for it to change except for component failure. If there is component failure, then obviously the bad component must be replaced, and conceivably R15 readjusted. R15 is correctly adjusted when the line meter reads precisely on the indication LINE and the voltage from TB3-4 to TB3-1 is precisely 126 volts. If the closest voltage to 126 volts is slightly higher, approximately 127.5, then the line meter should indicate slightly above the LINE indication, and if the voltage is lower, approximately 125, then the meter should indicate slightly below the LINE indication.

4.2 VERIFYING NO LOAD AUTOTRANSFORMER OUTPUT VOLTAGES.

Hook an AC voltmeter (.75% accuracy) across terminals L1 and L2 of RY10. This places the voltmeter across the center taps of the kv major and minor power switches and will permit voltage measurements indicating the no load output voltage from the autotransformer which will feed the high tension generator.

Set the kv minor switch on the 5th position clockwise from its fully counter clockwise position. Set the kv major switch fully counter clockwise. The voltmeter should now read 99 volts. Rotate the kv major switch in one step increments. The voltages indicated on the voltmeter should be those on the right-hand side of the autotransformer as shown on the schematic diagram. There should be exactly 24 volts between each step. The voltmeter should read exactly these voltages ± a fraction of a volt. This will be true provided your voltmeter has its intended accuracy, and provided the incoming line voltage is exactly those voltages indicated on the left-hand side of the autotransformer, taking into account the adding or subtraction of voltages caused by the position of the line adjust switch SW5.

For example assume the incoming line voltage measures 215 volts, and the auto major lead has been set on the 209 volt tap. The line adjust switch, SW5 should then have to be set on its #3 position (+ 6 volts) in order to make the line meter read exactly on the line position (209 volts + 6 volts equals 216 volts input voltage). Under these coditions, the autotransformer output voltages as measured across the center taps of the kv major and minor switches will be precisely those voltages shown on the diagram. If the incoming line voltage differs from the autotransformer incoming taps which it can do because the incoming line taps are approximately 3 volts apart, then the output voltages which are being measured will be off by whatever percentage the input voltage is off from its incoming taps. The line meter should indicate exactly on LINE under conditions of exact input voltages, while it will indicate slightly above or slightly below, under conditions where the input voltage is not precisely one of the input voltages available to the autotransformer.

This must be understood, since an accurate voltmeter is being used, and those voltages as shown on the diagram should be precise or the slight difference should be explainable. Failure to read these exact voltages or account for a slight difference by variance in input voltage would indicate a voltmeter inaccuracy. If these voltages cannot be read as indicated, the assembler should verify whether or not his meter is reading properly, and then if this is not the problem, the factory should be consulted.

The above tests are redundant in that they were performed at the Transworld factory; however, the assembler is requested to perform them in order to familiarize himself with the 325V autotransformer and its output voltages, as well as verify that his voltmeter which will be used for subsequent measurements is accurate.

Refer to the installation data sheet and record the data requested under paragraph 4.2. The panel kvp column should be the kv closest to the nominal panel kvp's called for. In some cases it will not be possible to precisely set the kvp meter on the nominal kvp settings because of the input line voltage variations, and because A1-5020 control increases in minor steps of kv of approximately 1.3 kv per step. The panel kvp meter can be read to the nearest .5 kvp. The voltage in the third column requested is the no load primary high tension generator voltages at the respective ma's and kv's.

4.3 FINAL WIRING OF THE FILAMENT CIRCUIT.

Do not have the high voltage transformer primary terminals hooked-up for this test.

Turn the tube in such a fashion that the tube filaments can be seen. With the machine set on any of the small focus stations, and with someone depressing the rotor button, carefully touch the common filament lead to the common filament transformer terminal; there should be a small arc and the small focus tube filament should momentarily have a dim glow. Now put the machine on large focus and repeat the above procedure, again, there should be a small arc and the large focus should have a dim glow momentarily. The purpose of making this final hook-up in this manner is simply to prevent the accidental burning out of the tube filament due to a careless wiring error.

Once proper wiring has been verified, make the connections permanent at the transformer. Once you have verified that the focal spots are properly wired and will light when depressing the rotor button, you may depress the rotor button for a slightly longer period of time to simply verify that boost conditions are as you previously observed and the rotor is getting up to speed in approximately 1 second.

The x-ray control is shipped from the factory fully calibrated and tested with its generator on a Machlett Dynamax 40 tube and a pair of Machlett Dynaflex cables 25" long. The adjustable taps on the large and small focus filament resistors, R1 and R2 are left in the final factory calibrated position. Do not alter these taps unless you have sufficient reason to expect that the ma will be considerably higher because of a different high voltage cable or very short high voltage cables.

4.4 VERIFICATION OF PROPER TUBE ROTOR OPERATING CONDITIONS.

Place a voltmeter between terminals TB4-6 and TB4-7. When you depress the rotor button, the voltmeter should indicate approximately 120 volts then drop to a figure of approximately 50 volts after the rotor time delay. Now move the meter lead from TB4-7 to TB4-8 and repeat the measurement. This measurement should be slightly higher than the previous one due to the influence of the start capacitor in the start winding. Above terminal strip TB4 is the main relay chassis within the control. In the center of this chassis towards the bottom there are two resistors, R10 and R11, that shunt the rotor relays. Place the voltmeter from 1 R10 to 3 R10, depress the rotor button and after the time delay the voltage across R10 should be a minimum of 5 volts. Now place the meter in the same position across R11 and the reading should be a minimum of 5 volts on run. Should these voltages fall below 5 volts after the time delay, then relays RY 5 and RY 6 may chatter and prevent an exposure from being made. Adjust R10 and R11 after the time delay for a minimum of 5 volts AC.

4.5 VERIFICATION OF ROTOR TIME DELAY TIME.

The rotor time delay has been set to 1 second at the factory. Use a stop watch, oscilliscope or other time measuring device to verify that 1 second elapses from the time the rotor start button is depressed until RY10 (backup contactor) pulls in.

At the same time you are doing all of this, you might observe the other relays that are energizing during the exposure preparation sequence. RY1 and RY2 pull in immediately upon depressing the rotor push button; RY5 and RY6 pull in immediately upon the x-ray tube starter drawing current; after the rotor time delay, RY4 pulls in; RY4 closes RY10 which is the backup contactor. The exposure circuit is now ready to the point that only the x-ray exposure button needs to be depressed for a non-bucky exposure or that a bucky be in circuit to make an exposure.

Once RY3 energizes the timer gets a signal to expose.

NOTE: The rotor time delay can only be adjusted by changing a capacitor in the logic board. Consult the factory if you feel this is necessary for any reason.

4.6 VERIFYING CORRECT BUCKY OPERATION.

Two buckys can be hooked up to the 325V generator. The schematic shows the normal grid drive of an x-ray exposure hook-up for a Liebel-Flarsheim par speed bucky. For installation of a super speed bucky, contact the factory.

Without making an x-ray exposure, you can verify correct operation of the bucky by simply depressing the Bucky 1 position and observing to see if RY3 pulls in once the bucky starts to operate by depressing the rotor and x-ray exposure button. If a second bucky is hooked up to Bucky 2 position, RY3 should also pull in when Bucky 2 is energized.

4.7 VERIFICATION OF X-RAY EXPOSURE CIRCUIT.

Depress the rotor button and after the time delay all relays should be closed except RY3. Now depress the x-ray exposure button and RY3 should pull in. This verifies correct operation of the x-ray exposure circuit. Had the x-ray primaries P1 and P2 been hooked up to the high tension transformer, you would have received an x-ray exposure at this point.

4.8 VERIFICATION OR ADJUSTMENT OF KV LIMIT.

The A1-5020 control has a relay cutout, RY15, which will energize at a preset kv meter reading of 125 kv or above and a preset lower kv limit in the range of 40 to 50 kv. The higher kv setting is set at the factory and it should not require any adjustments by the assembler. Under proper operation, when the kv meter reads approximately 125 kv, one additional turn of the kvp minor switch will cause RY15 to energize; once RY15 has energized, nothing occurs when depressing the rotor button.

The lower kv limit is available if the assembler wishes to limit the operation of the machine at a lower kv range; however, it is not set to operate at the factory since the kv tap switches tend to limit the lower kv of the unit to between 40 and 50 kv depending on what ma station the operator is on.

To adjust the kv limit R110 on the timer logic board must be turned clockwise to increase the upper kv limit and turned counter clockwise to decrease the upper kv limit. This variable resistor operates a comparator circuit which locks out the exposure logic on the timer logic board.

R110 is the lower kv limit. Turning it clockwise will decrease the lower kv limit; counter clockwise will increase the lower kv limit.

5.0 PRINCIPLES OF OPERATION.

The 325 V control can be broken down for the purposes of circuit explanation into the following circuits:

1. Power Circuit
2. X-Ray Filament Circuit
3. KV Meter and Line Meter Circuit
4. Exposure Preparation Circuit (Tube Rotor Circuit)
5. X-Ray Exposure Control Circuit
6. X-Ray Timing Circuit
7. Circuit Breaker Circuit

5.1 POWER CIRCUIT.

This circuit is composed of the 60 amp line fuses, the circuit breaker load contacts, RY11, the autotransformer, the line adjust switch and the kv major and minor switches, RY10 (the back up contactor), the SCR contactor and the high tension generator.

5.2 FILAMENT CIRCUIT.

This circuit is powered from the constant voltage filament stabilizer TR2. This transformer receives its 110 volts signal power via the autotransformer through normally opened contacts relay 1 (contacts 6-9). Voltage leaves the filament stabilizer and from that point on the circuit is a series circuit fed from the output terminals of TR2 and composed of space charge compensation network (TR3, TR4, R4, R5); switch SW2B and switch SW2A; large focus resistor R1 or small focus resistor R2 and R3; and either the large focus or small focus filament transformer.

The space charge compensation works as follows. TR3 primary senses autotransformer voltage in relation to the major tap switch. TR4 secondary senses autotransformer voltage in relation to the minor tap switch. The secondaries of both these transformers reflect a small amount of this voltage across resistor R5 under boost conditions. R4 is simply a ballast resistor to maintain the current through TR3 and TR4 to a very low value except during boost conditions. It is shunted out of the circuit by contacts 5 and 8 of RY1 during boost and exposure.

R1 is the large focus (150, 200 and 300 ma) adjustment resistor and R2 is the small focus (50, and 100 ma) adjustment resistor. R3 is additional series resistance in the small focus circuit.

It should be noted that any voltmeter readings in this circuit will only read valid voltages as long as an x-ray tube filament is connected into the circuit through the high voltage cables and the filament transformer secondaries. Unless there is a load on the filament transformer, the resistors have very little current flowing through them and consequently almost no voltage drops whatsoever; therefore any voltage measurements in the circuit would read only the output of the constant voltage filament stabilizer.

5.3 KV METER AND LINE METER CIRCUIT (INCLUDES THE COMPENSATION NETWORK FOR KV DROP IN THE HIGH VOLTAGE GENERATOR).

KV Meter Circuit. This is a series circuit consisting of R16 through normally closed contacts of line push button switch, SW7, the kv meter, Deck C of ma selector SW2, and a negative voltage source consisting of TR5 secondary, R7 and R8.

This circuit works as follows. The entire series circuit is connected across the center tap of the kv major and kv minor. R16 is full scale adjustment potentiometer for the kv meter, and can be considered as part of the internal resistance of the meter. The negative voltage source consisting of TR5 secondary, R7 and R8 provides discreet values of voltage for each ma; these voltages are 180 degrees out of phase with the auto-transformer voltage. These voltages represent to the kv meter proportional voltage to the amount of kv drop in the high tension transformer that occurs for a particular tube current (ma).

These voltages are carefully set at the Transworld factory and in a normal operation should not change with time and consequently should not be altered in the field.

Line Meter Circuit. By depressing the line adjust momentary push button on the panel of the control, the kv meter becomes an ordinary voltage reading meter across the 219 volt tap and the plus 3 volt tap of the auto-transformer. The series combination of R15 and the meter sees a total voltage of 222 volts. The purpose of R15 is to bring a meter indication to the point marked line on the meter. Once again, this is carefully set at the factory, and there is no reason except component failure for the reading not to be correct.

The primary of TR3 and the primary of TR4 each have a center tap winding. Out of the full primary winding or ½ of it is in circuit on each transformer depending on the energized or non-energized condition of RY9. A comparative circuit located on the main relay printed circuit board in the front of the x-ray control senses a preset level of kv and causes RY9 to energize at whatever kv desired. At the factory the kv level is preset at 80 kv.

The effect of the circuit is such that at all kv's below 80 kv the rate of increase of compensation voltage added into the filament circuit for space charge is greater than the similar voltage added for kv's above 80 kv.

Refer to section 5.10 for instructions on calibration of this circuit.

5.4 EXPOSURE PREPARATION CIRCUIT.

This circuit is composed of the rotor panel push button, the time-ma interlock, relay contacts from RY15, RY8, RY13 and relay coils RY1 and RY2.

When looking at the schematic it may appear that RY7 is part of this circuit also; RY7 is concerned only with shunting of the circuit breaker on a large focus. It has nothing to do with either the exposure preparation circuit or the exposure initiation circuit.

When the rotor push button is depressed and, provided the time-ma interlock setting is not in open circuit, and, providing RY15 has not been energized, and, the automatic collimator interlock relay (RY13) is closed, then relay coils RY1 and RY2 will be energized. The closing of RY1 and RY2 cause R4 and R6 in the filament circuit to be shorted out. R6 is the standby filament resistor and R4 is a ballast resistor in the space charge circuit. This puts the x-ray tube filament at the proper boosted value for the particular kv selected.

The closing of RY1 causes voltage to be put on the stator windings of the x-ray tube rotor through the normally open contacts 7 and 4 of RY1. RY2 is soldered in place on the timer power supply board and provides a signal to the timer logic that the rotor time delay is to begin.

The rotor time delay circuit is part of the time logic board and has a fixed time delay of approximately 1.2 seconds. When RY2 is energized, the rotor time delay begins after the time period will allow an x-ray exposure to be made.

After the time delay, RY4 (located on the timer power supply board, closes and causes the backup contactor RY10 to close which completes the power circuit up to the SCR contactors and will permit instantaneous firing once the SCR's are energized.

The moment RY1 is closed 132 volts is placed across series circuit of the sensing relays and the start and run windings of the x-ray tube stator. The start winding has a 25 MFD phase shifting capacitor and series with it. The start winding and the run winding have also in series with them respectively, relay coils of RY6 and RY5. These relays will only be energized when each of the stator windings is drawing current.

After the time delay has come in RY4 energizes and removes a short circuit across R9. Now the voltage across the run and start windings drops to approximately 50 volts and the remainder of the 132 volts is dropped across R8. Approximately 5 volts under the run condition are dropped across RY5 and RY6.

The exposure preparation circuit is now complete and the tube stator is running at normal speed.

5.5 EXPOSURE CIRCUIT

The exposure circuit is composed of the x-ray push button switch, SW11, the Bucky 1 and 2 switches, relay contacts of RY5, RY6, RY4, and the coil of RY3.

If one of the buckys is in circuit, then the particular bucky exposure contact is also in series in the circuit between the bucky switch and RY5.

Switches SW8 and SW9 are the Bucky 1 and Bucky 2 push button switches on the front panel of the control. In their unlighted position (BUCKY OUT), they provide a closed circuit from the x-ray push button to the contacts of RY5. If either Bucky 1 or Bucky 2 push button is depressed, then the appropriate bucky or other external exposure switching device must provide the completed circuit to the contacts of RY5. The normally open series relay contacts RY5, RY6, and RY4 are closed due to action of the rotor push button. Both windings of the tube stator are energized when relays 5 and 6 are closed, and if the rotor circuit has worked properly, then RY4 has closed. Therefore a complete circuit to the coil of RY3 is set up, only requiring that the x-ray push button be depressed to initiate an x-ray exposure. The rotor button must previously have been closed in order to complete its circuit down to one side of the x-ray push button. It is therefore impossible to push the x-ray exposure button and initiate an exposure, without first having pushed the rotor push button.

5.6 X-RAY TIMING CIRCUIT, ROTOR TIME DELAY CIRCUIT, KV LIMIT CIRCUIT, SCR SHORT CIRCUIT TEST.

The rotor time delay circuit is initiated by the closing of relay RY-2 which occurs when the rotor button is depressed, providing the tube protection circuit allows voltage to be put between 3TB8 and 8TB8. If relay RY-1 closes, then also RY-2 should close. Closing of RY-2 starts a time delay function on the logic board to operate and after approximately 1 second the timer logic board is ready to receive an exposure signal from relay RY-3.

If relay RY-2 operates and after 1 second RY-4 does not operate, then the logic board is defective and should be replaced.

X-ray timing begins when relay RY-3 closes which is caused by a string of relay contact closures and push button closures including the rotor button, RY-5, RY-6, RY-4 and the final closing of the x-ray push button through the appropriate bucky if selected.

Once RY-3 closes, the selected exposure time begin and initiate after the 1 second rotor time delay and providing the upper or lower kv limit circuit has not operated and provided the SCR short circuit test does not shut the machine down.

Timing occurs if RY-3 closes and resistors R155 and R156 on the timer power supply board have SCR gate current through them. Refer to drawing #C301.170E.

Upper and lower kv limits are provided on the timer logic board through pot adjustments made on R138 (upper kv) and R136 (lower kv) Relay RY-15 mounted on the top of the ma time sub-chassis will energize when either the upper or lower kv limit has pulled in. When RY-15 energizes signal voltage immediately after the rotor push button, SW10 is prevented from reaching relays RY-1 and RY-2, thus preventing an x-ray exposure. Transformer TR104 on the power supply board senses the presence of primary load voltage before an exposure on terminals 10TB8 and 14TB8. This voltage is then fed through comparator circuits which compare the chosen kv against reference voltage levels set by the upper and lower kv limit pots.

The SCR short circuit test will activate relay RY-12 immediately after the back-up contactor pulls in if one of the SCR's is short circuited. It will also activate relay RY-12 when an x-ray exposure is supposed to be terminated but does not because of a shorted SCR.

Relay RY-12 will also be energized should the circuitry of the short circuit test fail to operate in a proper manner during an exposure. This was designed into the circuit because it is assumed that rarely will an SCR ever short circuit and it is important that the SCR short circuit test circuitry be periodically tested to insure its proper operation. While the check circuitry does not check all the components in the circuit, it does provide reasonable assurance that the circuitry is working properly.

When relay RY-12 energizes it locks out the main contactor RY-11 by energizing the coil of relay RY-14 which in turn locks itself in through one of its own contacts.

Only by turning the circuit breaker on and off, or by switching the wall switch on and off will the control be able to be turned back on.

MANY TIMES AN OPERATOR OR SERVICE PERSONNEL CONFUSE RE-SETTING THE CIRCUIT BREAKER IN THIS MANNER WITH CIRCUIT BREAKER TRIPPING. THE CIRCUIT BREAKER ONLY TRIPS UNDER A HIGH VOLTAGE OVERLOAD. When the SCR short circuit test operates, the main line contactor is automatically locked out of the circuit. Only by removing the voltage from relay RY-14 can the control be turned back on. Switching the circuit breaker on and off performs this function. Do not confuse this with high voltage failure or the circuit breaker tripping.

Refer to 325V General Troubleshooting Manual for a step by step procedural outline for troubleshooting the three circuit boards in the rear of the control. By following these methods you may determine which of the boards is causing a problem.

In general we do not expect the power supply board to cause any problems. If mis-counts occur, they are either probably due to the counter board or the logic board; most probably the counter board.

Failures to expose, failures to turn off, in other words control circuit type failures, are probably due to the logic board. However, one must follow the steps outlined in the 325V General Troubleshooting Manual to be sure.

5.7 SONALERT CIRCUIT.

At the termination of an x-ray exposure the x-ray push button light is held on and through the same circuitry the sonalert beeper is energized to signal the end of an x-ray exposure. Even on very short times, there is a time delay built in to hold the light and the beeper on for an extended period of time so that it can be heard and the light seen. Refer to drawing #D301.146E for trouble-shooting procedures in this circuit.

5.8 CIRCUIT BREAKER CIRCUIT.

This is a series circuit composed of the complete high tension circuit (x-ray tube, high voltage cables, high voltage rectifiers, ma meter, circuit breaker coils). Refer to drawing #D301.193E for a simplified explanation of this circuit.

Circuit breaker coil CB1 will sense any ground fault occurring in the x-ray tube, the cathode high voltage cable or secondary coil TR7A. Circuit breaker CB2 will sense a ground fault in the x-ray tube, anode high voltage cable, or TR7B secondary.

Each circuit breaker coil is shunted by a fixed amount of resistance put in the circuit by a contact from RY7 when the ma selector is on large focus station. On a small focus there is no shunt.

6.0 FINAL TESTING AND CALIBRATION.

With the machine turned off wire up leads P1 and P2 at the high tension transformer. Turn the machine on and set the time selector for 1/120 of a second and the ma selector for 50 ma. Set the kv to approximately 70. Make an exposure and you should observe a very small deflection on the ma meter. Now increase the time to 1/30 of a second and make another exposure. The deflection should be larger but still not very great. Go to 1/4 of a second and repeat an exposure, the deflection should be greater than previous; now go to 1/2 second and the meter should give a deflection of approximately 30 to 50 ma. This is a reasonable indication of proper operation of the machine provided all previous checks have been made.

Now remove one of the meter leads on the back of the ma meter and insert an MAS meter of known accuracy (2% or less) in series with the control panel ma meter. Set the timer on 1/10 of a second and proceed to make exposures at 50 ma and at 200 ma. The nominal MAS readings should be 5 and 20 MAS respectively.

Make a spin top film or other time check at 1/10 of a second on 200 ma and verify that you have 12 dots on the film. This verifies correct timing so that you may proceed with MAS measurements at other stations.

If your readings are lower this indicates the factory settings on the resistors are slightly lower than what will be needed for final settings at the installation. If the readings are higher, adjust the appropriate resistor slider until the correct values are obtained. Whatever distance the 50 ma and 200 ma sliders are moved, also move the 100 ma and 300 ma sliders so as to maintain the original distance between sliders. This will prevent any accidental overload of the tube at the small focus or large focus when going to the maximum ratings. Now switch exposures at 100 ma and 300 ma to verify approximate MAS readings.

Re-check all stations several times to verify that at 70 kvp your MAS meter is repeating consistently the same reading.

Set the x-ray control on 50 ma and make successive 1 second exposures, approximately 30 seconds between each exposure from 50 to 120 kvp, recording the value of the ma at each station. For 50 ma the ma meter should read within one scale division over the entire range of 50 to 125 kv. There will be more of a noticeable difference between 50 and 60 kv than any other 10 kv increment. If the 50 ma readings are not within 1 scale division as specified, then space charge adjustment will probably be necessary.

6.1 FINAL MA CALIBRATION

Now go to the 300 ma station and exposure time of 1/10 second and the kv set between 70 and 80 kvp. Switch exposures and adjust the 300 ma slider until the MAS is approximately 30. If the timer is operating properly, the exposure time will be precisely 1/10 of a second ($\pm$0 deviation). This means that whatever value the MAS meter reads either above or below 30 MAS represents error in ma only - - not time. For example if the MAS meter reads 27 then the tube current is 270 and if the MAS meter reads 31 then the tube current is 310.

The first adjustment in the final calibration of the control is adjustment of the space charge compensation. This may not be necessary, since it was set at the factory on a factory test tube; however, it cannot be guaranteed that the factory space charge settings will be correct for the particular x-ray tube on this installation.

When making space charge checks, it is only necessary that the ma be within approximately 15% of the nominal labeled control values. Any adjustment on the space charge resistor affects the final ma setting; it is a waste of time to attempt to adjust the ma first, without verifying space charge compensation settings.

At this point in the final calibration procedure, it is very important that the assembler assure himself that his MAS meter is sufficiently accurate (2% or less) at the particular exposure time being used. This time will usually be 1/10 of a second for calibration purposes. If the MAS meter is not accurate, then the tube current is going to be inaccurate, making subsequent load voltage checks for kv output inaccurate, and also making the line regulation test inaccurate.

The 300 ma station should now be set so that on 1/10 of a second the MAS meter reads approximately 30. Switch exposures at this technique over the 50 to 120 kv range and record the values.

To tell in what direction the space charge circuit must be adjusted observe the recorded readings over the kv range tested. If, as the kv is increased, the readings go up in value, this indicates not enough space charge compensation. If the readings go down as the kv is increased, this indicates too much space charge compensation.

In the first case, not enough space charge compensation, the 300 ma slider on resistor R4 must be moved in a direction away from the 200 ma slider. In the second case where there is too much space charge compensation, the 300 ma slider must be moved in a direction towards the other slider.

It will be necessary during the course of this adjustment to switch exposures over the entire kv range several times before the assembler is certain that the space charge is set properly.

Re-check for 30 MAS over the entire kv range. There should be no deviation greater than 5% between 40 and 120 kvp. Calibration of the 300 ma station is now complete.

Now go to the 200 ma station and repeat the above procedure in exactly the same order using an MAS meter. After 200 ma go on to the small focus and utilize the above procedure for 150, 100, and 50 ma.

The control panel ma meter may be used at this time; however, the assembler must assure himself that he reads the meter properly. The accuracy of the panel meter is 3% of full scale which allows for almost 1 scale division due to panel meter inaccuracies. By not taking into account this possible inaccuracy, significant errors in the linearity HEW test could result. In using the control panel ma meter for ma calibration, the assembler must take into account the deviations from true ma readings due to panel meter inaccuracies.

In lieu of using the control panel ma meter, the assembler may use a DC milliampere meter of his choice which has a known accuracy of 1% or less.

After the space charge has been calibrated, all other final ma calibrations should have been done with the thermistor temperature compensating package in circuit. At this time the constant voltage stabilizer should be sufficiently warm to have brought the thermistor pack to its lowest impedance value. At the conclusion of all testing, the assembler should allow the control to cool for several hours, and come back in and make the exposures indicated on the test sheet with the x-ray control completely cold.

These readings should be as close as possible to the final ma calibration readings previously done. In any event, the maximum deviation between these readings and the final ma readings should not exceed 5%. If the assembler has indications that the thermistor pack is not working properly or properly adjusted, then it may be necessary to adjust the slider on R13.

CAUTION: Allow sufficient time between x-ray exposures for proper x-ray tube cooling. If there is any question about what time is required, please refer to the appropriate x-ray tube instruction sheets, anode and tube housing cooling curves, etc.

6.2 VERIFICATION OF PROPER CIRCUIT BREAKER OPERATION.

The x-ray tube must have minimum ratings of a Dynamax 40. MAKE THESE MEASUREMENTS AT 70 KV ONLY. This will assure that the x-ray tube level is not exceeded while you are trying to read the ma meter.

On large focus adjust the 300 ma station upward towards 370 ma. The circuit breaker should trip out at approximately this level.

On the 100 ma small focus setting, adjust the ma upward towards 130 ma, until the circuit breaker trips out at approximately 130 ma.

It is not possible to adjust these values since the trip point of the small focus is determined by the coil within the Heinemann circuit breaker. On the large focus there is a fixed value shunt resistor across each circuit breaker coil.

IT IS ONLY NECESSARY THAT YOU VERIFY THAT THE CIRCUIT BREAKER IS WORKING SO THAT YOU HAVE ASSURANCE THAT IN THE EVENT OF ANY HIGH VOLTAGE FAILURE, THE MACHINE WILL BE SHUT DOWN.

Using a clip lead wire jumper short out the coil of CB1. Make an exposure; the high ma should cause CB2 to trip out. Now repeat the procedure, shorting out CB2 and allowing CB1 to trip out the machine.

6.3 LINE REGULATION TEST.

PRELIMINARY CALCULATIONS.

1. Measure and record input voltage to control (no exposure) V_n at TB1-1 and TB1-2.

2. Calculate line current for 200 ma at 90 kv - I_1.

$$I_1 = \frac{(72)(221)}{V_n}$$

3. Calculate maximum load current 300 ma at 125 kvp - I_2.

$$I_2 = \frac{(149)(221)}{V_n}$$

TEST UNDER LOAD.

4. Set machine on 200 ma, primary transformer volts at 201 VAC, no load, measured at TB1-5 and T1 of RY10.

5. Time set to 1 1/2 to 2 seconds.

6. Voltmeter on input line at TB1-1 and TB1-2.

7. Record voltmeter readings just before exposure (V_1) and during an exposure (V_2).

8. Calculate $\frac{V_1 - V_2}{I_1}$ = Line Resistance (LR)

9. Calculate $LR \times I_2 = V_3$

10. Calculate Line Regulation (%) $= \frac{V_3}{V_1 - V_3} \times 100$

NOTE: Accuracy of line regulation will depend on accuracy of V_1 and V_2 readings.

LINE REGULATION TEST EXAMPLE:

1. $V_n = 210V$ (Incoming Voltage)

2. $I_1 = \frac{(72)(221)}{210} = 75.77$

3. $I_2 = \frac{(149)(221)}{210} = 156.8$

7. $V_1 = 210$ $\quad V_2$ (during exposure) $= 206.7$

8. LR (line resistance) $= \frac{210-206.7}{75.77} = \frac{3.3}{75.7} = .0435931$

9. $(.0435931)(149) = 6.495$

10. Line Regulation % $= \frac{6.495}{210-6.495} \times 100 = 3.19\%$

6.5 Voltage L1RY10 to L2RY10
200 ma @ 1-1/2 sec.

Panel KV	Pre Exposure	During Exposure
100	______	______
80	______	______
60	______	______

6.6 Time Check Technique 50 ma at 70 kv

1/120	________
1/60	________
1/40	________
1/30	________
1/24	________
1/20	________
1/15	________
1/10	________
2/15	________
3/20	________
2/10	________
1/4	________
3/10	________
2/5	________
1/2	________
3/5	________
4/5	________
1	________
1-1/2	________
2	________
3	________
4	________
6	________

6.4 HIGH TENSION GENERATOR LOAD VOLTAGE MEASUREMENTS.

On the installation data sheet make load voltage measurements across L1 and L2 of RY10. Initial voltage reading prior to exposure will be a no load reading and should be recorded, and the lower reading during exposure represents the load voltage reading and should be recorded.

The technique factors given in section 6.3 on the data sheet are those factors that a Dynamax 40 tube will accept. If a tube of lighter capacity is used, refer to the tube rating charts for derating of those factors.

Furnishing the factory this data will aid factory quality control personnel in evaluating this particular installation in terms of

1. Test data on the machine here at the factory under the factory test conditions.

2. Factory test data corrected for high line voltage regulation which may be the case for this particular installation.

3. Accuracy of the assembler's test instruments.

4. Accuracy of the assembler in following the instructions in making the measurements.

6.5 LINEARITY AND REPRODUCABILITY TEST.

The HEW performance standard requires all x-ray controls and generators to meet the linearity and reproducability tests. Discussion of these tests is given in other papers published by Transworld. It is important to point out that the assembler, having followed all of the instructions as outlined in this manual, using instruments of less than 1% accuracy, should have test results, and should have recorded data, that will put this machine well within acceptance factors under the above described tests for linearity and reproducability.

If the assembler wishes to perform linearity and reproducability tests on the equipment, he is welcome to do so as a further cross check on the installation and the accuracy of the calibration. Transworld X-Ray does not require the assembler to perform these tests, since it is assumed that he will perform the calibration and other tests as outlined for this installation in accordance with our instructions. However, performing the tests will provide a further cross check on the assembler's methods, and the accuracy of his instruments.

6.6 FINAL X-RAY TIMER CHECK.

Set the x-ray control for a technique of 50 ma at 70 kv. Use an electronic counter such as the one described in Section 1.4 of this manual, or any other electronic counter that will count the whole (integral) one-half cycles going to the high voltage transformer.

Make x-ray exposures at every time setting on the control sheet TWXQCE104 under section 6.6.

A counter that utilizes a radiation probe under the x-ray tube to sense the pulses and form of radiation output may also be utilized; however, the assembler is cautioned that these counters are subject to erratic counts due to transient spikes which may be occurring in a new x-ray tube. This has been our experience at the factory, and the best method, we feel, is to measure the one-half cycles of voltage going to the high voltage transformer.

REFER TO THE X-RAY TUBE SPECIFICATION SHEET OR INSTRUCTION MANUAL TO DETERMINE HOW MANY TIMES PER MINUTE EXPOSURES CAN BE MADE BECAUSE OF X-RAY TUBE STATOR START VOLTAGE BEING APPLIED TO THE TUBE. IN THIS TIME CHECK, TUBE LOADING IS NOT A PROBLEM, BUT UNNECESSARY HEATING OF THE STATOR BY REPETITIVE START VOLTAGE CAN BE A PROBLEM.

7.0 PREVENTIVE MAINTENANCE.

This section outlines the preventive maintenance necessary for the purchaser to maintain consistent information as to whether the A1-5020 control and the A2-5000 generator are remaining in compliance with the HEW performance standard.

It is assumed that the person or persons who will be performing maintenance on this machine are well experienced in x-ray service. Under no circumstances should service technicians other than experienced x-ray service personnel be utilized for performing maintenance on this equipment.

The purchaser and service personnel are cautioned that any wiring changes, any changes in the circuits of the control, any alterations in the assembly of the control that will affect whether or not the machine is in compliance are expressly forbidden by Transworld X-Ray. Any such changes made will invalidate all warranties and HEW certification of the A1-5020 control and its associated A2-5000 generator. Alterations to circuits or wiring may only be made with the written consent of Transworld X-Ray for the particular A1-5020 control and A2-5000 generator involved, and written correspondence identifying the changes to the equipment showing dates and serial numbers, must become part of the permanent maintenance manual to be maintained by the purchaser of this machine.

7.1 MAINTENANCE INTERVALS.

Preventive maintenance should be performed on the A1-5020 control and A2-5000 generator at intervals of approximately 10,000 exposures or every 6 months, which ever period comes first. The figure of 10,000 exposures is arrived at based on 20 patients per day with an average of 3 exposures per patient. The purchaser should be able to tell from his work load at approximately what time interval 10,000 exposures would have been accomplished.

7.2 ADVANTAGES OF PREVENTIVE MAINTENANCE.

Simply because an x-ray control and generator will make x-ray exposures, and produce what appear to be consistent x-ray films, etc. it is not necessarily an indication that the machinery is performing properly, or is in compliance with the performance standard. As a general rule it is difficult to observe the changes or deviations in x-ray exposure on x-ray films until the deviations exceed 20% of the pre-set exposure. By performing at regular intervals the preventive maintenance checks as outlined in this section, the purchaser can be assured on a periodic time interval that his machine is remaining in compliance with the performance standard, and generally it will be possible to pick up indications of problems that could develop into serious and expensive repair situations before they occur.

Prior to this machine leaving the Transworld factory, it was thoroughly tested, and carefully calibrated. When this machine was installed, the assembler was required to perform sufficient measurements and tests to verify that the machine was still in the same operating condition that it was when it left the factory. The maintenance schedule calls for a periodic repeat of the measurements as performed at initial installation. A record of preventive maintenance should be kept with the installation manual and become a permanent part of the manual.

7.3 OPERATOR AIDS TO SERVICE.

When a service technician is called, the operator is generally asked to describe the problem. It is certainly helpful if the most accurate information possible be given the service technician.

After a short period of time the operator should be familiar with how various switches on the A1-5020 control operate, and how they "feel" for proper operation. Therefore if any switch appears to become loose, improper indexing, etc., the operator should be able to pick this up and point it out to a service technician. Information of this nature could lead a service technician to spot and repair a minor problem before it could lead into more serious trouble, and possibly damage other components.

The operator can get a reasonable indication of proper radiation output of the machine only by following pre-set technique factors for the various x-ray examinations being made. Good indication of proper machine output is the consistency of high kv chest films made at 300 ma, at short exposure times (1/120 to 1/30 of a second) at 120 kvp. Any significant changes in x-ray timing, x-ray tube current or kvp will show up on a technique such as this. The cause of changes in x-ray technique could generally be attributed to one of three areas: x-ray tube output rapidly falling off, failure of the x-ray control and generator to deliver proper output, or changes in the x-ray film, intensifying screen, or automatic processing operations involved.

7.4 MAINTENANCE SCHEDULE.

Every 10,000 exposures or every 6 months, the tests required to gather the data for TWX form E104, should be repeated, and the data recorded on a new test sheet, and this test sheet placed in the installation and maintenance manual.

In addition to performing these tests, the interior of the x-ray control should be carefully cleaned out to remove the accumulation of dust that always occurs around heated components.

All high voltage cable terminals, transformer cable wells and x-ray tube cable wells should be cleaned and covered with vapor proof compound (or other technique as recommended by the x-ray tube manufacturer).

The anode of the x-ray tube, and the port of the x-ray tube should be inspected for visible signs of anode etching, pitting, or cracking. The port of the tube should be inspected for deposits of tungsten across the port, and the port should not be distorted in any way.

Periodic cleaning and recoating of the high voltage terminals should prevent high voltage breakdown from occurring at these points. Failure to follow this procedure may lead to momentary or permanent high voltage breakdown of the cable or cable well, which can produce transients throughout the control and generator system, which may in turn damage other components of the x-ray system such as the x-ray tube, high voltage rectifiers, produce arcing within the transformer, etc.

Inspection of the x-ray tube port will give the service technician a general indication whether or not the tube is being overloaded by the operator. It is also possible that towards the end of useful life of an x-ray tube, the deposit of tungsten around the glass wall of the insert can affect the space charge characteristics of the tube to the point that it is impossible to maintain the calibration of the A1-5020 control and A2-5000 generator within the specifications stated, and, or in HEW compliance.

7.5 COMPONENT REPLACEMENT WITHIN THE CONTROL.

MA SELECTOR AND TIME SELECTOR.

If the index mechanism on these switches becomes inoperative or very sloppy, then the switches should be replaced.

POWER TAP SWITCHES (KV MAJOR, KV MINOR, LINE ADJUST).

The index mechanism on these switches has a life proportional to the amount of use each switch receives. Depending on the operator's technique, and the variance in line voltage, it is entirely possible one switch will receive a lot more use than another. If the index mechanism wears out, it is necessary that the switch be replaced.

Occasionally this type switch will develop a poor resistance contact at one or more of its voltage taps. If this happens, heat is produced during an exposure, and eventually this leads to switch deterioration and breakdown. This would normally manifest itself in a switch that becomes very difficult to turn or difficult to index properly. Certainly in a case such as this, the switch must be replaced.

PANEL PUSH BUTTON SWITCHES.

The contact ratings on these switches are much overrated for the applications they are used for; however, care should be exercised if any wires are unsoldered from the back of the switches. Too much heat on the switch can lead to improper operation or inoperable operation of the switch.

PANEL KV METER.

This is a rugged voltmeter of the taut band type construction. It should give exceptionally long life, but if for any reason it fails to indicate the proper kv when correct voltages are applied to it, it will have to be replaced.

PANEL MA METER.

This meter was tested at the factory and corrected ma values were true readings tagged on the back of the meter. These readings may change over a period of time due to slight changes in the wear on the meter movement. At every preventive maintenance interval, the service technician should verify that the meter still reads according to the corrected values as shown on the meter tag. The service technician should also realize that in the case of a high voltage breakdown, the meter will peg quite hard, and it is possible that the meter pointer could be bent, or the meter movement otherwise damaged. In the event of high voltage breakdown, the meter should be re-checked for proper calibration. Should high voltage breakdown damage the meter due to excessive meter current, then the meter should be replaced.

RELAYS.

With the exception of one 3 amp 4 pole relay located on the sonalert, kv limit chassis, all other small relays have contact ratings of 10 amperes. Relays 5 and 6 drop the voltage going to the x-ray tube stator, and consequently are subject to contact pitting due to inductive currents caused by the motor operation of the x-ray tube. Generally speaking of all the small relays in the control only relays 5 and 6 should ever give problems. From time to time it may be necessary to burnish the contacts of other relays if poor contact is the cause of service interruptations. If the contacts are burnished for any reason, then a correct relay contact burnishing tool should be used - - never a rough abrasive file or sandpaper.

Generally speaking, relays give hundreds of thousands of cycles of operation before ever causing any trouble, and the service technician should not assume he has a relay problem unless he very definitely verifies that is the case.

The large contactors RY11and RY10, under normal operation should never fail. Both of the contactors under improper machine operation such as SCR fault or releasing the rotor button during exposure, will cause arcing between the contacts. Normally during the life of the machine this should not occur enough times to damage the contactors.

FUSES.

The main line fuses are Buss SC60 fuses. These are miniature 60 amp fuses, and have a shorter overload/time delay characteristic than the larger time delay fuses.

All other fuses within the control are 1/4" x 1 1/4" glass type fuses. There are five 6 ampere, type MTH fuses and eight 1 ampere type AGC fuses. Under no circumstances should fuses of greater current ratings be utilized.

PRINTED CIRCUIT BOARDS.

The control is furnished with three printed circuit boards which have the timing circuit, sonalert beeper circuit, SCR safety circuit and kv limit circuit on them. One of the three boards is a power supply board. One is a counter board and the other is the logic board which contains the majority of the circuits. Proper operation of these boards can be determined from the information furnished in Section 5.6. If any one of these boards fails to operate properly, then the board must be returned to the Transworld factory for repair or replacement. Under no circumstances should service technicians attempt to repair any of these boards in the field nor should they use a soldering iron of any type on the board. If a board is returned to Transworld for repair, and is damaged to the point where it cannot be used in the circuit board exchange program, then no credit whatsoever will be given on the board.

SCR CONTACTOR.

The SCR's used in this control are very dependable devices, and are overrated for the electrical current that passes through them. They have a 2,000 ampere 1 cycle instantaneous rating and an 800 ampere 10 cycle rating. Their continuous current rating is 160 amperes. The PRV rating is 800 volts. These SCR's were chosen to maximize their useful life.

The SCR's are still subject to misuse due to transients within the machine from high voltage faults, or other transients produced by incoming voltage faults due to power line interruptions.

Because of the tremendous overrating of the SCR compared to the actual current it receives, they should, on the average, exhibit extremely long life.

POWER RESISTORS.

A number of high wattage power resistors are used in the filament circuits and metering circuits of the A1-5020 control. In all cases, wattages were chosen that exceed the necessary power dissipation for the circuit involved. Under normal operating conditions, there is no reason for these resistors to fail.

LOW VOLTAGE TRANSFORMERS.

There are six low voltage transformers within the A1-5020 control. Again the electrical ratings of these transformers exceed the conditions they normally operate under. Under normal operating conditions, there is no reason for them to fail.

7.6 USEFUL LIFE OF THE A1-5020 CONTROL.

This control has been designed to give many years of trouble free service, provided proper maintenance is performed on the equipment, and provided the components that do wear out are replaced in good order. The purchaser should expect controls that the operator normally uses on a day to day basis to eventually wear out. The amount of life these controls will give depends on the amount of use they receive which is proportional to the number of patients being examined with the machine.

If the controls fail to index properly, or otherwise become inoperable, they obviously will have to be replaced. During the routine preventive maintenance performed on the machine, the service technician should check these controls for proper operation.

If the control cannot be kept in compliance through the preventive maintenance program and routine replacement of components as necessary, then the control will have to be removed from service.

7.7 This installation and maintenance manual is assigned to this control and generator by serial number, and all preventive maintenance records and tests must be inserted in this manual, and become a permanent part of the manual as evidence that maintenance has been performed as required.

Initial Installation:__________________ Date
Maintenance: __________________ Date
Catalog #A1-5020 Control Serial #__________________
Catalog #A2-5000 Generator Serial #________________

4.1 Mfg. & model voltmeter used ________________________
Input voltage (TB1-1 to TB1-2) ___________vac
Auto major adjust set on TB2- ___________
Voltage reading TB3-1 to TB3-4 ___________vac

4.2

KV	MA	300	200	150	100	50
120		___	___	___	___	___
100		___	___	___	___	___
80		___	___	___	___	___
60		___	___	___	___	___

Voltage measured at L1RY10 to L2RY10

4.4 Voltage reading TB4-6 to TB4-7 after time delay _____vac.

4.5 Rotor time delay _____sec.

6.1

KV	MA	300	200	150	100	50
120		___	___	___	___	___
100		___	___	___	___	___
80		___	___	___	___	___
60		___	___	___	___	___
50		___	___	___	___	___

After ma calibration is complete, record the ma or MAS (1/10 sec) for the above ma's and kv settings.
CONTROL SHOULD BE HOT

6.2 Circuit breaker trips at:

___________ma large focus
___________ma small focus

6.4 Line regulation test

V_n______ I_1______ I_2______

V_1______ V_2______ LR______

Line regulation (%) ___________

Mfg. & model voltmeter used ______________________

INSTALLATION, SERVICE AND MAINTENANCE INSTRUCTIONS FOR A2-5000 GENERATOR

INSTALLATION, SERVICE AND MAINTENANCE INSTRUCTIONS.

1.0 Compatibility with other certified components.

1.1 The A2-5000 generator is compatible only with the Transworld A1-5000 x-ray control, and any other controls Transworld may subsequently designate at a later date.

1.2 The A2-5000 generator is compatible with any shock proof rotating anode x-ray tube which has a minimum rating of 300 ma at 125 pkv at the tube manufacturer's minimum rotor speed.

2.0 Modification and maintenance restrictions.

2.1 The installation, service and maintenance instructions should be thoroughly read and understood before you begin the installation of this generator.

2.2 It is assumed that all persons installing, calibrating, and maintaining this generator and associated components installed with it have the knowledge and experience necessary to achieve the objectives outlined to make the entire system function properly.

Alteration of any part of this generator, either electrical system or mechanical is prohibited without the written approval of Transworld X-Ray Corporation and will invalidate any warranty of certification that originally applied.

3.0 Warranty.

Transworld X-Ray Corporation warrants its equipment to be free of defects in material and workmanship that would cause the equipment not to operate under its published specifications. Any parts proving defective will be repaired or replaced free of charge, f.o.b. factory, if the defective parts are returned to the factory for inspection, charges prepaid. This warranty does not apply to glass ware or high voltage cables or x-ray tubes or to damage caused by accident, misuse, neglect or normal wear and tear, and is void if service or maintenance is performed by persons other than authorized Transworld dealers or representatives.

Components not manufactured by Transworld X-Ray Corporation are not covered by this warranty but only the warranty of the original manufacturer. Transworld X-Ray Corporation reserves the right to pass judgment on the cause of the defect or failure.

Claims under this warranty must be made within 6 months after installation of not later than 12 months after shipment from the Transworld factory.

4.0 Unpacking the generator.

4.1 The A2-5000 generator is steel banded in two places to a wooden skid and covered with a heavy cardboard shroud. Before removing the cardboard shroud carefully inspect the entire package for any evidence of damage, such as crushed corners on the wooden skid, crushed cardboard corners, or any other evidence that indicates the generator may have been dropped, or run into with power handling equipment.

Particular attention should be paid to whether or not there is any evidence of leaking transformer oil. A very small amount of oil leakage may be noticed around the transformer top which would be considered normal under conditions of motor transport; however, significant amounts of oil leakage should be investigated, and could be the result of the generator being severely dropped and the high tension tank being warped.

Evidence of any such damage described above should be promptly reported to the freight carrier so that proof of damage in shipment can be established should the unit be defective. All packing materials should be saved until the freight carrier has made an inspection and a claim filed.

4.2 Packed in the side of the generator carton separately is the low voltage cable retaining bracket, and the low voltage terminal box cover.

5.0 Location of the generator.

5.1 The generator can be located anywhere in the x-ray room that is most convenient for the installation; however, it is suggested that sufficient overhead clearance be left above the generator (approximately 30") so that if it ever becomes necessary to remove the generator from its tank, this can be done without having to relocate the generator.

5.2 It is for the longest possible generator life that lcoation of the unit should be in an area that has the typical embient temperature and humidity of a medical office of hospital.

6.0 Installation of the generator.

6.1 Electrical wiring. The generator is provided with a total of 8 terminals on the top of the tank unit. 7 of these terminals are for low voltage connections and 1 terminal is a ground terminal. Refer to drawing #300.39E for specific location of these terminals and wiring information. CAUTION: These terminal posts are all brass; care should be exercised when tightening down the brass nuts to avoid possible stripping of the threads.

6.2 Wire up the generator in accordance with drawing #B300.39E. Insulated wire terminals are recommended to prevent possible shorts between adjacent terminals. It may be desirable at this stage of the installation to leave the primary terminals p1 and p2 disconnected until other low voltage checks in the system are made.

6.3 Installation of the cathode and anode high voltage cables. As a general rule Transworld recommends the use of vapor proof compound such as that supplied by Machlett Laboratories and the other x-ray tube manufacturers. Application of this compound should be performed only using wooden tongue depressors or some other stiff material that you know to be clean and dry and cannot leave a residue.

Proper cleaning of the high voltage cable terminals and cable wells in the generator cannot be over-emphasized. If the equipment is new then all wells should be reasonable clean; however, if the generator wells or transformer terminals have previously had compound on them, then they should be thoroughly cleaned before being put back into use.

Best cleaning is accomplished by repeated applications of a clean lint free cloth until the terminal or generator well is clean. Electrical solvents may be used; however, they must not leave a residue and must be completely evaporated before applying new compound. Care should be exercised in cleaning around the high voltage cable terminal pins since these are fragile and can be easily broken.

When the transformer has been wired correctly and the high voltage cables installed in accordance with the manufacturer's instructions, the high tension generator is ready for use.

7.0 Service and maintenance instructions.

7.1 If a problem develops in the high voltage portion of an x-ray system, it is either due to a fault in the x-ray tube, high voltage cables, or high voltage generator. The high voltage generator is the least likely source of high voltage break-down problems, and the serviceman should be absolutely certain that the x-ray tube or high voltage cables is not the source of a problem before going into the high voltage generator looking for evidence of a breakdown.

The A1-5000 control circuit breaker senses a breakdown to ground on either side of the high voltage secondary; therefore, x-ray tube, cables, or the generator will cause the breaker to trip.

If the breaker is tripping, then either the tube milliamperes are set too high, or there is indeed a high voltage break over in the secondary system somewhere.

7.2 The most likely service problem to be encountered with the A2-5000 generator is either an open circuited or short circuited high voltage silicon rectifier assembly. In the event that one of the rectifiers becomes an open circuit this will be evidenced by a significant drop in x-ray output, approximately 50%. The ma meter on the x-ray control will read almost 1/2 of the indicated milliamperes. A spin top test will indicate at this time whether the generator is half waving or not.

Should this trouble occur, the entire generator section must be lifted from the oil and the defective rectifier replaced.

7.3 Should a high voltage rectifier assembly become short circuited, this will be evidenced by the circuit breaker on the x-ray control tripping, since it senses any short circuit in either side of the high voltage secondary circuit.

Should this trouble occur, the entire generator section must be lifted from the oil and the defective rectifier replaced.

7.4 Should it become necessary to remove the generator from the oil for any reason, care should be taken that no foreign matter is introduced into the tank while it is up in the air, and once the generator is again in the oil and sealed high voltage above 70 kv should not be applied to the unit at first. Any time the generator is out of oil, it should only be there for a minimal amount of time, approximately one hour.

7.5 Putting the generator back into oil. Lower the generator back into the oil filled tank and over a 15 minute period bump the sides of the transformer tank to cause the oil to move in the tank and drive out air pockets. After this time you may make low ma exposures at a kv of 70 kv or below to determine if the rectifier problem has been cleared up.

Once you are sure the trouble is clear, reseal the transformer using the 10/32 hardware. At the same time you are sealing the transformer and over a period of one hour at approximate intervals of 5 minutes, bump the sides of the transformer tank with a stiff object using a towel as a cushioning device. This will cause the transformer oil to stir about in the tank causing most of the air pockets to be filled with oil.

Slowly bring the kilovoltage from 70 to 125 kv in steps of 5 kv each over a period of one hour. Several exposures at 50 ma 1/2 second should be made at the appropriate kv at approximate 5 minute intervals. If any spitting of arcing is heard during this time then the entire procedure for clearing air pockets out of the transformer should be repeated and the kv build-up begun again.

7.6 Other internal problems of the transformer.

High voltage breakdown. A shorted rectifier is one form of a high voltage breakdown, and is the most likely form that will ever occur. Very rarely, and this must be emphasized, other components within the transformer subject to high voltage stress can break over. This is highly unlikely and the serviceman should not look for such evidence of breakdown except as a last resort. Any case of a high voltage breakdown to ground will cause the circuit breaker in the x-ray control to trip.

If the problem is not a high voltage rectifier, then it has to be an insulator leaking over to ground or a high voltage coil breaking down. Should the serviceman feel that such a problem is occuring, he should go no further, and the factory should be consulted to determine whether further field repair is warranted or not.

Again it must be emphasized that before any high voltage breakdown within the high tension generator is considered, the serviceman must first conclude that the problem is not due to high voltage cables or the x-ray tube.

7.7 Summary on permissible maintenance on a high tension generator. The only authorized field maintenance on the generator is replacement of high voltage rectifier assemblies. Further problems in the high tension tank before being repaired in the field must be first approved and authorized by Transworld from their home office or other authorized representative.

8.0 Checking the high kv output.

8.1 For checking the high kv output of this generator, we recommend the use of a high voltage resistance type divider such as the GE model 46-154966G-1. Normally the output of this divider is read through the use of a storage type oscilliscope. When using such a divider, it must be used in conjunction with the specified no load voltages, panel kv meter readings of the particular x-ray control wired up to this generator.

8.2 A load voltage versus high kv output chart is included with this manual; however, this is an impractical chart to use for checking kv in the field. To measure load voltage accurately on the generator takes several seconds, and it is unlikely that the x-ray tubes used in conjunction with this generator will have the capacity to withstand the high ma load at the higher kv's required in order to measure maximum output. It is possible to use this chart in conjunction with an oscilliscope to read peak load voltages and convert them to RMS by dividing the peak value by a factor of 1.414. This method assumes the wave shape to be a pure sinusoidal shape; this method also requires the scope be set on voltage divisions of probably 50 volts per division, which is inherently inaccurate as compared to using an accurate iron vane type volt meter.

9.0 Specifications of the generator. The generator is housed in a steel tank that measures 14 1/2" X 15 1/2" X 22 1/8". A low voltage terminal box cover is provided and when in place, the overall height of the generator is 23 5/8". The A2-5000 generator will operate one double focus x-ray tube; it is supplied with two federal standard high voltage cable wells. Four 125 pkv silicon diode rectifier assemblies are included in the generator. The generator contains 2 x-ray filament transformers for the purpose of running one double focus x-ray tube.

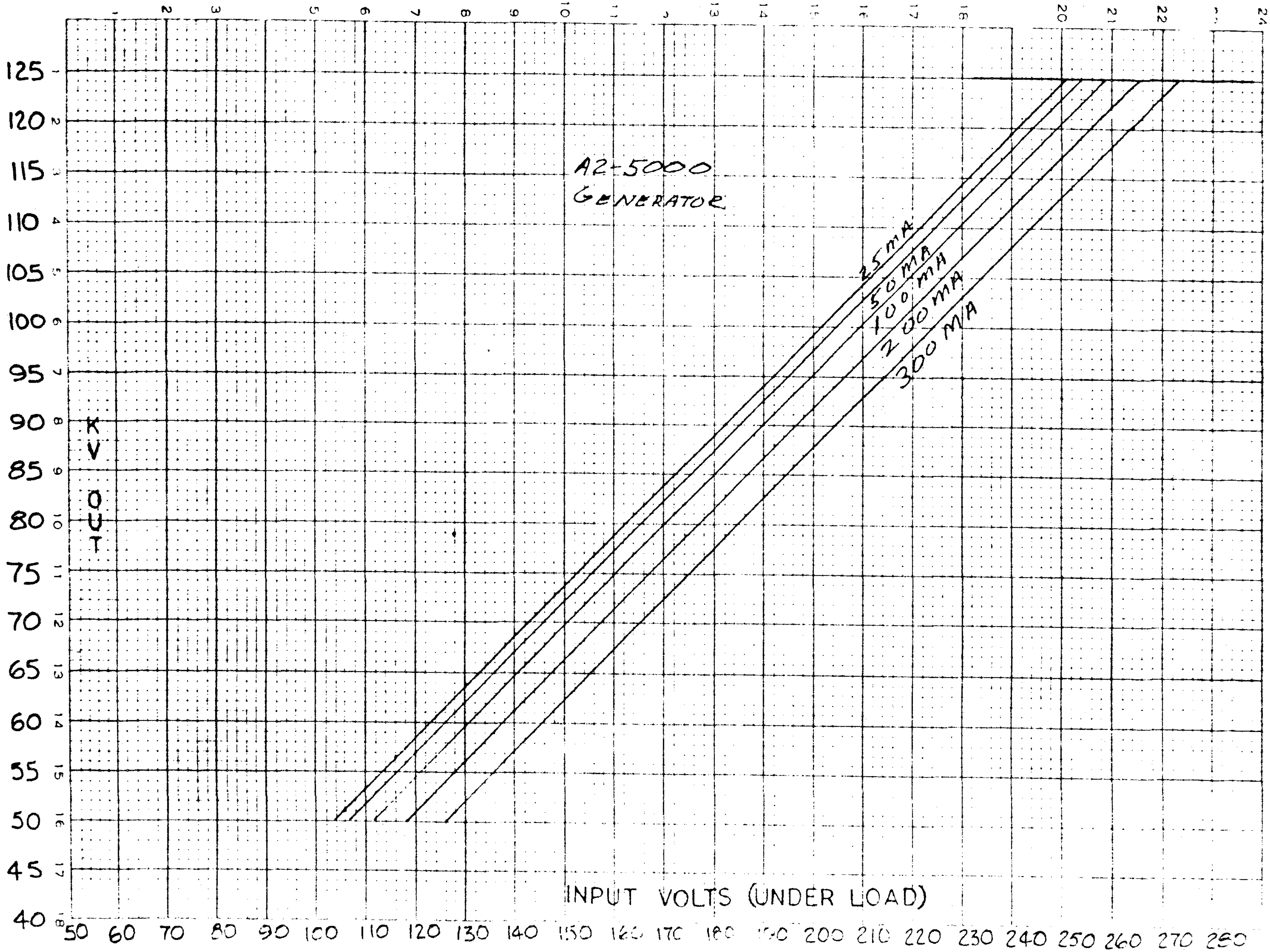
The generator is filled with high grade electrical insulating oil, Shell Diala AX, or equivilent.

Electrical specifications: The output of the A2-5000 generator shall be within ± 5% of 125 pkv when the output in current is 300 ma RMS, full wave, and the voltage under load supplied the primary terminals of the generator is 269 volts AC, RMS value.

The panel kv meter of the A1-5000 control shall indicate the relative kv output of the A2-5000 generator within 2 pkv over the range of 50 to 125 pkv for any indicated ma chosen when the input line regulation at maximum output is 1.5% or less. The relative pkv output of the generator may differ from the absolute kv output by ± 6 kv due to the inaccuracy of kv measuring techniques.

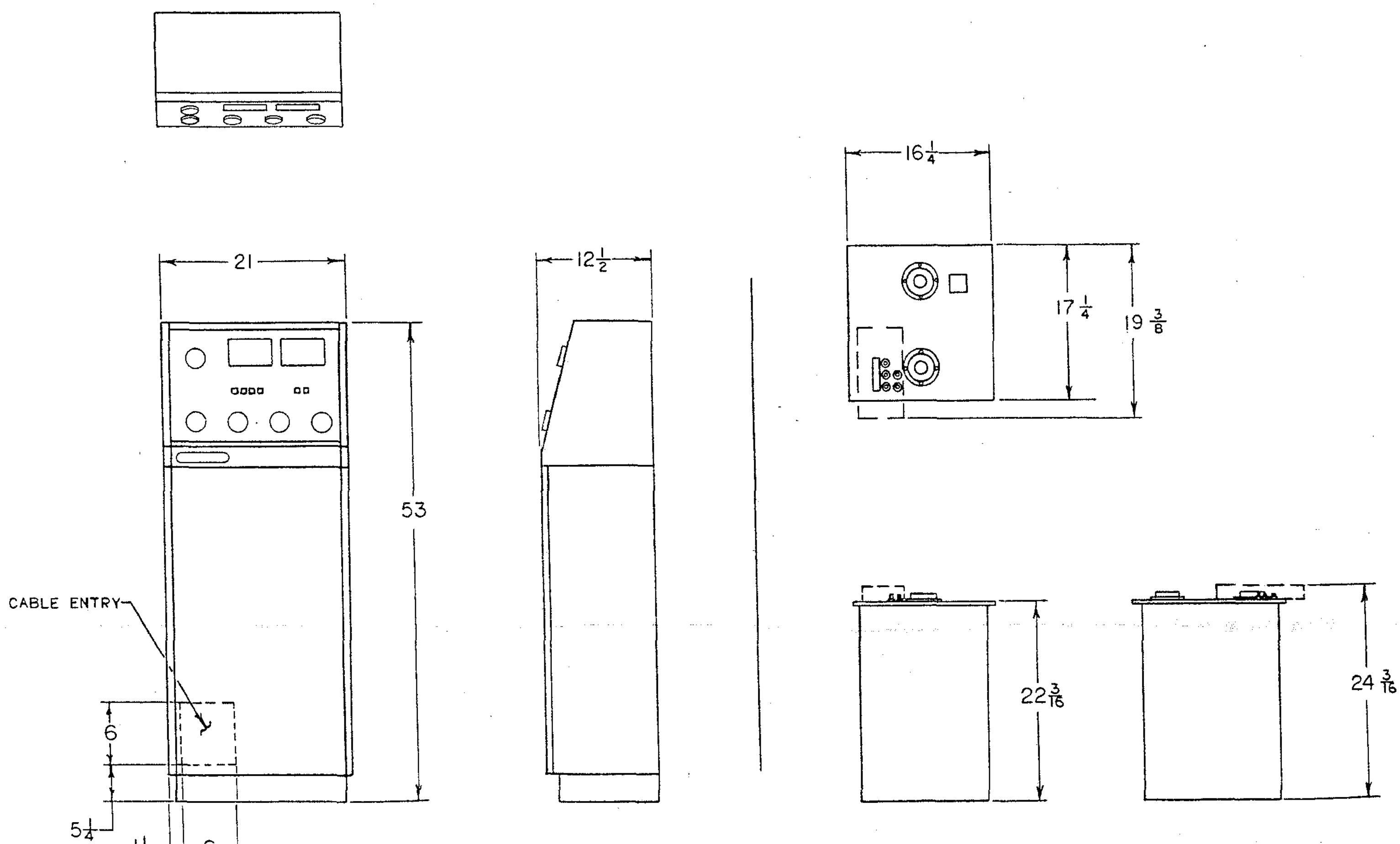
Duty cycle: 60 kilowatt seconds/5 minutes.

10.0 Useful life of the generator. If at any time, the generator will not perform in accordance with the above specifications, then it should be repaired so that the above specifications are met. In the event that repair is not feasible, then replacement becomes necessary.



A2-5000
GENERATOR
25MA
50MA
100MA
200MA
300MA
KV OUT
INPUT VOLTS (UNDER LOAD)
125 120 115 110 105 100 95 90 85 80 75 70 65 60 55 50 45 40
50 60 70 80 90 100 110 120 130 140 150 170 180 200 210 220 230 240 250 260 270 280

DATE	SYM	REVISION RECORD	AUTH	DR.	CK.

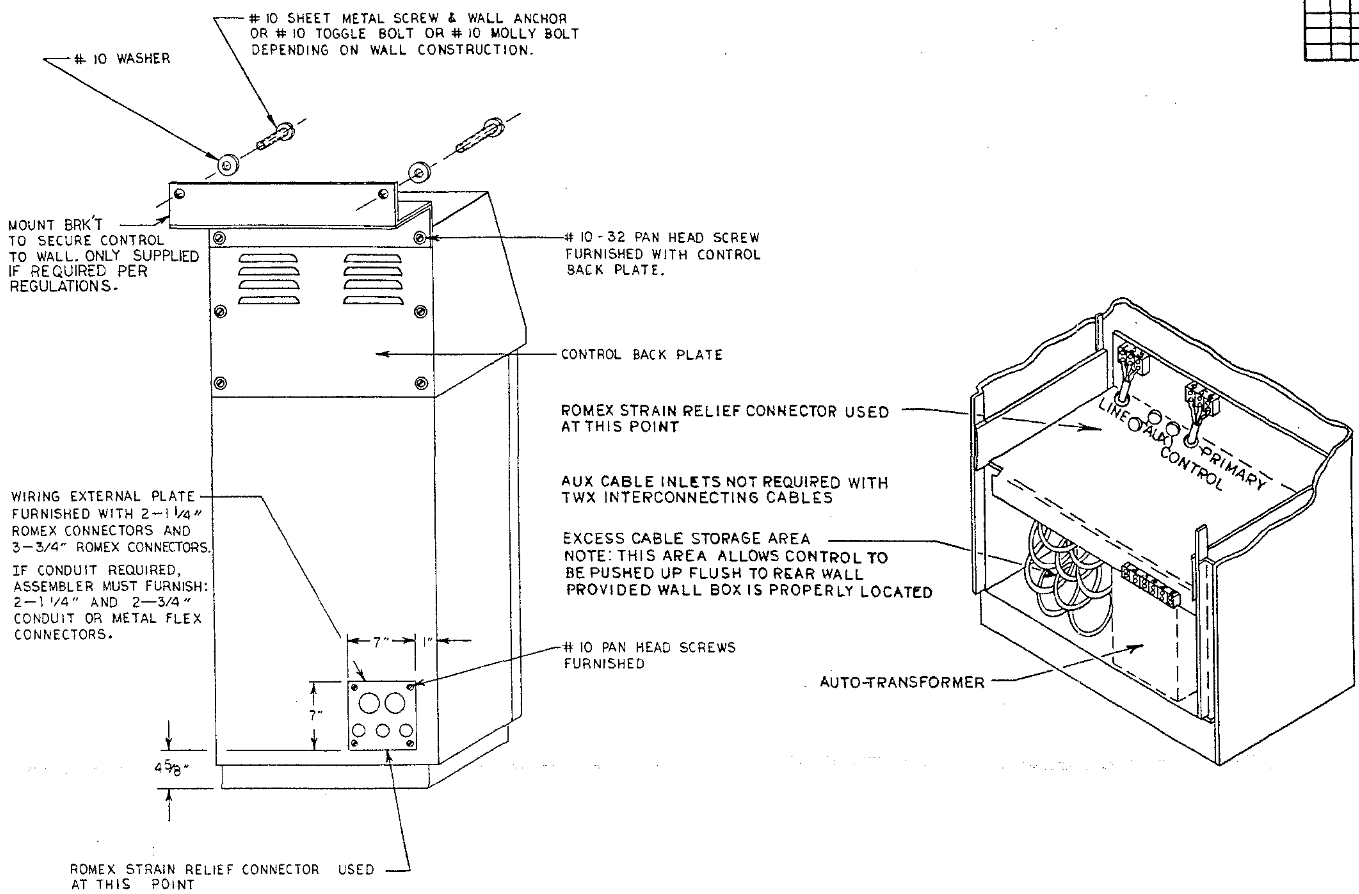


X-RAY CONTROL

HIGH VOLTAGE TRANSFORMER

TOLERANCES (EXCEPT AS NOTED)	TRANSWORLD X-RAY CORP.		
DECIMAL ±		SCALE	DRAWN BY I. ZELDIN APPROVED BY
FRACTIONAL ±	TITLE DIMENSIONS CONTROL & TRANSFORMER		
ANGULAR ±	DATE 7-17-85	DRAWING NUMBER C301I525	

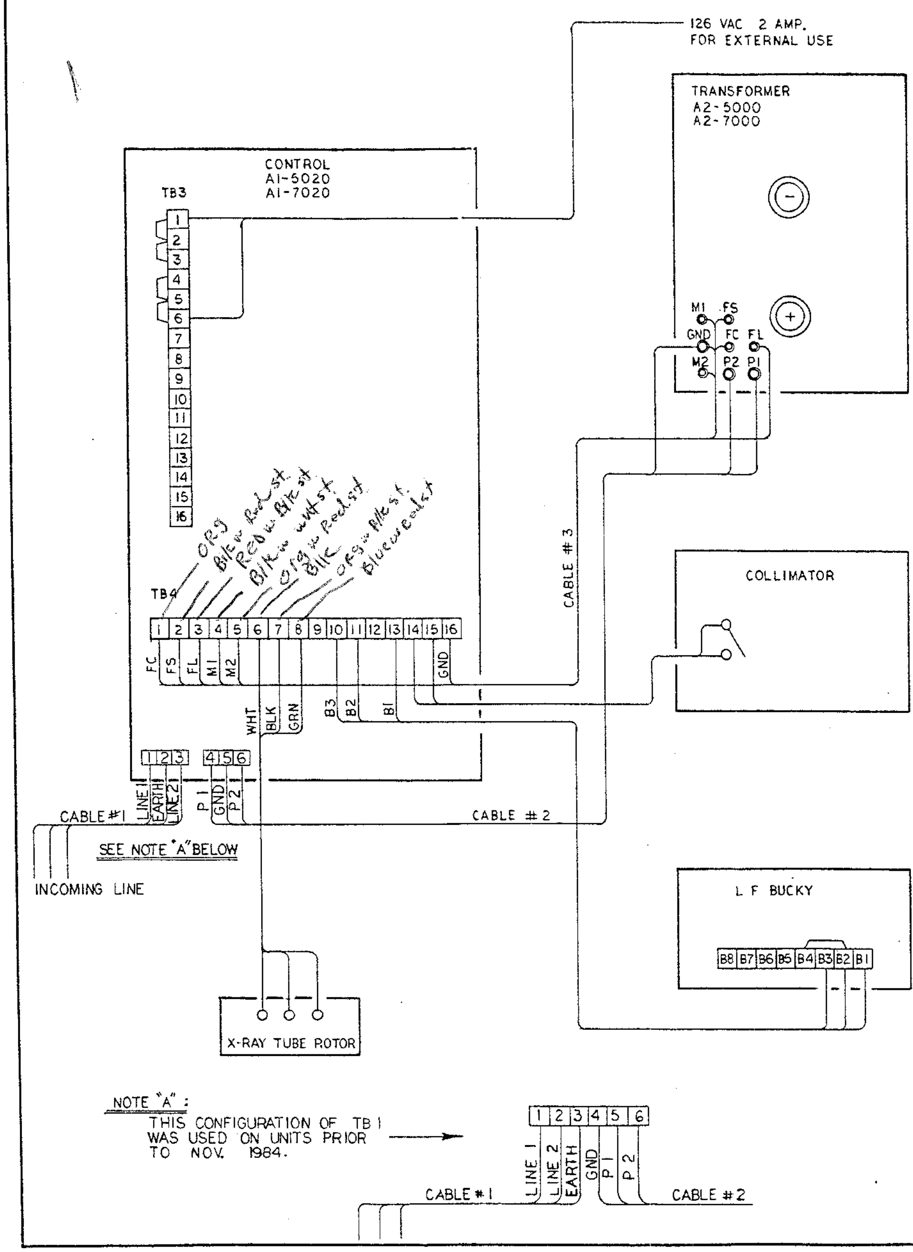
DATE	SYM.	REVISION RECORD	AUTH.	DR.	CK.
7-17-85	A	REDRAWN FROM [illegible] C3011320 DATED [illegible]		I.Z.	



TOLERANCES (EXCEPT AS NOTED)	TRANSWORLD X-RAY CORP CHARLOTTE, N.C.			
DECIMAL ±		SCALE NONE	DRAWN BY I. ZELDIN / APPROVED BY [illegible]	
FRACTIONAL ±	TITLE CONTROL INSTALLATION			
ANGULAR ±	DATE 7-17-85	DRAWING NUMBER C3011320		REV. A

K+E ALBANENE ® 10 2463 ENGINEERS' STANDARD FORM

MADE IN U.S.A.



"INSTALLATION CABLES"

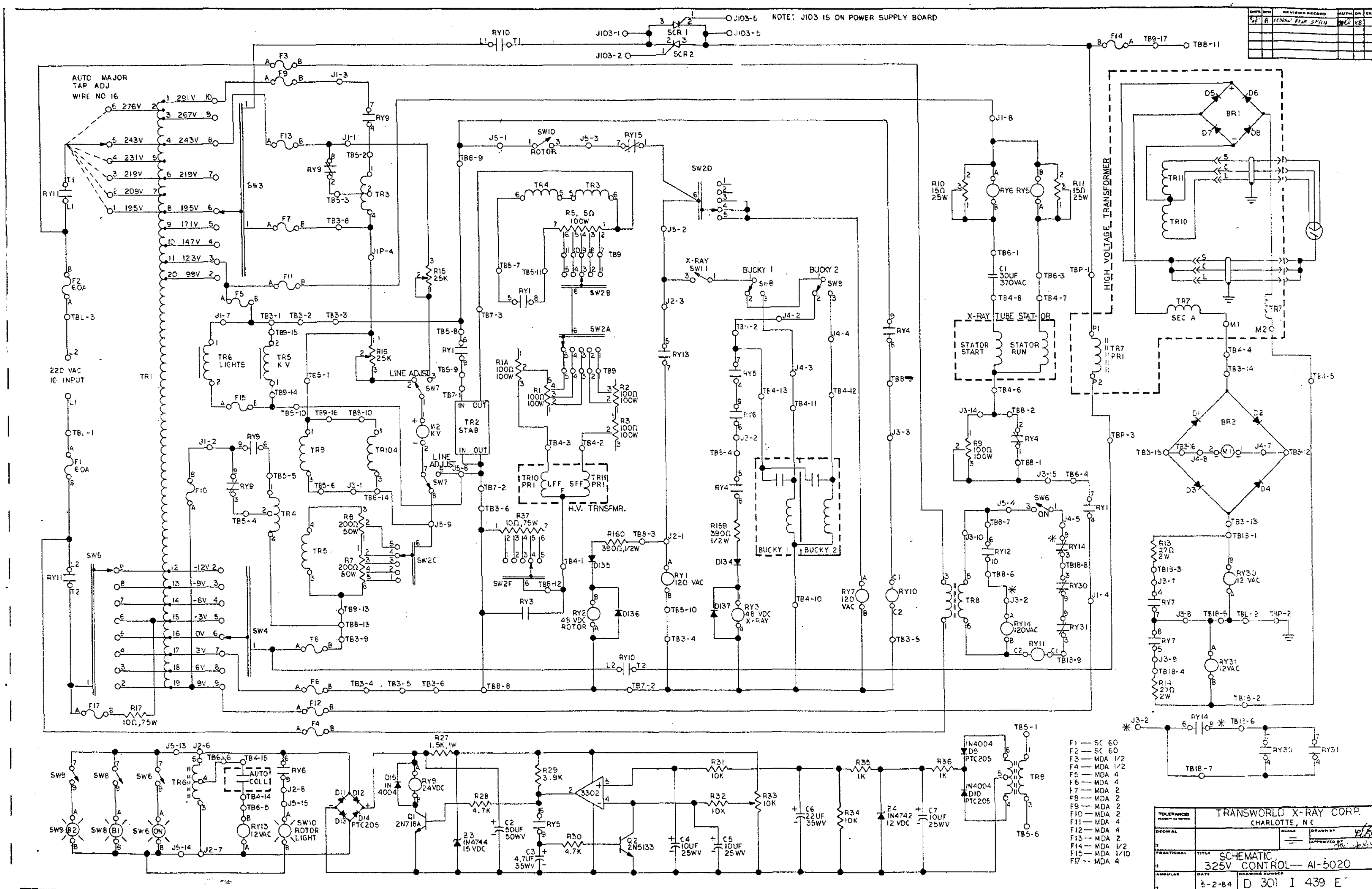
(MAY BE ORDERED AS AN OPTION)

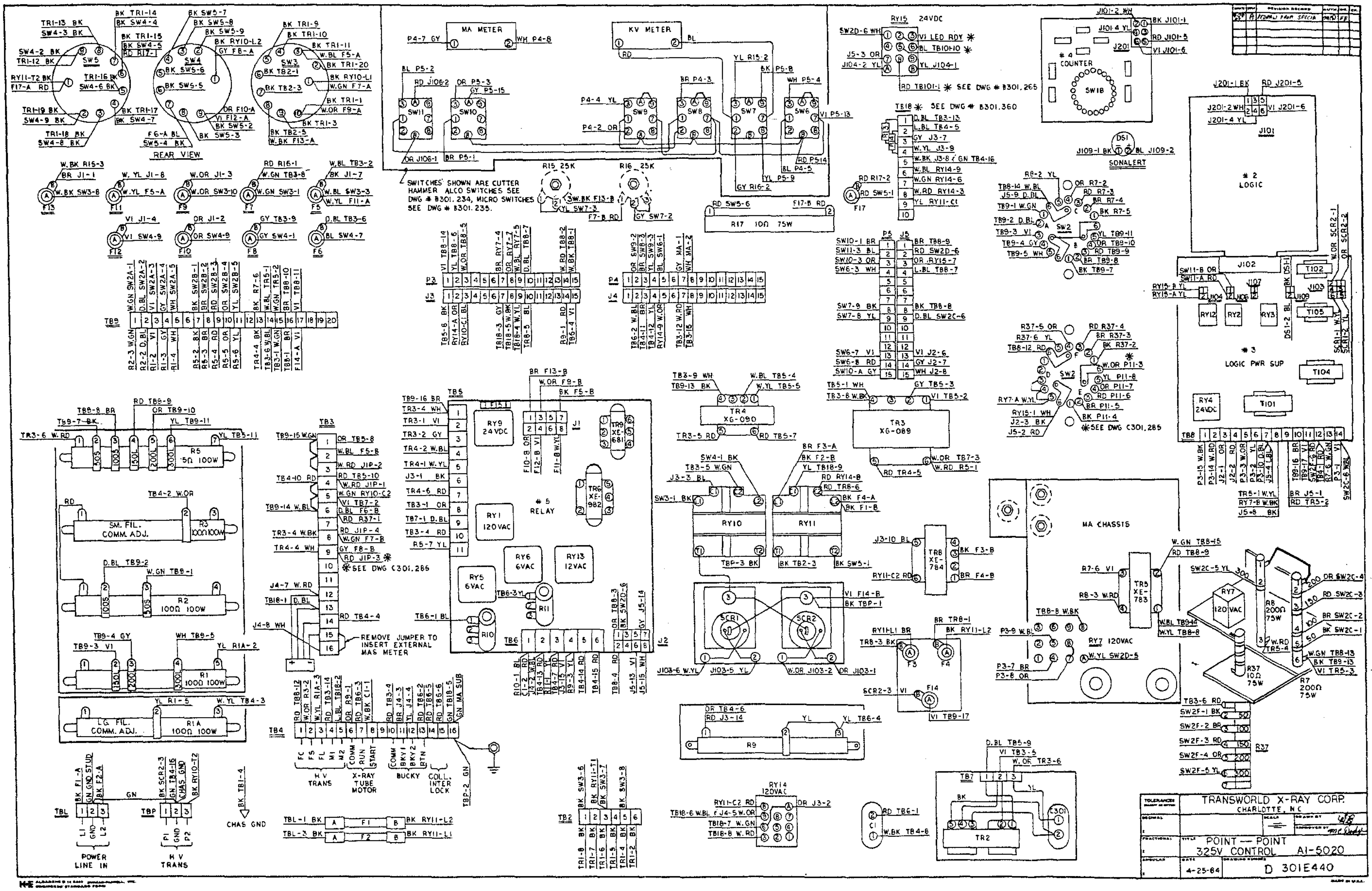
CABLE #1 == LINE, 6/3 TYPE S.O.
CABLE #2 == PRIMARY, 6/3 TYPE SO.
CABLE #3 == I.C., 19 CONDUCTOR (INCLUDES TB 9 AND 10 TERMINAL STRIPS MOUNTING PLATE AND TERMINAL COVER.)
(SHOWN IS 7 CONDUCTOR SUPPLIED BY ASSEMBLER.)

NOTES: WHEN ORDERING, ONE MUST SPECIFY LENGTHS OF ABOVE CABLES.
ALL OTHER CABLES SUPPLIED BY ASSEMBLER AND/OR TUBE/COLLIMATOR MFR.

NOTE:
FOR MANUAL COLLIMATOR, PLACE JUMPER BETWEEN TB4-14 & TB4-15.

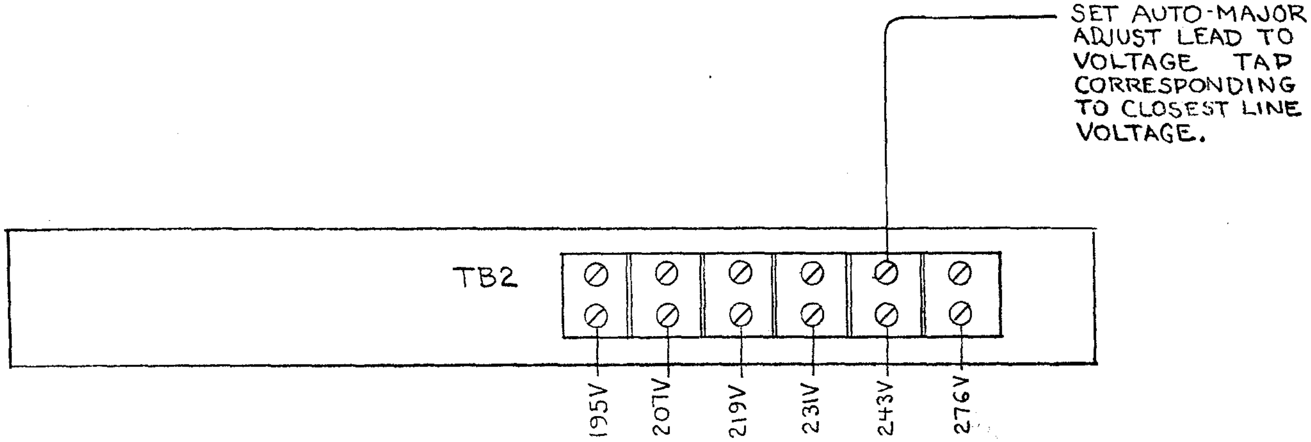
TRANSWORLD X-RAY CORP. CHARLOTTE, N.C.	
SCALE: —	DRAWN BY:
TITLE: INTERCONNECTION DIAGRAM 325V, 625V SINGLE TUBE	APPROVED BY:
DATE: 3-27-81	DRAWING NUMBER: C301 I 314 E


NOTE: J103 IS ON POWER SUPPLY BOARD
AUTO MAJOR TAP ADJ WIRE NO 16
220 VAC 1φ INPUT
HIGH VOLTAGE TRANSFORMER
X-RAY TUBE STATOR
H.V. TRNSFMR.
F1 — SC 60
F2 — SC 60
F3 — MDA 1/2
F4 — MDA 1/2
F5 — MDA 4
F6 — MDA 4
F7 — MDA 2
F8 — MDA 2
F9 — MDA 2
F10 — MDA 2
F11 — MDA 4
F12 — MDA 4
F13 — MDA 2
F14 — MDA 1/2
F15 — MDA 1/10
F17 — MDA 4
TRANSWORLD X-RAY CORP.
CHARLOTTE, N.C.
SCHEMATIC 325V CONTROL — AI-5020
5-2-84
D 301 I 439 E

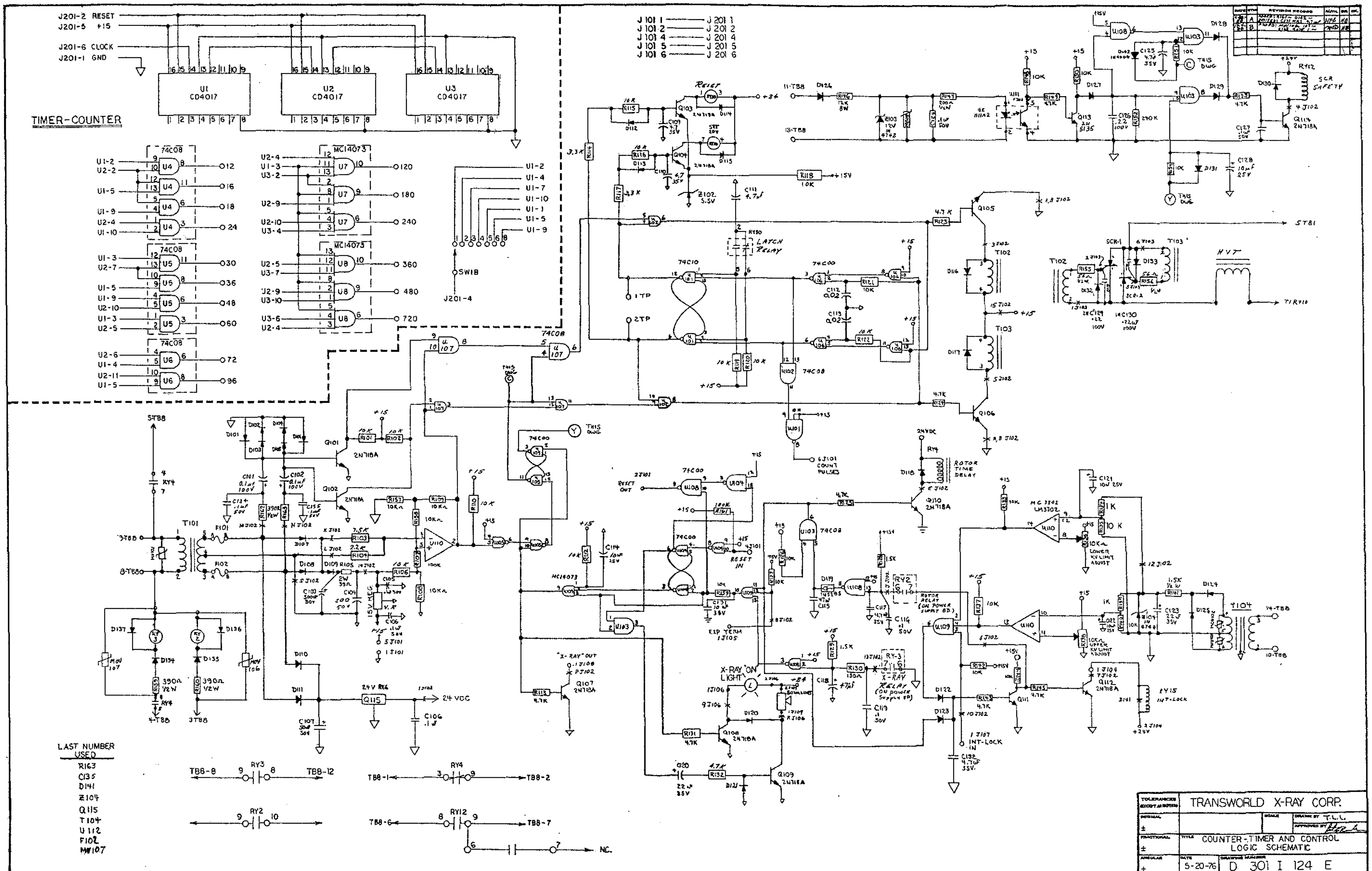


TRANSWORLD X-RAY CORP.
CHARLOTTE, N.C.
POINT — POINT
325V CONTROL AI-5020
4-25-84
D 301E440
SWITCHES SHOWN ARE CUTTER HAMMER ALCO SWITCHES SEE DWG # B301.234, MICRO SWITCHES SEE DWG # B301.235.
REAR VIEW
MA METER
KV METER
4 COUNTER
2 LOGIC
3 LOGIC PWR SUP
5 RELAY
MA CHASSIS
SONALERT
REMOVE JUMPER TO INSERT EXTERNAL MAS METER
POWER LINE IN
H V TRANS
X-RAY TUBE MOTOR
BUCKY
COLL. INTER LOCK
CHAS GND
SM. FIL. COMM. ADJ.
LG. FIL. COMM. ADJ.

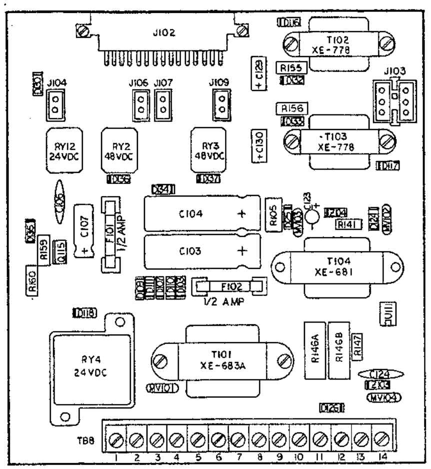
DATE	SYM	REVISION RECORD	AUTH.	DR.	CK.



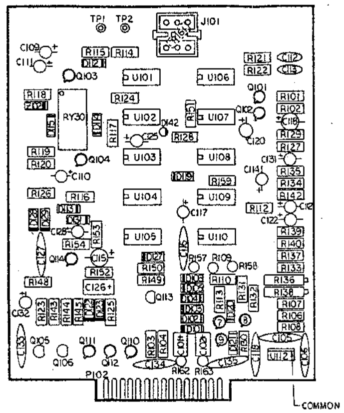
TOLERANCES (EXCEPT AS NOTED)	TRANSWORLD X-RAY CORP.		
DECIMAL ±		SCALE	DRAWN BY TLL APPROVED BY SMcD
FRACTIONAL ±	TITLE AUTO TRANS./MAJOR ADJUST TAPS.		
ANGULAR ±	DATE 6-12-76	DRAWING NUMBER B 301 I 147 E	


TIMER-COUNTER
J201-2 RESET
J201-5 +15
J201-6 CLOCK
J201-1 GND
U1 CD4017
U2 CD4017
U3 CD4017
74C08
MC14073
LATCH RELAY
X-RAY "ON" LIGHT
ROTOR TIME DELAY
RESET OUT
RESET IN
EXP TERM
INT-LOCK IN
SCR SAFETY
HVT
24 VDC
LAST NUMBER USED
R163
C135
D141
Z104
Q115
T104
U112
F102
MOV107
TRANSWORLD X-RAY CORP.
COUNTER-TIMER AND CONTROL LOGIC SCHEMATIC
5-20-76
D 301 I 124 E

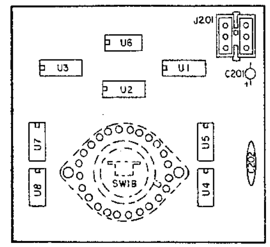
POWER SUPPLY



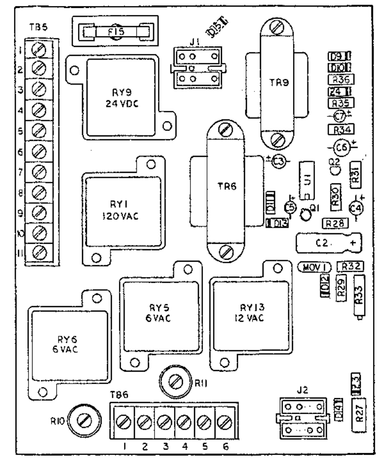
LOGIC



COUNTER



RELAY

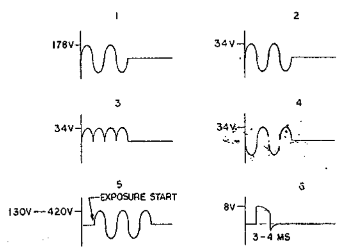


POWER SUPPLY BD. TROUBLESHOOTING

1. CHECK TB8-8 TO TB8-9 FOR WAVEFORM # 1.
2. CHECK ANODE OF D107 TO COM FOR WAVEFORM # 2.
3. CHECK CATHODE OF D107 TO COM FOR WAVEFORM # 3.
4. CHECK ANODE OF D108 TO COM FOR WAVEFORM # 4.
5. CHECK J102-1 TO COM FOR +24 VDC.

Δ 6. CHECK TB8-11 TO TB8-13 FOR WAVEFORM # 5.

Δ 7. CHECK R155 AND R156 FOR WAVEFORM # 6.



LOGIC BD. TROUBLESHOOTING

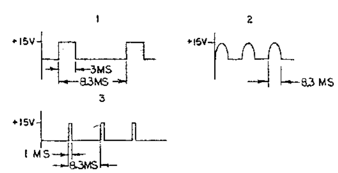
1. CHECK U107-3 & -8 TO COM FOR WAVEFORM # 1.

Δ 2. CHECK U109-10 TO COM FOR +15V.

Δ 3. CHECK LEFT SIDE OF R149 TO COM FOR WAVEFORM # 2.

Δ 4. CHECK J101-6 TO COM FOR WAVEFORM # 3.

5. CHECK J102-4 TO COM FOR +24V.
6. CHECK J101-2 TO COM FOR +15V.

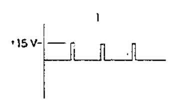


NOTE: CIRCUIT COMMON IS LOCATED ON TAB OF +15V REGULATOR LOCATED ON LOWER RIGHT CORNER OF LOGIC BOARD (2).

COUNTER BD. TROUBLESHOOTING

Δ 1. CHECK J201-6 TO J201-1 FOR WAVEFORM # 1.

2. CHECK J201-2 TO J201-1 FOR +15V.



NOTE:
Δ = DURING EXPOSURE

COMPARATOR TROUBLESHOOTING

1. WITH APPROX. 75 KVP SELECTED, CHECK U1-4 TO COM FOR APPROX. 10.8V.
2. WITH APPROX 45 KVP SELECTED CHECK U1 4 TO COM FOR APPROX 7V. (RY9 SHOULD BE DEENERGIZED.)
3. CHECK U1-5 TO COM FOR APPROX 11V.

NOTE: COMMON IS LOCATED ON ANODE OF D11.

TRANSWORLD X-RAY CORP.
CHARLOTTE, NC

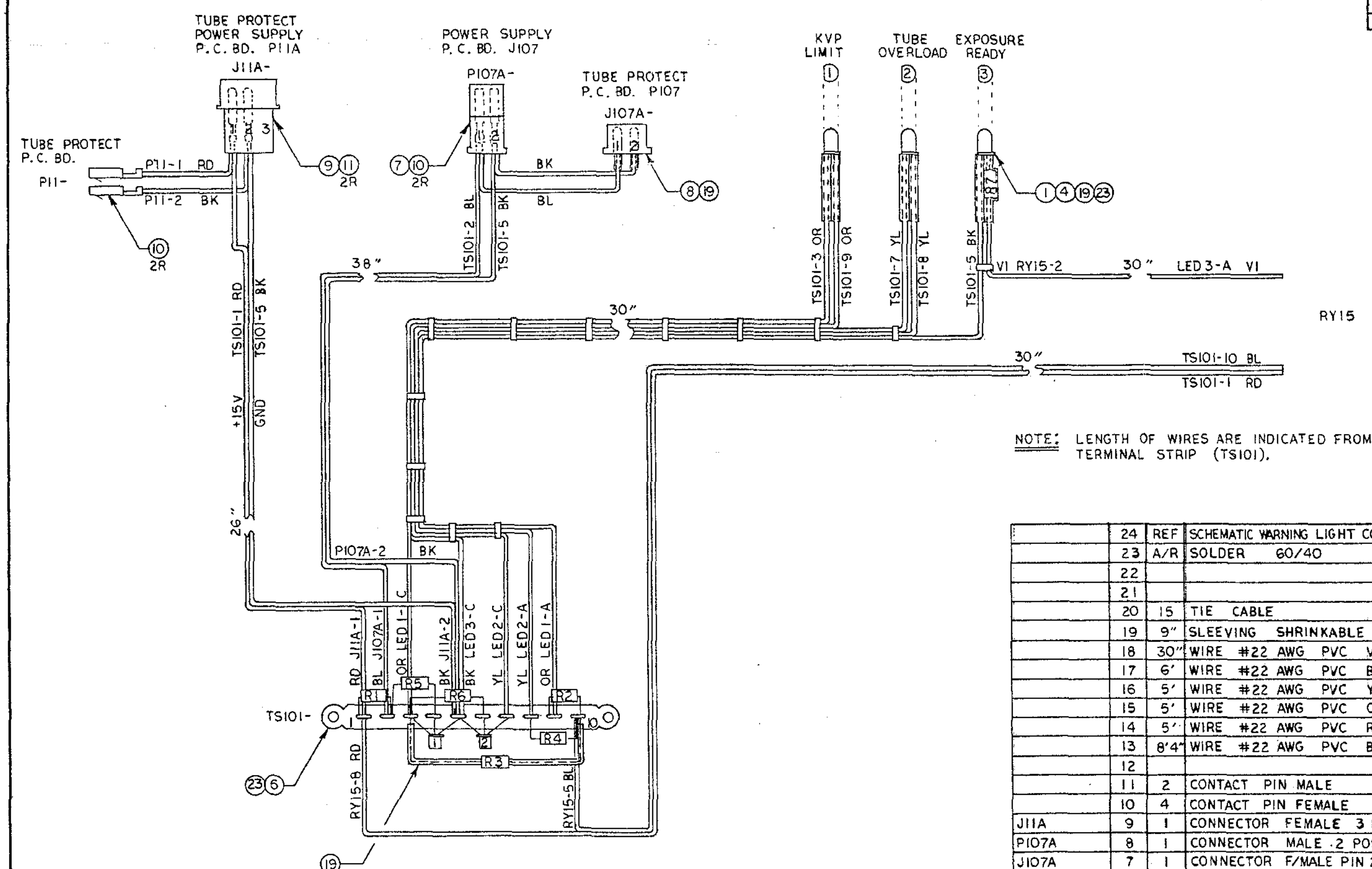
SCALE: FULL

TITLE: PRINTED CIRCUIT BOARDS LAYOUT & TROUBLESHOOTING

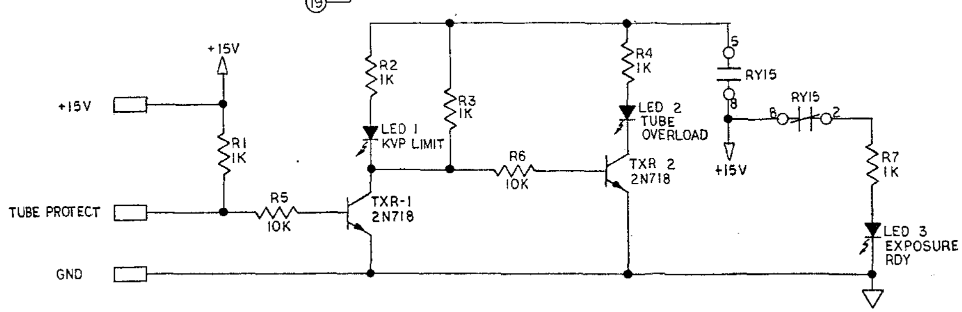
DATE: 6-22-81

DRAWING NUMBER: D301 I 136 E

DATE	SYM	REVISION RECORD	AUTH.	DR.	CK.



NOTE: LENGTH OF WIRES ARE INDICATED FROM TERMINAL STRIP (TS101).

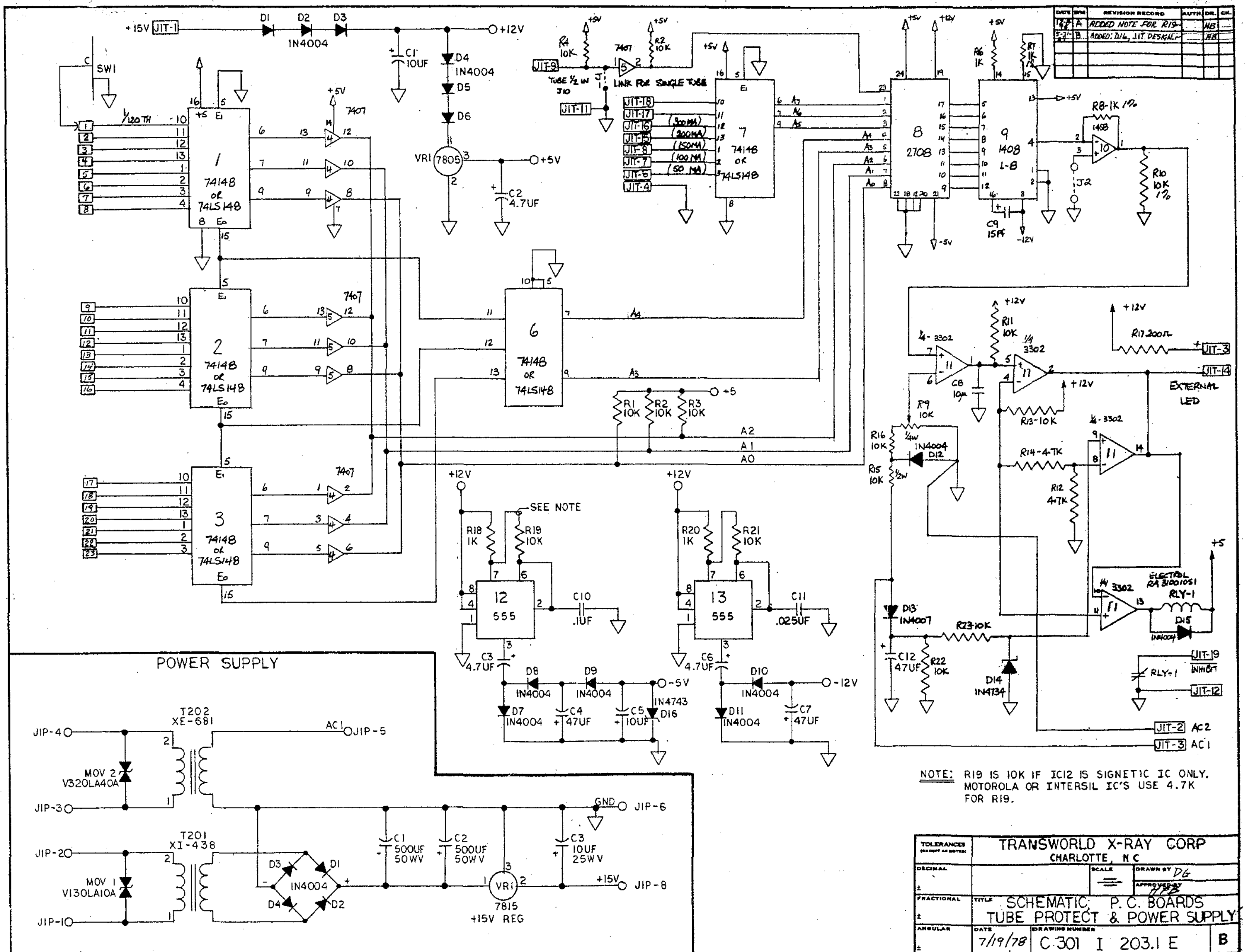


	24	REF	SCHEMATIC WARNING LIGHT CONTR.	TWX	B301.265E
	23	A/R	SOLDER 60/40		
	22				
	21				
	20	15	TIE CABLE	PAND	MS3367-4-9
	19	9"	SLEEVING SHRINKABLE BLK		
	18	30"	WIRE #22 AWG PVC VIO		
	17	6'	WIRE #22 AWG PVC BLU		
	16	5'	WIRE #22 AWG PVC YEL		
	15	5'	WIRE #22 AWG PVC ORN		
	14	5'	WIRE #22 AWG PVC RED		
	13	8'4"	WIRE #22 AWG PVC BLK		
	12				
	11	2	CONTACT PIN MALE	AMP	61116-1
	10	4	CONTACT PIN FEMALE	AMP	61314-1
J11A	9	1	CONNECTOR FEMALE 3 POS	AMP	1-480-305-0
P107A	8	1	CONNECTOR MALE 2 POS	AMP	1-480-318-0
J107A	7	1	CONNECTOR F/MALE PIN 2 POS	AMP	350-209-1
TS101	6	1	TERMINAL STRIP 10 POS	TRW	2010
	5				
LED 1,2,3	4	3	SOLID STATE LAMP LUM INTY	IEE	LLM152ET
TXR 1,2	3	2	TRANSISTOR		2N718
R5,6	2	2	RES 10K 5% 1/4W		CARBON FILM
R1—4,7	1	5	RES 1K 5% 1/4W		CARBON FILM
DESIGNATION	ITEM	QTY	DESCRIPTION	MF'R & PART NO.	

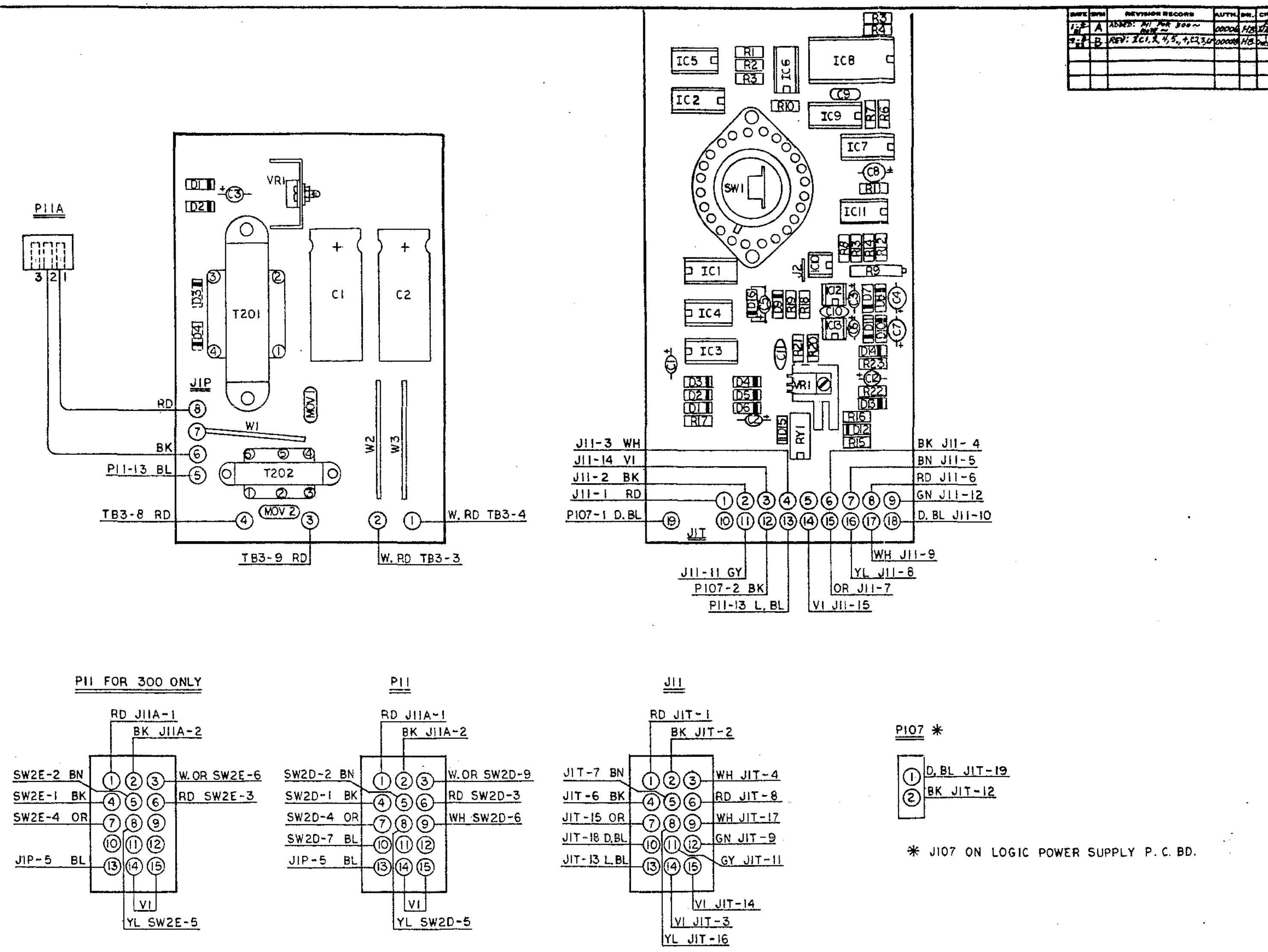
TOLERANCES (EXCEPT AS NOTED)	TRANSWORLD X-RAY CORP. CHARLOTTE, N.C.	
DECIMAL ±	SCALE NONE	DRAWN BY [signature] APPROVED BY [signature]
FRACTIONAL ±	TITLE ASS'Y. & SCHEMATIC WARNING LIGHT CONTROL 325 & 625	
ANGULAR ±	DATE 7-22-80	DRAWING NUMBER C301 E 266

K+E ALBANENE® ENGINEERS' STANDARD FORM

MADE IN U.S.A.



K+E ALBANENE ENGINEERS' STANDARD FORM
MADE IN U.S.A.

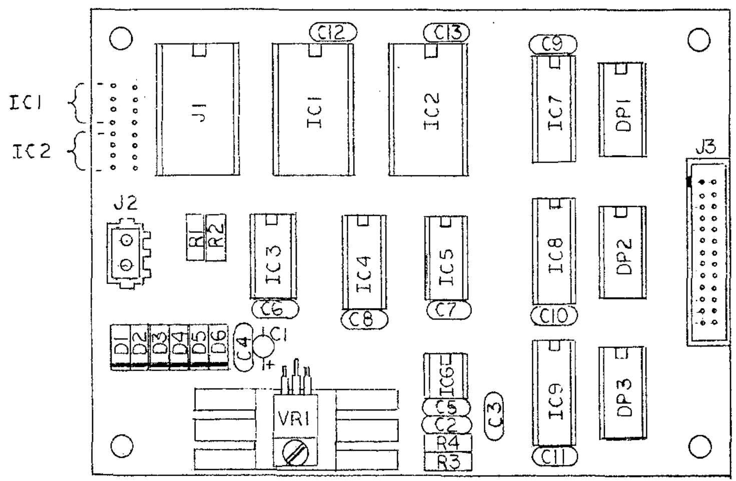


NOTE: WIRING FOR 300 & 600 CONTROL ARE SAME EXCEPT FOR P11.

TOLERANCES (EXCEPT AS NOTED)	TRANSWORLD X-RAY CORP. CHARLOTTE, N.C.		
DECIMAL ±		SCALE	DRAWN BY / APPROVED BY
FRACTIONAL ±	TITLE POINT TO POINT TUBE PROTECT SYSTEM		
ANGULAR ±	DATE 10-17-80	DRAWING NUMBER C 301 E 285	B

DATE	SYM	REVISION RECORD	AUTH.	DR.	CK.

DESIGN	ITEM	QTY	DESCRIPTION	TWX PART NO
	25	1	NUT HEX #6	0016S30
	24	1	SCREW PAN HD 6-32 X 3/8	0019S6
	23	1	HEATSINK	5076S8
J3	22	1	CONNECTOR 26 POS PCB	5069S71
J2	21	1	CONNECTOR 2 POS F/M	5069S3
IC1,2,J1	20	3	IC SOCKET 24 POS	5069S44
IC7, 8, 9	19	3	IC SOCKET 20 POS	5069S42
IC4, DP1 3	18	4	IC SOCKET 16 POS	5069S40
IC3, 5	17	2	IC SOCKET 14 POS	5069S38
IC6	16	1	IC SOCKET 8 POS	5069S36
VR1	15	1	VOLTAGE REGULATOR	5025S1
D1—6	14	6	DIODE 1N4004	5037S1
R4	13	1	RES 20K 1% 1/4W	5007S24
C4—13	12	10	CAP .01UF 50WV	5016S2
C2, 3	11	2	CAP .1UF 50WV	5016S6
C1	10	1	CAP 4.7UF 35WV	5015S3
R1,2,3	9	3	RES 1K 5% 1/4W	5001S16
DP1,2,3	8	3	DIP RES NETWORK 330Ω	5109S10
IC6	7	1	IC TIMER	5027S6
IC7, 8, 9	6	3	IC OCTAL D-TYPE FLIP FLOP	5020S22
IC4	5	1	IC 3-TO-8 DECOD/MULTIPLEX	5020S17
IC3	4	1	IC D-TYPE TRIG FLIP FLOP	5020S15
IC5	3	1	IC HEX INVERTER	5020S2
IC1, 2	2	REF	IC 1K X 8 UV PROM	5023S1 or 2
	1	1	DRILLING P C BD	5063S43

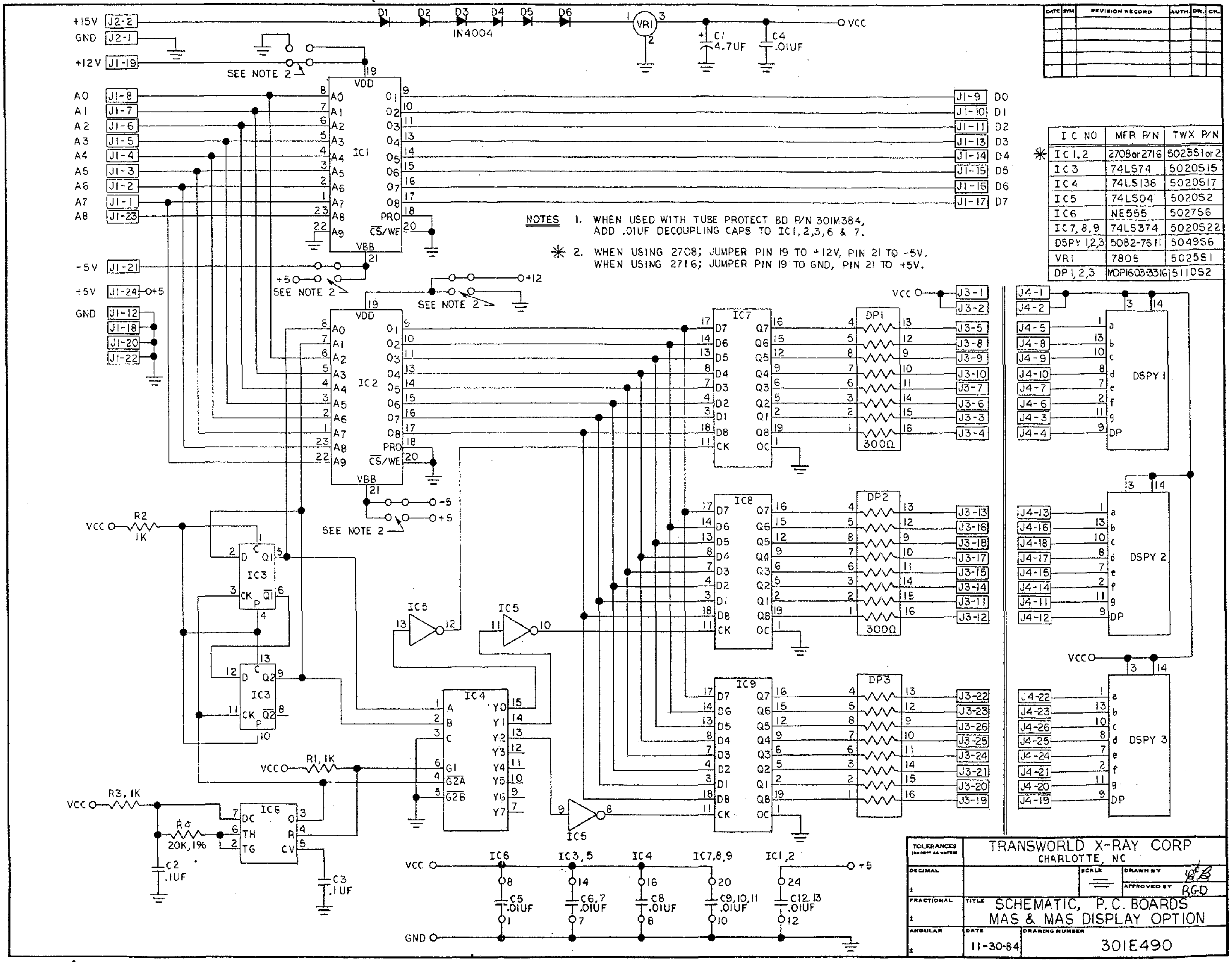


NOTES

1. IC1 & 2 CIRCUITY IS FOR A 2708 PROM ONLY, WHEN USING A 2716 PROM, MODIFY BD AS FOLLOWS:
   —CUT CIRCUITY TRACES ON FAR SIDE.
   —ADD JUMPERS ON COMPONENT SIDE.

2. WHEN USED WITH TUBE PROTECT BD P/N 301M384, MODIFY T/P BD BY ADDING .01UF DECOUPLING CAPS TO IC1,2,3,6 & 7.

TOLERANCES (EXCEPT AS NOTED)	TRANSWORLD X-RAY CORP CHARLOTTE, NC
DECIMAL ±	SCALE FULL — DRAWN BY [signature] — APPROVED BY RGD
FRACTIONAL ±	TITLE ASSY., P C BOARD MAS OPTION
ANGULAR ±	DATE 10-19-84 — DRAWING NUMBER 301M494



NOTES 1. WHEN USED WITH TUBE PROTECT BD P/N 301M384, ADD .01UF DECOUPLING CAPS TO IC1,2,3,6 & 7.

✳ 2. WHEN USING 2708; JUMPER PIN 19 TO +12V, PIN 21 TO -5V. WHEN USING 2716; JUMPER PIN 19 TO GND, PIN 21 TO +5V.

	I C NO	MFR P/N	TWX P/N
✳	IC1,2	2708 or 2716	502351 or 2
	IC3	74LS74	5020S15
	IC4	74LS138	5020S17
	IC5	74LS04	5020S2
	IC6	NE555	5027S6
	IC7,8,9	74LS374	5020S22
	DSPY 1,2,3	5082-7611	5049S6
	VR1	7805	5025S1
	DP1,2,3	MDP1603-3316	5110S2

TRANSWORLD X-RAY CORP
CHARLOTTE, NC

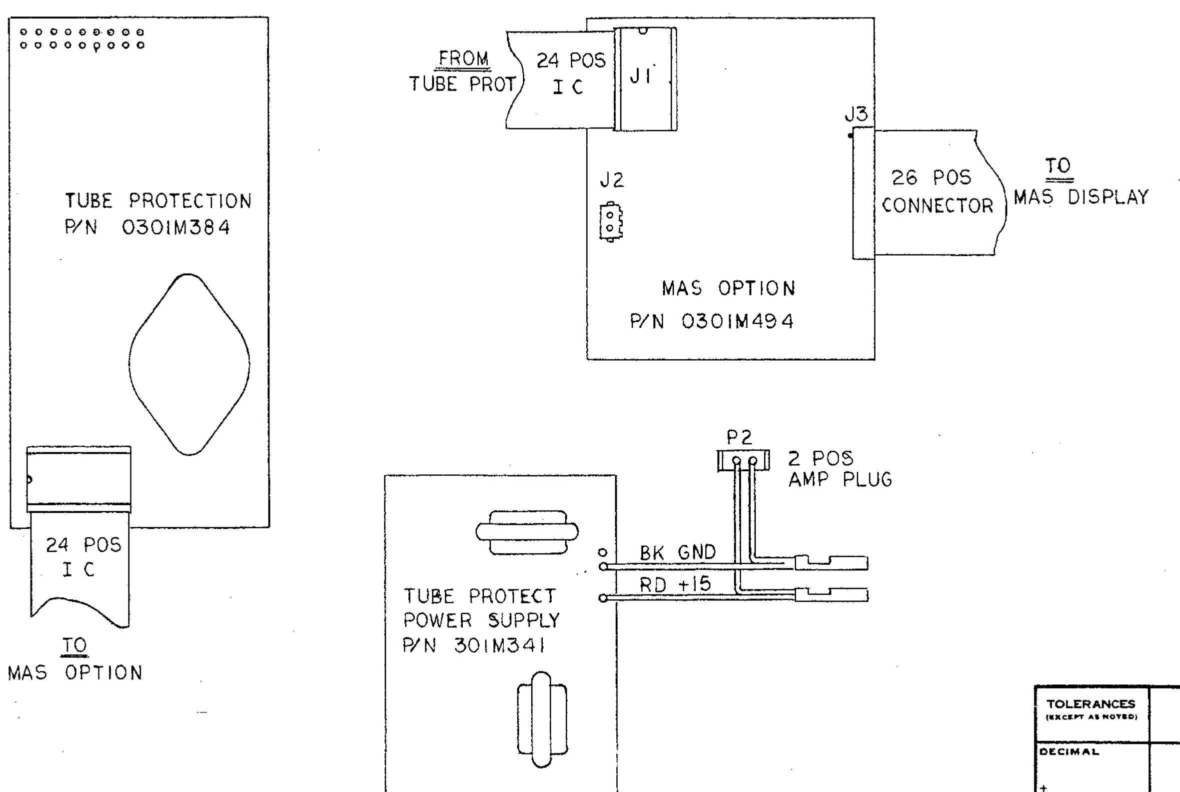
TITLE: SCHEMATIC, P.C. BOARDS MAS & MAS DISPLAY OPTION

DATE: 11-30-84

DRAWING NUMBER: 301E490

APPROVED BY: RGD

DATE	SYM	REVISION RECORD	AUTH.	DR.	CK.



TOLERANCES (EXCEPT AS NOTED)	TRANSWORLD X-RAY CORP CHARLOTTE, N C		
DECIMAL ±		SCALE	DRAWN BY *KB* APPROVED BY *RGO*
FRACTIONAL ±	TITLE INTERCONNECT MAS DISPLAY OPTION		
ANGULAR ±	DATE 12-3-84	DRAWING NUMBER 301E502	

K•E ALBANENE® 10 5465 DUNCAN-PARNELL, INC.
ENGINEERS' STANDARD FORM

MADE IN U.S.A.

325 Wiring Interconnect

Generator Terminal strip		Function		I.C. Cable	Transformer
TB4	1	Filament common	FC	orange	FC
	2	Small filament	FS	black/red	FS
	3	Large filament	FL	red/black	FL
	4	mA lead	M1	black/white	M1
	5		M2	orange/red	M2
	6	*tube stator 09	common		
	7	*tube stator 07	run		
	8	*tube stator 08	start		
	9	not used			
	10	B3	bucky		
	11	B2	bucky		
	12	not used			
	13	B1	bucky		
	14	Collimator interlock			
	15	Collimator interlock			
	16	Ground		green	

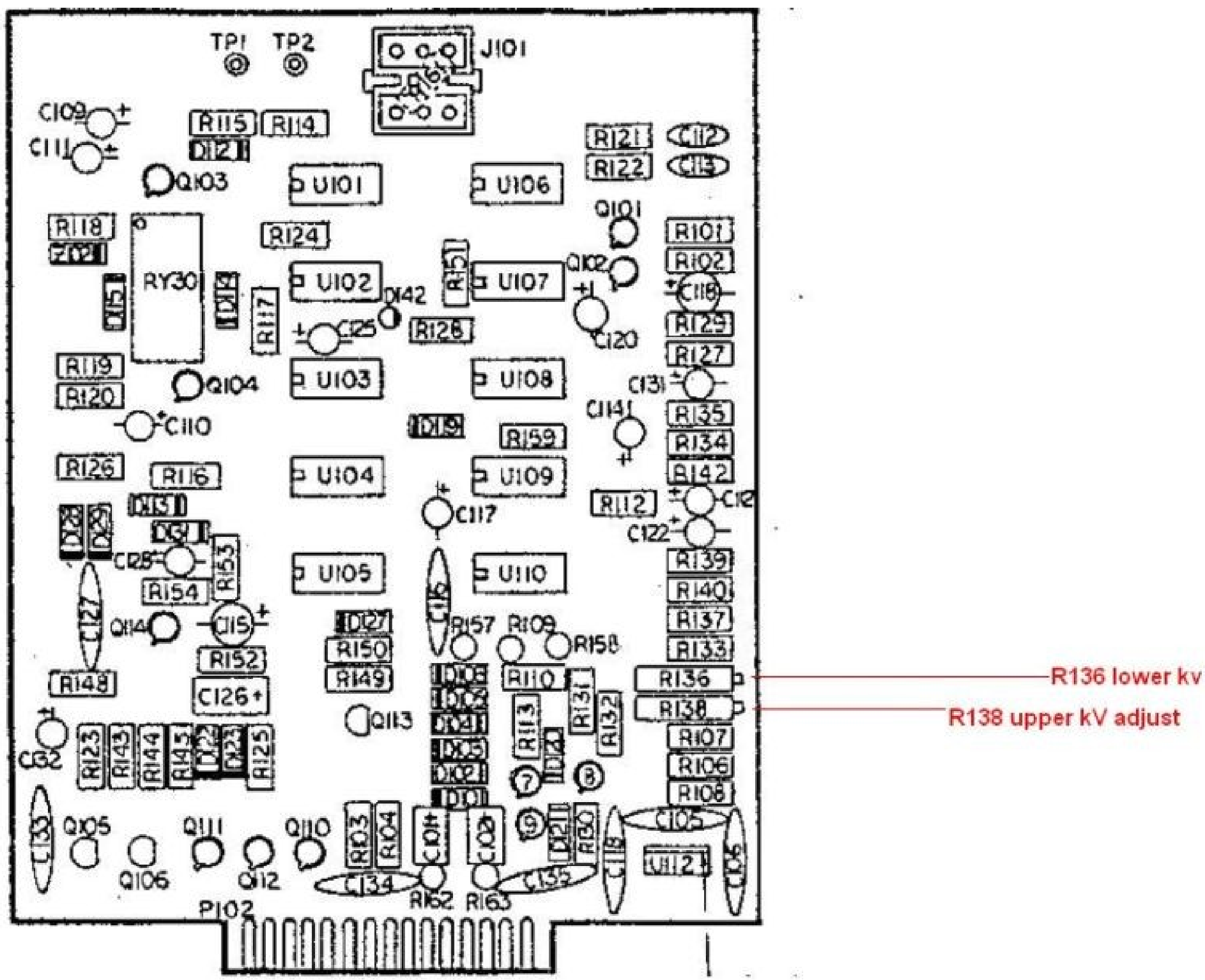
TB4-4, M1 lead is the connection to remove and install a mAs meter in series for calibration of mA. One lead of mAs meter on TB4-4 and the other lead of the mAs meter clipped onto the end of the wire M1 (black with a white stripe)

*X-ray tube stator/rotor connections for most x-ray tubes. Normally the x-ray tube rotor cable from the x-ray tube will be color coded as below:

09	common	white wire lead
08	start	either red or green wire
07	run	black wire lead

<u>Transworld 325V Tube Protect Adjustments</u>

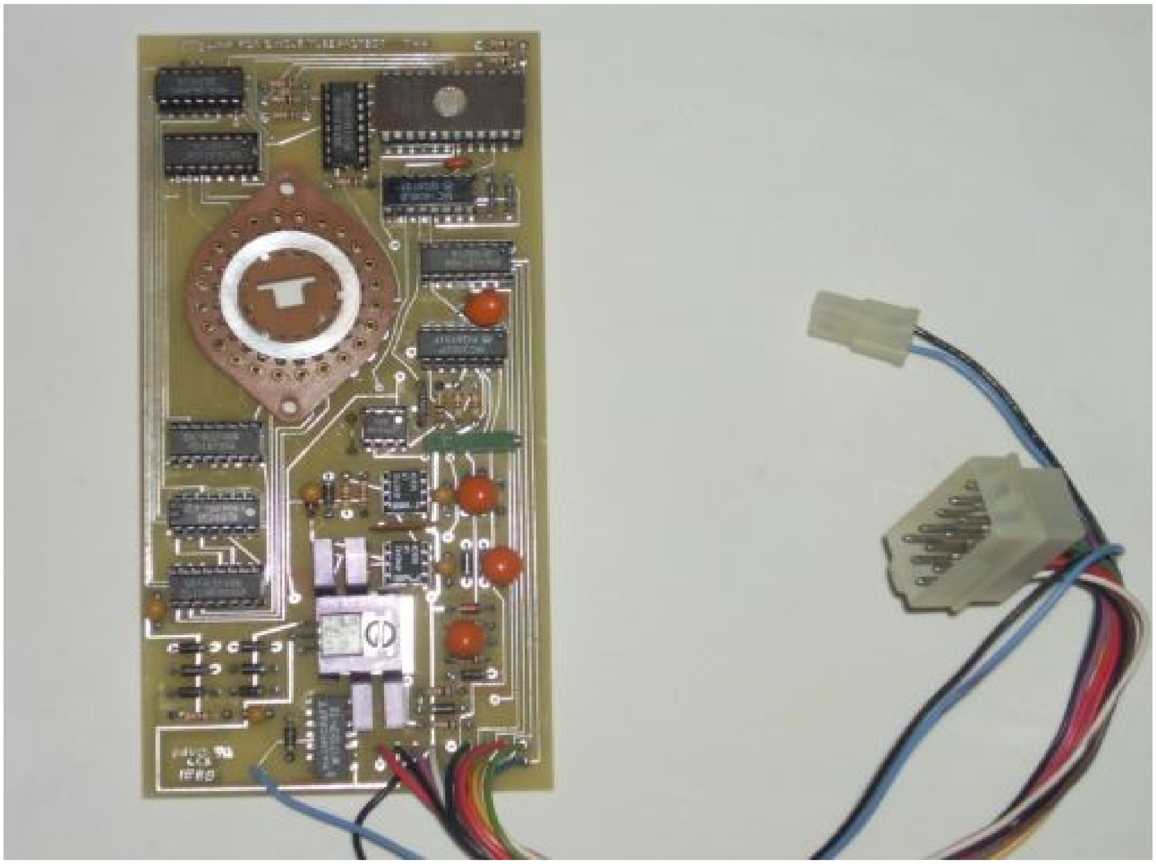
These adjustments are made on the Logic Board which is plugged into the top of the Power Supply Board by means of the p.c. board edge connector.



R138, multi-turn potentiometer. The upper kV limit adjusts the tube protect circuit for the range from 125 kV to about 80 kv. This adjustment sets at what point the tube protect turns on and prevents rotor/exposure.

R136 is the lower limit kV adjustment. Adjusting it will set where tube protection turns on to prevent rotor/exposure at a low kV setting from about 70kV to 40kV.

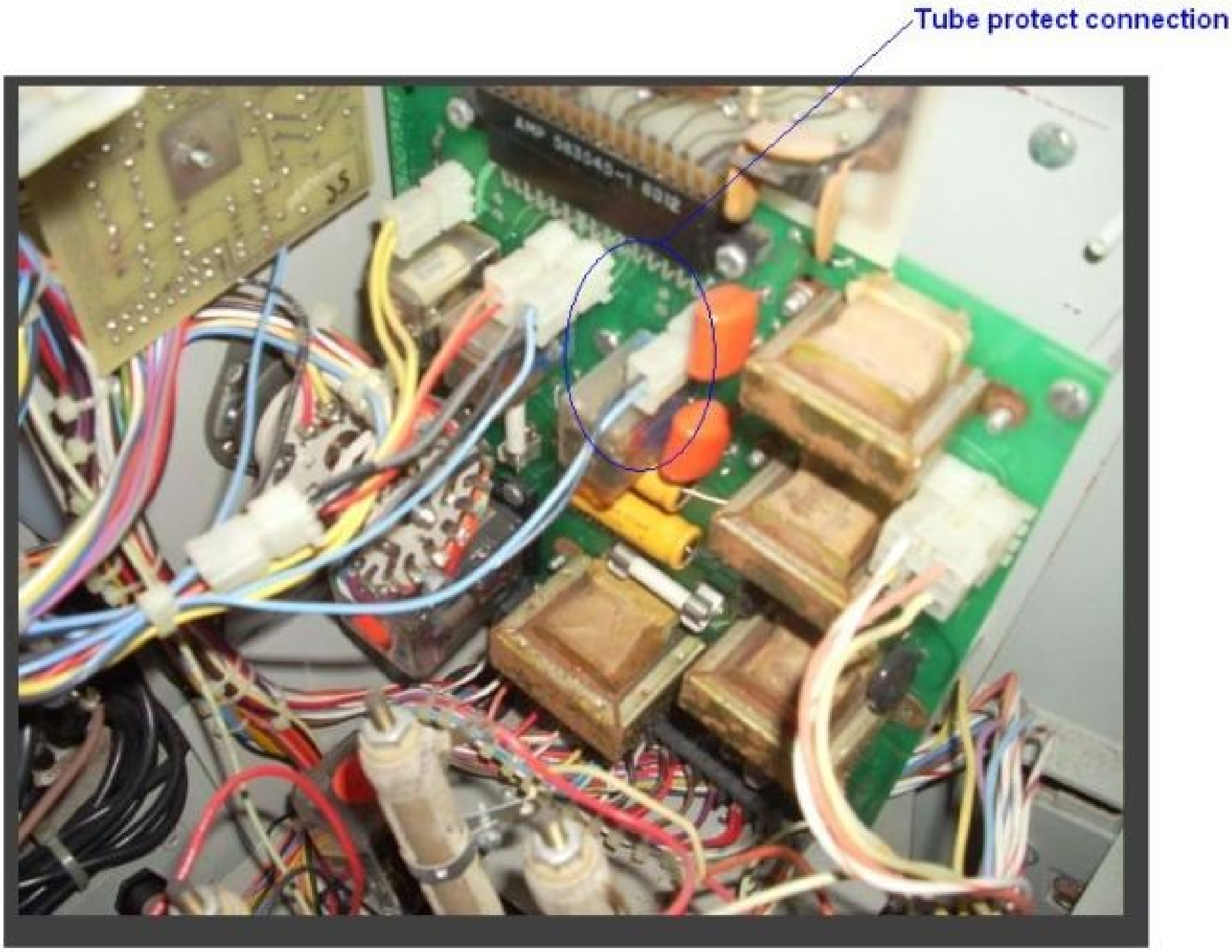
The majority of the tube protection is done on the Tube Protect p.c.b.



U8, top right hand corner of the board is the Eprom where the data is stored with the x-ray tube data from the factory for the x-ray tube that was originally shipped with the generator. The small molex connector with the black and blue wire (as shown above) plugs into the Power Supply Board. Disconnecting this plug from the Power Supply Board will disable the tube protect function of the generator allowing for any setting of kV or time regardless of the mA station selected.

It should be noted that without any tube protection, the operator will need to observe that they don't exceed the ratings of the x-ray tube at particular technique settings that could damage the x-ray tube.

The next photo shows the above connection to the Power Supply Board. By unplugging the two wire molex connector (black and blue wire) the tube protection will be defeated.



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