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Time Projection Compton Spectrometer (TPCS) User's Guide

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Abstract

The Time Projection Compton Spectrometer (TPCS) is a radiation diagnostic designed to determine the time-integrated energy spectrum between 100keV-2MeV of flash X-ray sources. This guide is intended as a reference for the routine operator of the TPCS. Contents include a brief overview of the principle of operation, detailed component descriptions, detailed assembly and disassembly procedures, guide to routine operations, and troubleshooting flowcharts. Detailed principle of operation, signal analysis and spectrum unfold algorithms are beyond the scope of this guide; however, the guide makes reference to sources containing this information.

Acknowledgement

The authors would like to thank Andrew Beaudet, Blake Henderson, Mike Jones, Brad Peyton, Bob Ross, Pat Ryan, all Ktech Corporation, and the entire operations crew at the Sandia National Laboratories Saturn accelerator for their involvement with the setup, modification to, and operation of the TPCS during its development. Thanks also go to Ken Shimp, EG&G Albuquerque Operations, Perry Cowen, Kim Law, and Finis Long, Sandia National Laboratories Hardware Development and Applications Department, for their mechanical design and drafting assistance on the TPCS.

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1.0 Introduction

The Time Projection Compton Spectrometer (TPCS) is a radiation diagnostic designed to determine the time-integrated energy spectrum between 100keV - 2MeV of flash X-ray sources. The purpose of this manual is to provide the user with operating, assembly, disassembly, and troubleshooting instructions for the TPCS.

2.0 Principle of Operation

Flash X-ray sources produce a very intense burst of photons when fired. The energy of the photons can't be measured directly; therefore, some method must be used to infer a photon energy using a secondary measurable phenomenon. In the case of Compton spectrometers, photons interact with a conversion medium and are split into two (2) components, scattered photons and recoil/secondary or Compton electrons[1]. The Compton electron from the conversion medium can be measured in various ways and methods have been devised to allow determination of the energy of the incident photon. The TPCS is similar to conventional Compton spectrometers in that it too uses a conversion medium to interact with incident photons, but they are quite different in the manner in which they use the Compton electrons to determine the energy of the incident X-ray photons. Below is a brief discussion of the operation of a conventional-type of Compton spectrometer and the TPCS for comparison.

A conventional-type of Compton spectrometer, refer to figure 1, selectively collimates Compton electrons exiting the target at a pre designated angle. These collimated electrons enter a homogeneous magnetic field where they separate according to energy. Discrete electron detectors are placed at positions corresponding to certain radii of curvature at the edge of the magnetic field region where the electron will exit the field. Knowing the characteristics of the conversion medium, the angle at which the electron exited the conversion medium, and the radius of curvature of the electron in the magnetic field, it is possible to determine the energy of the incident X-ray photon.

Unlike a conventional Compton spectrometer, the TPCS, refer to figure 2, does not use a homogeneous magnetic field to capture and guide the Compton electron. Instead, the TPCS uses a *nonuniform* magnetic field created by a pulsed current flowing through a conductor that runs along the axis at the center of an evacuated cylindrical chamber, drift tube, to capture and guide the Compton electrons. Photons from the source enter the TPCS normal to the axis of the drift tube and are collimated onto a target located inside the spectrometer. Timing of events are such that the photons reach the target at approximately peak current through the center rod. Compton electrons exiting the conversion medium are trapped in the magnetic field, created by the current flowing in the center rod, at varying radial positions. The electrons are transported in the evacuated chamber for ~ 1m according to gradient-B and curvature-B drift theories[2,3,4,5,6]. Electrons with the highest energy travel with the greatest velocity in the magnetic field while the lowest energy electrons travel with the slowest velocity. At the end of the drift tube, the electrons are totally stopped in a plastic scintillator[7] that converts the deposited energy from the electrons into photons in the 400nm wavelength range. The light from the scintillator is coupled across an air gap to ultraviolet transmitting acrylic light pipes that guide the photons to the input of a photomultiplier tube (PMT)[8]. The PMT converts the impinging photons into an amplified electrical signal that is coupled to transient digitizers that record the signal. The recorded electrical signal represents the arrival times of the Compton electrons at the plastic scintillator resulting in an integrated time of flight record of the Compton electrons. By superposing the appropriate response functions generated for the conversion medium so as to match the signal recorded on the digitizer, it is possible to determine the energy ranges of the incident X-ray photons. The energy resolution of the TPCS is determined by the number of response functions that have been generated for the conversion medium not the number of detectors used to collect the electrons as is the case with conventional Compton spectrometers.

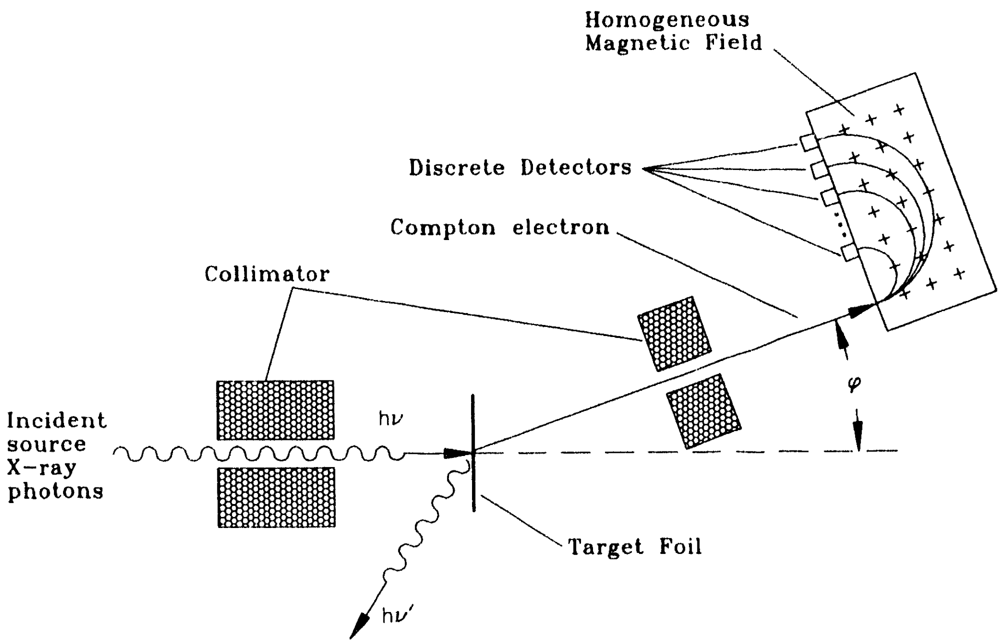


Figure 1: Schematic of Compton Spectrometer

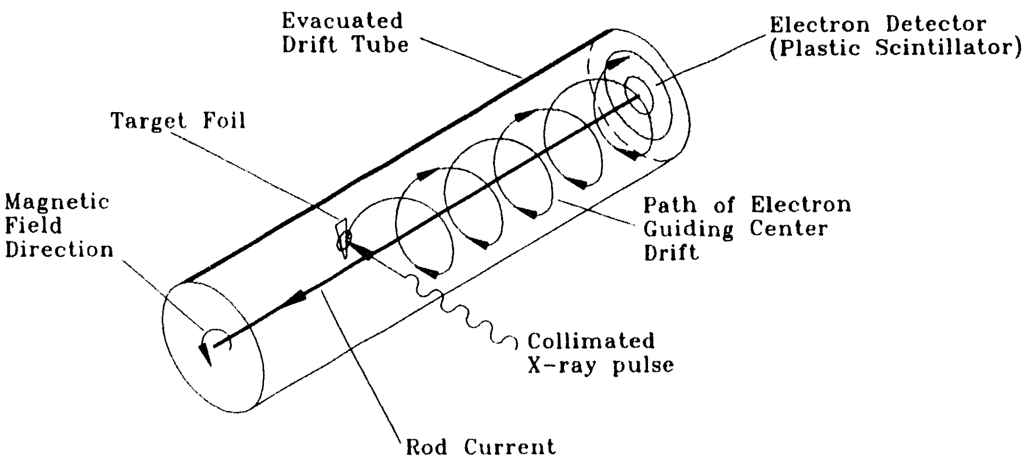


Figure 2: Schematic of Time Projection Compton Spectrometer

3.0 Description of System Components

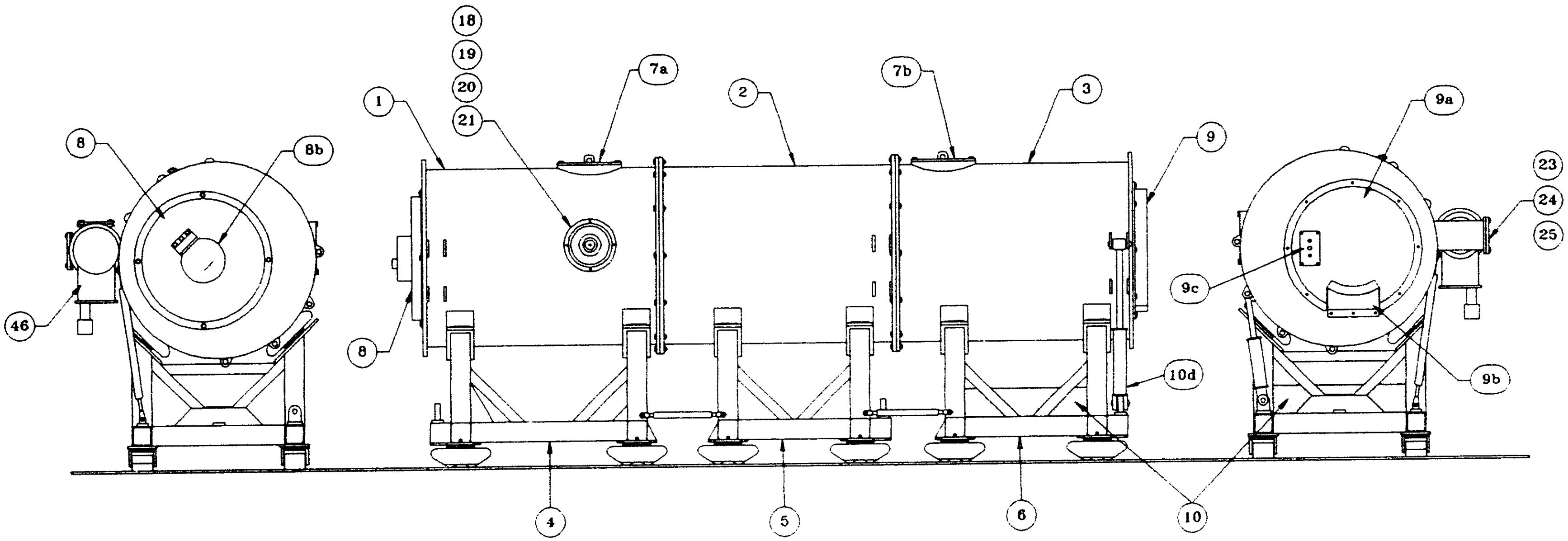


Figure 3a: Parts Breakdown for the TPCS

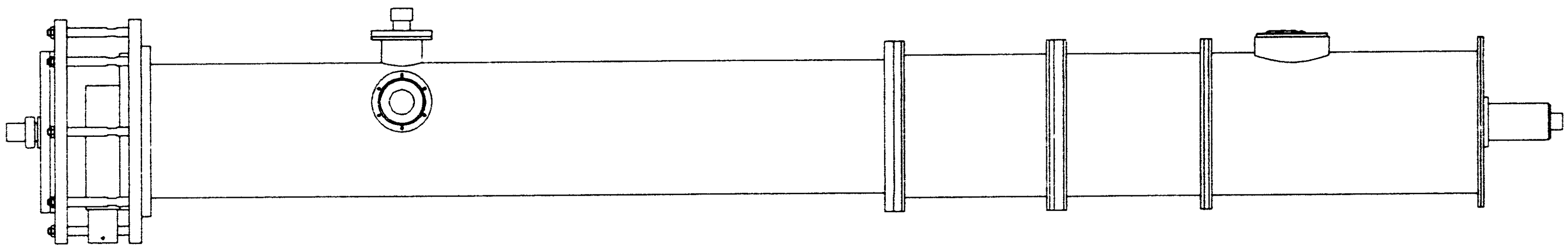


Figure 3b: Parts Breakdown for the TPCS
(Full Spectrometer Assembly)

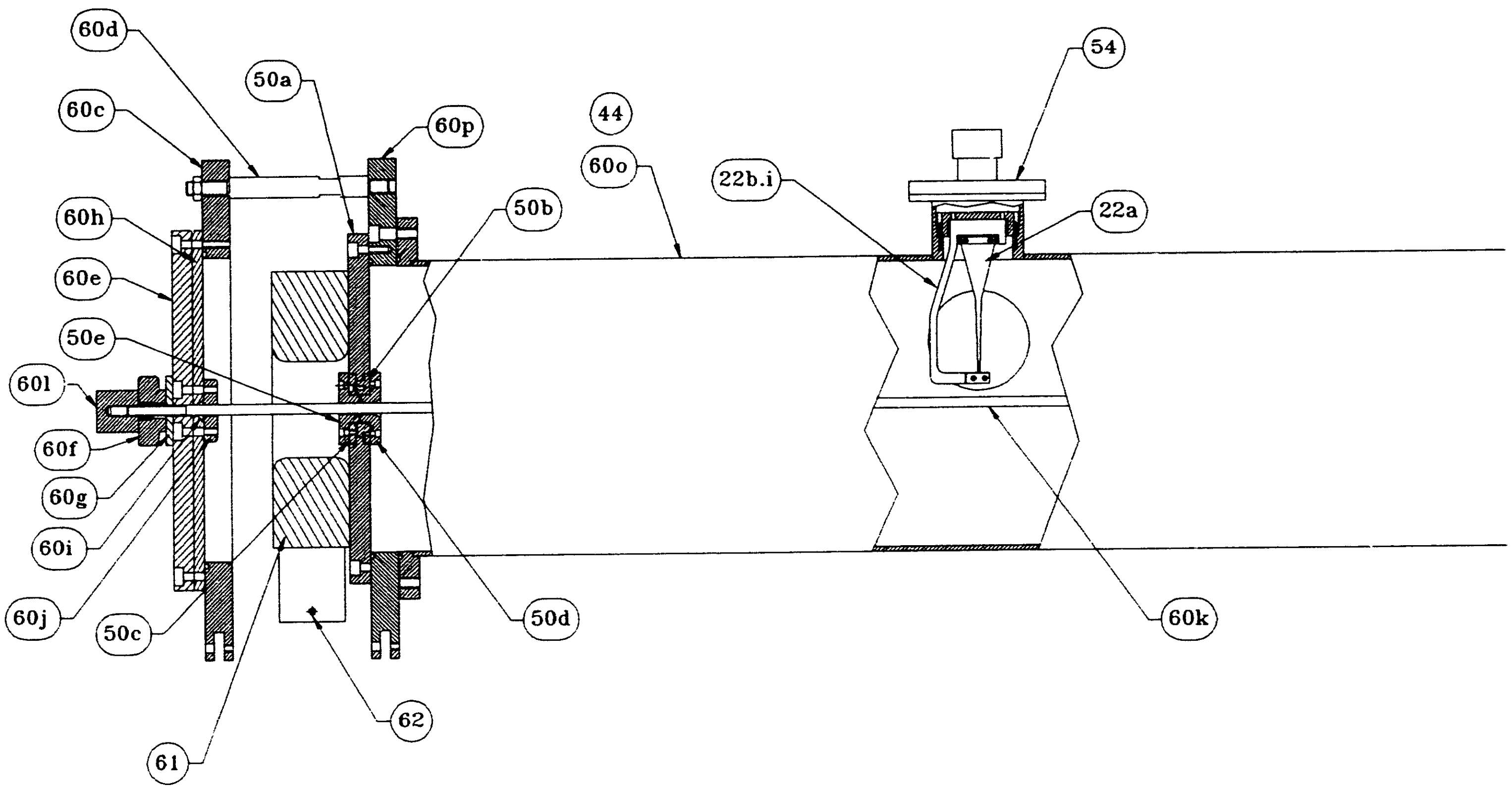


Figure 3c: Parts Breakdown for the TPCS

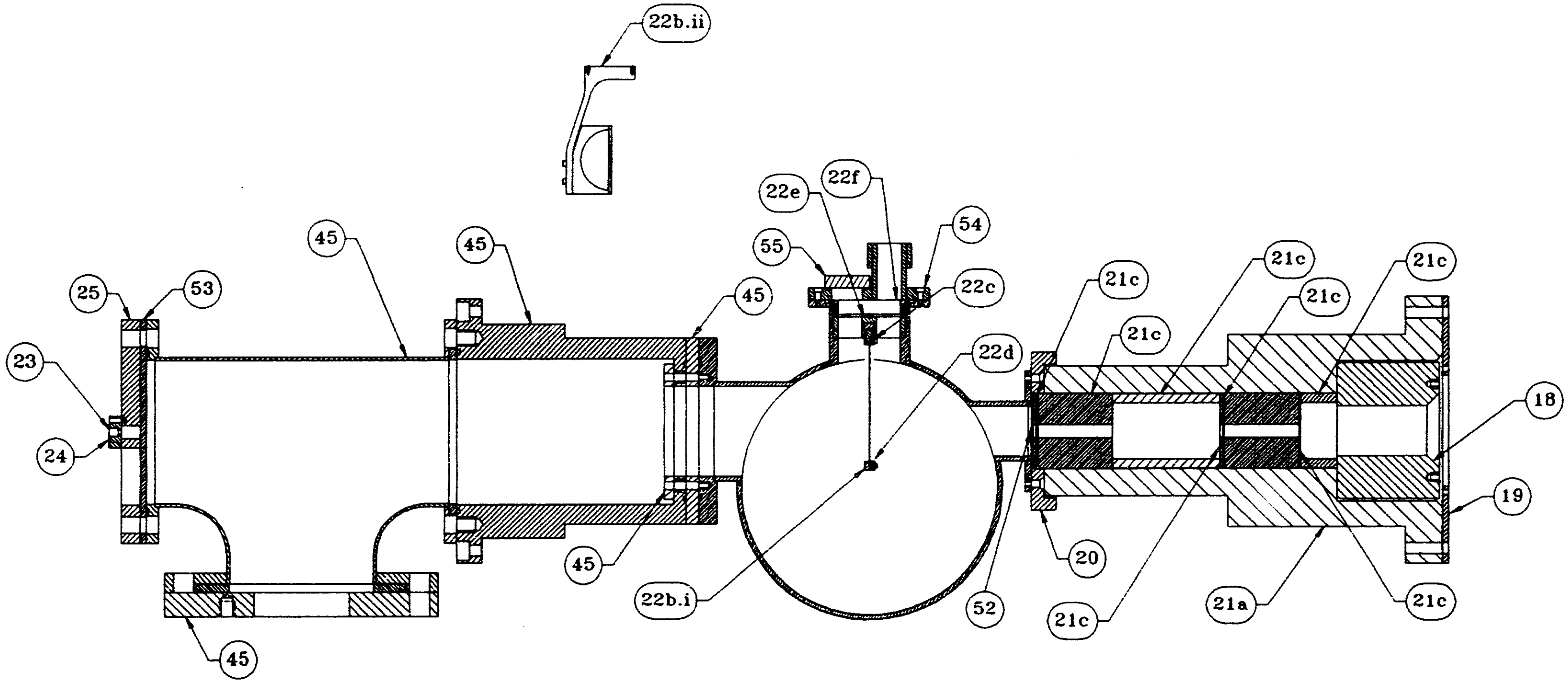


Figure 3d: Parts Breakdown for the TPCS

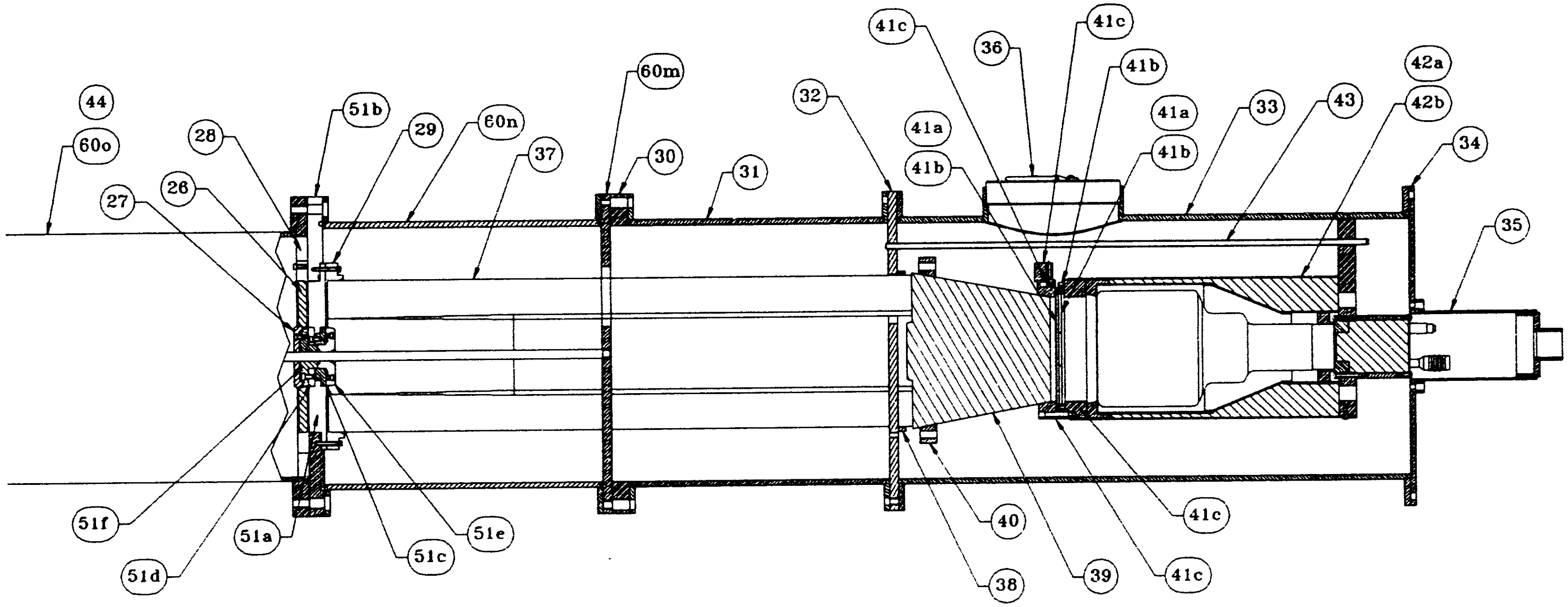


Figure 3e: Parts Breakdown for the TPCS

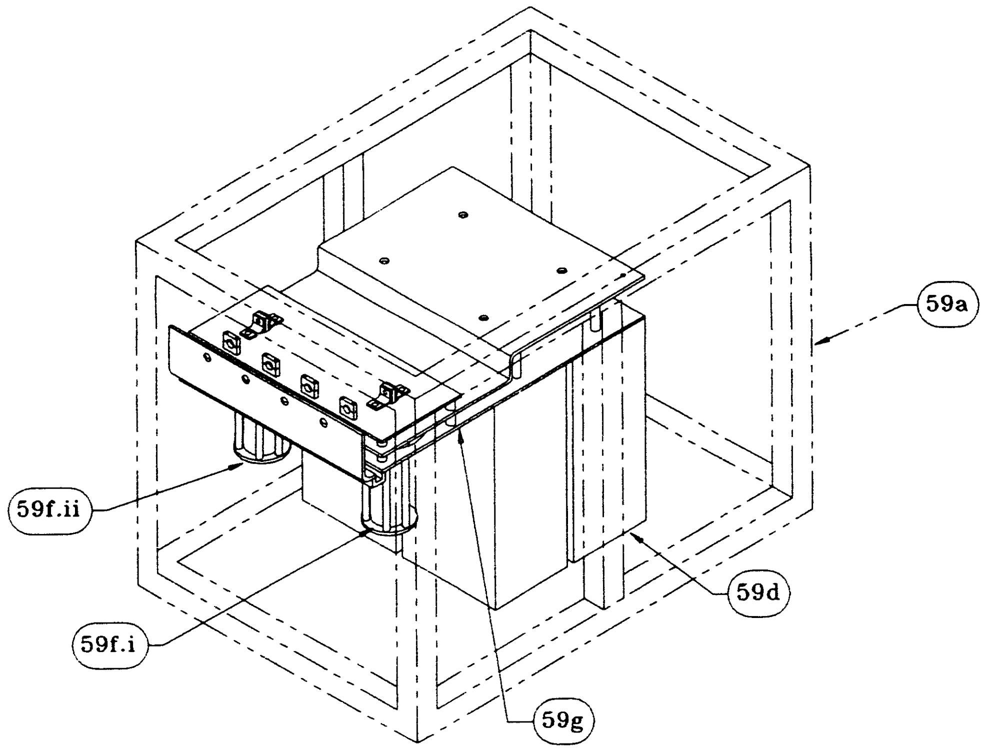


Figure 3f: Parts Breakdown for the TPCS

3.1 Radiation Shield

The radiation shield provides shielding of the spectrometer from direct and scattered source X-rays. Physically, the shield is a 22 ton (20,000kg), 12.14ft (3.7m) long, 2.95ft (0.09m) diameter cylindrically-shaped rolled steel plate outer shell, steel tube inner shell, cast lead filled unit. The shield's longitudinal axis is parallel to the floor. A collimator port located in the target end radiation shield module allows a small sample of the source X-rays to enter the shield and impact a target. When the collimator port is aligned to the source, X-rays from the source normal to the shield surface have to penetrate ~ 0.88in (2.2cm) of steel and 10.4in (26.4cm) of lead, and scattered X-rays normal to the shield's backside have to penetrate ~ 0.88in (2.2cm) of steel and 4.6in (11.7cm) of lead before reaching the spectrometer.

The outer diameter of the shield contacts rollers that are affixed to the top of a support and alignment system consisting of three carts, one for each radiation shield module. The rollers allow the shield to be rotated about its longitudinal axis using an electrohydraulically driven system that is capable of rotating the shield unit's collimator port from 0°, collimator port axis parallel to the plane of the floor, to 90°, collimator port axis perpendicular to the plane of the floor.

The shield consists of three modules. Each module bolts to its neighboring module with a 3.33ft (1.02m) diameter, 0.75in (1.91cm) thick flange. At each of the flange joints, the shield overlaps in order to improve shield effectiveness at that joint, refer to figure 3.

1 - *Radiation Shield Module One (Target End)*: Provides: 1) radiation shielding to the upstream portion of the spectrometer, 2) end-on access to the high-voltage connections of the detector, 3) a collimated port of entry for the X-ray photons from the source into the detector, 4) access to the vacuum gauges on the detector, 5) access to the converter foil port on the detector, and 6) access to the vacuum port on the detector.

2 - *Radiation Shield Module Two (Middle Section)*: Shields the middle section of the spectrometer and the scintillator from direct and scattered source radiation.

3 - *Radiation Shield Module Three (PMT End)*: Provides: 1) radiation shielding to the electron detector section of the TPCS, 2) access to the Neutral Density Filter Assembly in the electron detector section, and 3) end-on access to the electron detector section of the TPCS.

4,5,6 - *Radiation Shield Carts*: Supports the radiation shield modules and allows the positioning of the TPCS. The carts, fabricated from structural steel tube, provide support for the radiation shield modules. Rollers mounted on top of the carts allow the rotation of the radiation shield modules about the longitudinal axis, and rotatable casters affixed to the bottom of each cart provide steering capability for the TPCS when it is being moved into position.

7 - *Radiation Shield Access Plugs*:
a. target foil access port - Shields the target foil access port of the spectrometer from scattered radiation from the source. The removable radiation shield plug also allows access to the target foil and the vacuum gauges on the spectrometer with the spectrometer loaded in the radiation shield.
b. neutral density filter access port - Shields the neutral density filter port of the electron detector from scattered radiation from the source. The removable radiation shield plug also allows access to the ND filter with the spectrometer loaded in the radiation shield.

8 - *Radiation Shield Module One End Plug Assembly*:
a. end plug - Provides scattered radiation shielding for the upstream section of the TPCS detector.
b. door - Allows access to the Center Rod Tension Adjustment Knob with the spectrometer loaded in the radiation shield.
c. inner plug - Provides scattered radiation shielding for the upstream section of the TPCS detector.

9 - *Radiation Shield Module Three End Plug Assembly*:
a. end plug - Shields the electron detector section of the TPCS detector from scattered source radiation. The end plug provides feedthru ports for the coaxial cables from the TPCS Capacitor Bank.
b. Line-of-Sight (LOS) inserts - Shields the electron detector section of the TPCS detector from scattered source radiation.
c. cable feedthru panel - Allows for quick disconnect of the signal and bias cables from the radiation shield.

10 - *Electrohydraulic Rotation System*:
a. pump[9] - Drives the hydraulic cylinder connected to the TPCS radiation shield. The electrically driven pump has a capacity of 1/2 gpm.
b. hose - Transmits the hydraulic forces from the pump to the hydraulic cylinder.
c. metering valve - Regulates the flow of the hydraulic fluid from the pump to the actuator. The valve is a manually operated throttling-type valve that allows adjustment of the speed of rotation of the spectrometer.
d. actuator - Receives the hydraulic force from the pump and transmits the force to the TPCS radiation shield allowing rotation of the shield about its longitudinal axis. The actuator has a 5 ton capacity.
e. vacuum pump oil containment pan - Traps and retains any vacuum pump oil spilled by the vacuum roughing pump.
f. hydraulic fluid containment pan - Traps and retains any hydraulic fluid spilled by the electrohydraulic pump.

11,12,13,14 - *Centering Ring Assembly*; Supports and centers the TPCS detector inside the Radiation Shield Assembly.

15,16,17 - *Liner*: Electrically insulates the TPCS detector from the Radiation Shield Assembly. The liner is fabricated from 0.030" thick G-10 fiberglass sheet.

18 - *Collimator Stack Retaining Slug*: Prevents the collimator element stack from moving inside the Collimator Shielded Port. It also attenuates the line-of-sight X-rays entering the spectrometer in the gap between the Collimator Shielded Port inner diameter and the collimator element stack outer diameter.

19 - *Collimator Element Retaining Plate*: Holds the collimator stack captive in the Radiation Shield.

20 - *Collimator Shielded Port Insulating Adaptor Ring*: Aligns the Collimator Shielded Port to the spectrometer and electrically insulates the Radiation Shield from the spectrometer Drift Tube.

3.2 Photon Target

X-ray photons from the accelerator source enter the spectrometer and illuminate a thin target foil producing Compton electrons and photoelectrons that are transported down the drift tube and detected, mapped, by the electron detection section. Most of the photons pass through the target and exit the spectrometer through a get-lost port, minimizing scatter inside of the detector. A PIN diode located in the get-lost port measures the incident X-ray pulse as a function of time.

21 - *Collimator Assembly (X-ray photon input)*:
- a. collimator shielded port - Houses the X-ray collimator elements and provides collimator element coupling from the radiation shield to the TPCS detector. The shielded port also provides autoaligning of the collimator elements to the target foil.
- b. blank off lead plug - Attenuates incident X-rays from the input of the TPCS detector when inserted into the shielded collimator port. The blank off lead plug is used during initial setup and characterization of the TPCS to determine the zero-input background of the system.
- c. collimator - Collimates the incident X-ray photons prior to entering the TPCS detector using a graded collimation element design.

22 - *Target Foil Assembly*:
- a. target foil - Converts incident X-ray photons into Compton e^-s and photoelectrons. A low Z, i.e., polypropylene, target foil is used when the desired dominant effect is to be Compton e^-s. A high Z, i.e., gold, target foil is used when the desired dominant effect is to be photoelectrons.
- b. foil frame-
  - i. polypropylene foil frame - Supports the polypropylene foil in the spectrometer. The target foil frame's design ensures the target foil's correct positioning in the magnetic field, and the surface of the target foil is normal to the incoming source photons.
  - ii. gold foil frame - Supports the Au foil in the spectrometer. The target foil frame's design ensures the target foil's correct positioning in the magnetic field, and the surface of the target foil is normal to the incoming source photons.

c. top clamp - Secures the top of the polypropylene foil to the top of the foil frame. The top clamp also provides adjustment of the tension on the target foil allowing removal of wrinkles providing a smooth uniform surface for the incoming source photons

d. bottom clamp - Secures the bottom of the polypropylene foil to the bottom of the foil frame.

e. bracket - Couples the foil frame to the spectrometer and aligns the foil with respect to the spectrometer axis and the source.

f. target foil retaining ring - Ensures that the target foil assembly is properly seated in the spectrometer regardless of spectrometer orientation.

23 - *PIN Diode* [10]: Provides a time-dependent electrical output signal proportional to the dose-rate of the incident source X-rays viewed though the collimator port. The signal is also used as a timing fiducial for the other TPCS signals recorded in the DAS.

24 - *PIN Detector Holder*: Secures the PIN diode to the get-lost port on the spectrometer.

25 - *PIN Holder*: Provides a mounting structure for the PIN Detector Holder and PIN.

3.3 Electron Detection

The electron detection section of the TPCS receives the Compton e^-s and photoelectrons transported down the drift tube. An electron to photon conversion takes place at the input to the electron detection section using a plastic scintillator. The photons are transported, using optical-grade ultraviolet transmitting (UVT) acrylic light guides, to the input of a PMT where they are converted back to electrons and amplified before being output. The output signal from the PMT represents the amplified time integrated Compton e^- and photoelectron signal that originated from the target foil.

26 - *Scintillator* [11]: Stops the Compton e^-s and photoelectrons emitted from the target foil that were transported down the spectrometer. Scintillator emission is visible light (~ 400nm peak wavelength) that is proportional to the energy deposited by the impinging e^-s. The scintillator has an annular geometry and is fabricated from plastic scintillation material. A 2000Å thick aluminum coating, deposited on the surface of the scintillator that faces the target foil, reduces the amount of visible light allowed to enter the electron detector from the drift tube section.

27 - *Scintillator Center Clamp*: Secures the Scintillator to the spectrometer.

28 - *Scintillator Support Ring*: Supports the outer diameter of the scintillator and maintains a uniform spacing between the downstream surface of the scintillator and the upstream surface of the Downstream End Plate Window.

29 - *Light Pipe Guide*: Forces the outer diameter of the Light Pipes to be contained within the inner diameter boundary of the Light Pipe Guide.

30 - *Electron Detector Insulating Spacer*: Electrically insulates the electron detector from the Drift Tube.

31 - *Light Pipe Enclosure*: Encases the light pipes providing a light tight seal between the current return plate and the PMT Housing Entrance Plate.

32 - *PMT Housing Entrance Plate*: Provides a feedthru port for the light pipes to the sum coupler. The PMT Housing Entrance Plate also serves as a mounting structure for the Sum Coupler and the PMT.

33 - *PMT Housing*: Encases the Light Pipes, Sum Coupler, Neutral Density Filter Assembly, and PMT, and provides a light tight seal for the Electron Detector Assembly.

34 - *PMT Housing End Plate*: Provides a light tight seal for the downstream end of the PMT Housing and a mounting structure for the PMT Cable Feedthru.

35 - *PMT Cable Feedthru*: Physically protects and provides a feedthru region for the PMT signal and bias cables.

36 - *PMT Housing ND Filter Access Port Lid*: Allows access to the ND Filter Holder Cassette when it is installed in the PMT Housing. It also provides a light tight seal for the top of the PMT housing.

37 - *Light Pipes*: Couples and guides the photons from the scintillator to the input of the sum coupler. The light pipes are precision-machined plastic optical devices fabricated from optical-grade UVT acrylic. Use of the UVT acrylic minimizes transmission losses of the ultraviolet signal generated by the scintillator.

38 - *Light Pipe Grouping Ring*: Collects the Light Pipes into a tight grouping at the Sum Coupler end of the Light pipes ensuring good optical coupling between the Light Pipes and the Sum Coupler.

39 - *Sum Coupler*: Collects photons transported by the light pipes and couples them to the input of the PMT. The sum coupler is a precision-machined plastic optical device fabricated from optical-grade UVT acrylic. Use of the UVT acrylic minimizes transmission losses of the ultraviolet signal generated by the scintillator.

40 - *Sum Coupler Securing Clamp*: Attaches the Sum Coupler to the PMT Housing Entrance Plate. The Sum Coupler Securing Clamp ensures good mechanical contact between the Sum Coupler and the Light Pipes.

41 - *Neutral Density Filter Assembly*:

a. neutral density filters[12] - Attenuates the photons guided out of the sum coupler to an acceptable level prior to entry into the PMT.

b. filter frame - Holds the neutral density filters. The filter frame is an in-line insertable cassette that allows the user to change the attenuation of the input optical signal to the PMT with the electron detector in place and the spectrometer loaded in the radiation shield.

c. filter holder - Positions the neutral density filters in the optical path between the sum coupler and the PMT.

42 - *PMT*:

a. low gain tube - Converts incident photons from the scintillator into an electrical output signal. The PMT assembly contains a Hamamatsu model #R1250 5" head-on input tube with a semitransparent photocathode material having a spectral response range between 300-650nm and a peak wavelength of 450nm. A custom-designed voltage divider network fixes the gain of the tube at ~ 10^4 with a throughput delay of ~ 60ns and a risetime of <4ns.

b. high gain tube - Converts incident photons from the scintillator into an electrical output signal. The PMT assembly contains a Hamamatsu model #R1250 5" head-on input tube with a semitransparent photocathode material having a spectral response range between 300-650nm and a peak wavelength of 450nm. A custom-designed voltage divider network fixes the gain of the tube at ~ 10^6 with a throughput delay of ~ 60ns and a risetime of <4ns.

43 - *PMT Support Rods*: Attaches the PMT to the PMT Housing Entrance Plate. The PMT Support Rods ensure good mechanical and optical coupling between the PMT, ND Filter Holder Assembly, and the Sum Coupler.

3.4 Vacuum System

A high vacuum environment is necessary for the proper operation of the TPCS. Since the accuracy of the TPCS unfold depends, in part, on the unperturbed transport of the Compton e^-s in the vacuum chamber, it is necessary to minimize the possibility of electron to air molecule interactions while the electrons are being transported down the drift tube, or maximize the mean free path in the vacuum (the better the vacuum: the longer the mean free path). The TPCS vacuum system is capable of providing a vacuum pressure of <1 x 10^{-6} torr with system components that have been thoroughly cleaned before assembly. (*note- Due to the use of plastic and nonstainless steel parts in the design of the spectrometer, it is very difficult to reach pressure levels much less than 1 x 10^{-6}torr. However, a 1 x 10^{-6}torr vacuum is sufficient for the proper operation of the diagnostic.*) The primary components in the TPCS vacuum system are the vacuum chamber and associated connection and blank off hardware, a roughing pump, and a high vacuum pump.

44 - *Drift Tube*: Serves as the vacuum chamber for the spectrometer and as a current return path for the pulsed current from the TPCS capacitor bank.

45 - *Plumbing Hardware*: Couples the turbomolecular pump and the roughing pump to the spectrometer drift tube and electrically insulates the vacuum pump from the spectrometer.

46 - *Electropneumatic Gate Valve* [13]: Allows isolation and coupling of the vacuum pumps to the spectrometer.

47 - *Vent Valves*: Permits venting of the vacuum system to atmosphere.

48 - *Roughing Pump* [14]: Evacuates the drift tube to a pressure of ~ 4 x 10^{-3}torr. The roughing pump is a Leybold model D25B rotary vane vacuum pump with a pumping speed of 18.1 ft^3/min.

49 - *Turbomolecular Pump* [15]: Evacuates the drift tube to a pressure of ~ 1 x 10^{-6}torr. The pump takes the drift tube pressure to a range in which the mean free path for a drifting electron is ~ 12m to 50m for the vacuum range of 5 x 10^{-5}torr and 2 x 10^{-6}torr respectively. The turbomolecular vacuum pump is a Leybold model TMP1000 with a pumping speed of ~ 1100 liters/sec. The TMP1000 rotor, lubricated with a 20,000 hour reserve of lubricating grease, eliminates the need to regrease the unit during its normal lifetime. This model was chosen because of its ability to operate in any orientation, unlike many turbomolecular vacuum pumps, and its low maintenance requirements.

50 - *Upstream Vacuum Interface Assembly*:

a. upstream end plate - Provides a vacuum-tight seal for the upstream portion of the drift tube, and geometrically positions the center rod in the drift tube to be coincident with the spectrometer longitudinal axis. The upstream end plate, fabricated from opaque Lexan®, serves as an ambient light block and provides electrical insulation between the center rod and the drift tube.

b. feedthru adaptor - Serves as a vacuum seal between the upstream end plate and the upstream end plate o-ring retaining feedthru. It also serves as the mounting structure for the feedthru adaptor clamp and the upstream end plate o-ring retaining feedthru.

c. feedthru adaptor clamp - Compresses the o-ring on the feedthru adaptor making the vacuum seal between the feedthru adaptor and the upstream end plate. It also serves as a mounting structure for the upstream end plate o-ring compression clamp.

d. upstream end plate o-ring retaining feedthru - Provides a vacuum seal at the feedthru adaptor and holds the o-ring used to make the vacuum seal around the center rod.

e. upstream end plate o-ring compression clamp - Compresses the o-ring held in the upstream end plate o-ring retaining feedthru making the vacuum seal around the center rod.

51 - *Downstream Vacuum Interface Assembly*:

a. downstream end plate window - Serves as a vacuum to air interface window that allows the transmission of light from the scintillator to the light pipes. The window makes the vacuum seal with the stainless steel downstream outer end plate and the feedthru adaptor.

b. downstream outer end plate - Provides the electron detector interface vacuum seal for the drift tube.

c. feedthru adaptor - Serves as a vacuum seal between the downstream acrylic endplate and the light pipe centering feedthru. It also serves as the mounting structure for the feedthru adaptor clamp and the light pipe centering feedthru.

d. feedthru adaptor clamp - Compresses the o-ring on the feedthru adaptor making the vacuum seal between the feedthru adaptor and the downstream acrylic endplate. It also serves as a mounting structure for the scintillator centering feedthru.

e. light pipe centering feedthru - Provides a vacuum seal at the feedthru adaptor and holds the o-ring used to make the vacuum seal around the center rod. It also serves as a loading and centering guide for the light pipes.

f. scintillator centering feedthru - Compresses the o-ring held in the light pipe centering feedthru making the vacuum seal around the center rod. It also serves as the centering and mounting structure for the scintillator.

52 - *Collimator Port Vacuum Window*: Provides a vacuum-tight seal for the collimator port on the drift tube. The window, fabricated from thin mylar sheet, provides strength in a low z material that allows minimization of scatter and attenuation of the incoming source X-rays.

53 - *Get-Lost Port Vacuum Window*: Provides a vacuum-tight seal for the get-lost port of the drift tube.

54 - *Target Foil Access Port Plate*: Provides a vacuum-tight seal for the target foil access port, allows access to the target foil in the spectrometer with the spectrometer loaded in the radiation shield, and provides mounting ports for the vacuum gauges.

55 - *Target Foil Access Port Vacuum Window*: Allows for visual inspection of the target foil when the spectrometer is under vacuum.

3.5 Vacuum Diagnostics

The vacuum diagnostics used on the TPCS are capable of measuring pressures from atmosphere to ~ 1×10^{-7} Torr. A single remotely located control unit controls the vacuum sensors, collects signals from the vacuum sensors, and converts/displays the received vacuum sensor signals in Torr.

56 - *Thermistor Gauge* [16]: Senses the pressure of the drift tube over the range of ~ 1×10^{-4}torr to atmosphere.

57 - *Penning Gauge* [17]: Senses the pressure of the drift tube over the range of ~ 1×10^{-7}torr to ~ 1×10^{-4}torr.

58 - *GPT-450 Controller/Indicator* [18]: Controls the power switching for the gauges and provides a visual, analog gauge, readout for the thermistor and Penning vacuum gauges' signals.

3.6 High-Voltage System

The TPCS high voltage system drives the TPCS load with up to a 200kA current pulse ~ 400μs wide which sets up the magnetic field used to trap the electrons from the target foil. The system primarily consists of a capacitor bank system developed and fabricated by Physics International Co. and the TPCS load. The physical dimensions of the capacitor bank enclosure are 42"W x 60"L x 45"H. Four (4) coaxial cables connect the capacitor bank system output to the TPCS load.

59 - *TPCS capacitor bank*[19]:

- a. enclosure - Houses the energy storage capacitors, high voltage power supply, ignitron current switches, ignitron trigger generator, and energy dump circuit.
- b. TPCS Capacitor Bank Controller - Issues all the command and control signals to the TPCS capacitor bank. The controller is remotely located in the Facility Control Monitor to ensure operator safety during capacitor bank operation.
- c. high-voltage power supply - Charges the energy storage capacitors. The power supply is mounted inside the TPCS Capacitor Bank Enclosure.
- d. high-energy storage capacitors - Stores 100kJ of energy, at 10kV charge, required to drive the TPCS load with 200kA of current. Each energy storage capacitor has a capacitance of 500μF and 25kJ energy storage capacitance.
- e. ignitron trigger generator - Sends a trigger to fire the series ignitron current switch. A simultaneous trigger signal output can be sent to the Facility Control Monitor to trigger the accelerator.
- f. ignitrons (current switches):
  - i. series - Connects the charge from the energy storage capacitors to the TPCS load to initiate discharge of the capacitors.
  - ii. crowbar - Reroutes the current after peak to prevent voltage reversal on the energy storage capacitors.
- g. bus structure - Connects the energy stored in the capacitors to the TPCS through the ignitron current switches. The upper busplate distributes the negative high voltage and the lower busplate acts as a floating ground being separated from earth ground by a 20Ω resistor.
- h. dump/safing relay - Connects the bus structure to the dump/safing circuit to discharge the energy storage capacitors. The relay also acts as a charging current shunt path to prevent charge storage in the capacitors.
- i. dump resistors - Absorbs the total energy stored in the energy storage capacitors when the dump/safing relay directs the charge to the charge dump circuit.
- j. grounding stick[20] - Shorts the TPCS capacitor bank high-voltage bus to ground, when connected to the bus, to prevent inadvertent charging of the capacitors during maintenance or inspection procedures.

k. resistive grounding stick[21] - Enables the operator to safely discharge the full capacitor bank energy when connected to the high-voltage bus or capacitor terminal. The resistive grounding stick has a resistance of 500Ω making the RC time constant 1 second (~ 5 seconds total discharge time) for the full TPCS capacitor bank discharged through the resistive grounding stick. The RC time constant for a single capacitor through the resistive grounding stick is ~ 250ms (~ 1.25 seconds total discharge time).

l. shorting strap - Electrically shorts the top and bottom bus plates together on the capacitor bank, when installed. The shorting strap ensures that no charge accumulates on the capacitors when installed.

60 - *Current Delivery/Transport System*:

a. coaxial cable - Connects the current from the TPCS capacitor bank to the TPCS high-voltage plate through the center conductor of the RG220/U coaxial cable. The coaxial cables transport the charge from the TPCS Capacitor Bank in parallel to the TPCS load over a distance of ~ 20ft.

b. coaxial cable clamp - Ensures good mechanical contact between the coaxial cable center conductor and the High-Voltage Connection Plate. Also, ensures that good mechanical contact between the Electrical Ground Connection Plate and the shield of the coaxial cable. The clamps, fabricated from phenolic material, ensure electrical insulation of the clamps from the ferrules on the coaxial cables. Actuation of the clamps is accomplished by the engagement/disengagement of Camloc® latches that are anchored to the High-Voltage Connection Plate and the Electrical Ground Connection Plate. The quick-release design of the clamps/latches enable the operator to remove the coaxial cables, High-Voltage Connection Plate, and Electrical Ground Connection Plate from the spectrometer while the spectrometer is loaded in the radiation shield.

c. high-voltage connection plate - Couples the current from the coaxial cables to the high voltage bridge plate. The high voltage plate is designed to accept four (4) or eight (8) coaxial cables from the TPCS Capacitor Bank.

d. high-voltage plate support rod - Provides a support and mounting structure for the high-voltage connection plate. It also maintains a uniform spacing between the electrical ground connection plate and the high-voltage connection plate.

e. high-voltage bridge insulating plate - Electrically insulates the Center Rod Tension Adjustment Knob from the high-voltage bridge plate

f. center rod tension adjustment knob - Applies a longitudinal force to the Center Rod to remove the droop from the unsupported section of the Center Rod in the drift tube. (*note- It is necessary to remove the droop from the Center Rod so that it does not experience excessive movement when the current pulse is flowing in the spectrometer. Excessive Center Rod movement could result in the Center Rod contacting, and possibly damaging, the Target Foil Assembly forcing unplanned maintenance on the system.*)

g. center rod tension adjustment knob washer - Acts as a lubricating interfacing surface between the center rod tension adjustment knob and the high-voltage bridge insulating plate.

h. high-voltage bridge plate - Couples the current from the high-voltage connection plate to the center rod current contact gasket.

i. center rod current contact gasket - Couples the current from the high-voltage bridge plate to the center rod.

j. high-voltage bridge clamp - Ensures good mechanical contact between the center rod current contact gasket, the high-voltage bridge plate, and the center rod.

k. center rod - Transports the current from the energy storage capacitors through the spectrometer. The Center Rod and Current Return Plate must be soldered together during the initial assembly. A filleting solder joint at the threaded joint between the Center Rod and the Current Return Plate eliminates the possibility of arcing at the joint. (note- *An arc resulting from current flashover could produce an optical signal that would overdrive the PMT.*)

l. center rod insulating end cap - Electrically insulates the center rod from the Radiation Shield Module One End Plug.

m. current return plate - Couples the current from the Center Rod to the Current Return Tube. The Current Return Plate is separated from the Scintillator by the Current Return Tube so that the current continues past the Scintillator making the magnetic field consistent at the region of electron to photon conversion

n. current return tube - Couples the current from the Current Return Plate to the Drift Tube and houses the upstream end of the Light Pipes.

o. drift tube - Couples the current from the current return tube to the Electrical Ground Connection Plate and serves as the vacuum chamber for the spectrometer.

p. electrical ground connection plate - Connects the current from the Drift Tube to the shield of the coaxial cables for return to the TPCS capacitor bank.

3.7 Current Diagnostics

The current diagnostics fielded on the TPCS measure/sense the current pulse in the capacitor bank and the TPCS load. There are three (3) current diagnostics used on the TPCS: 1) a TPCS load current sensor, 2) a capacitor bank load current sensor, and 3) a capacitor bank crowbar current sensor.

61 - *Pearson Current Transformer*[22]: Senses the current pulse in the center rod, inductively, and produces a voltage signal that is proportional to the current. The polarity of the output signal depends on the direction of the current flow through the center of the transformer. A 10X attenuator placed in series with the output of the transformer minimizes the possibility of signal cross talk between the transformer signal cable and the PMT signal cable.

62 - *Current Transformer Mount*: Provides a mounting structure for the current transformer enabling it to be attached to and positioned on the spectrometer.

63 - *Load Current Monitor*: Senses the current pulse in the TPCS capacitor bank high-voltage bus, and through the series ignitron current switch. The output is a differentiated voltage signal that is proportional to the current through the TPCS.

64 - *Capacitor Bank Crowbar Current Monitor*: Senses the current pulse through the crowbar ignitron. The output is a differentiated voltage signal that is proportional to the crowbarred current.

3.8 Special Tools and Equipment

65 - *Collimator Element Removal and Replacement Tool*: Provides a positive, non marring, clamping action on the inside of the collimator element allowing removal and replacement of the collimator element from the radiation shield.

66 - *Shield Cart Caster Positioning Tool*: Allows the radiation shield cart casters to be turned during radiation shield moving and alignment operations providing *limited* steering capabilities.

67 - *Dummy Load*: Simulates the load "seen" by the TPCS capacitor bank. Used during testing and troubleshooting of the TPCS capacitor bank.

68 - *TPCS Spectrometer Loading Fixture*: Provides a support platform on which the spectrometer can be assembled and disassembled outside the Radiation Shield Assembly. The fixture consists of a steel tube attached to the top of a hydraulic lift table that is fitted with casters. The fixture gives the operator the flexibility to adjust the height of the spectrometer when it is loaded on the fixture as well as move the spectrometer as required during loading and unloading operations.

69 - *O-ring Protection Sleeve*: Prevents the o-ring seal around the center rod from becoming damaged during detector assembly.

70 - *Light Pipe Assembly Alignment Tool*: Ensures proper spacing of the light pipes during detector assembly.

71 - *Light Pipe Grouping Ring*: Assembles the light pipes into a tight grouping before the Light Pipe Assembly contacts the sum coupler.

72 - *Reversible Boom Crane* [23]: Assists the operator in the handling and positioning of the TPCS hardware. The crane has an electrohydraulically driven telescopic boom and an electric drive system that enables the crane to be moved and repositioned more precisely than a manually operated unit.

4.0 System Setup

4.1 Spectrometer Assembly

This procedure describes the steps required to assemble the spectrometer which includes the drift tube and the electron detector sections. Assembly of the spectrometer is made easier by allowing almost total assembly outside of the Radiation Shield Module Assembly on the TPCS Spectrometer Loading Fixture.

1. Position the TPCS Spectrometer Loading Fixture, dwg# 3A3383, and detector hardware in an uncongested area.
2. Engage the loading fixture brakes.
3. Turn the hydraulic relief valve on the TPCS Spectrometer Loading Fixture's hydraulic cylinder fully clockwise to prevent vertical movement of the fixture.
4. Position the One-piece Drift Tube, dwg# 3A3425, on two (2) 4" x 6" x 2' blocks located on the ground, or similar support, to allow the installation of the support/centering rings. Refer to figure 4.
5. Rotate the One-piece Drift Tube on the support blocks so the axis of the foil access port is positioned 90° with respect to the horizon.
6. Install the two (2) Centering Ring Assemblies, dwg# 3A3363, on the drift tube positioned as indicated in figure 4. (*note- Ensure that part # 3A3368 is located on the bottom of the drift tube.*)
7. Remove one (1) of the ball caster assemblies on top of the second Centering Ring Assembly.
8. Position the One-piece Drift Tube so the end nearest the three (3) ports protruding radially from the drift tube is toward the end of the loading fixture that has the bar welded across the opening.
9. Rig the One-piece Drift Tube using nylon straps and load it onto the loading fixture using the RBC2000 boom crane.
10. Clean all interior surfaces of the drift tube using ethanol, or methanol, and a clean cloth making sure all dirt, oil, and grease is removed from the surfaces.
11. Clean the end flanges of the drift tube using ethanol or methanol and a clean cloth making certain the o-ring grooves are thoroughly cleaned.
12. Clean all surfaces of the following parts using ethanol, or methanol, and a clean cloth:

    a. Downstream End Plate Window, dwg# 3A3397,
    b. Downstream Outer End Plate, dwg# 3A3396,
    c. Scintillator, dwg# 3A3312,
    d. Scintillator Center Clamp, dwg# 3A3393,
    e. Scintillator Centering Feedthru, dwg# 3A3394,
    f. Scintillator Support Ring, dwg# 3A3395,
    g. 2 ea.- Feedthru Adaptor, dwg# 3A3398,
    h. 2 ea.- Feedthru Adaptor Clamp, dwg# 3A3402,
    i. Light Pipe Centering Feedthru, dwg# 3A3399,
    j. Electrical Ground Connection Plate, dwg# 3A3427,
    k. Light Pipe Guide, dwg# 3A3400,
    l. Upstream End Plate, dwg# 3A3403,
    m. Upstream End Plate O-ring Retaining Feedthru, dwg# 3A3404,
    n. Upstream Endplate O-ring Compression Clamp, dwg# 3A3401.

13. Place the above parts aside in a clean location for installation at a later time.
14. Clean the following o-rings using ethanol, or methanol, and a clean lint-free cloth:

    a. 2 ea.- Parker #2-124,
    b. 1 ea.- Parker #2-125,
    c. 2 ea.- Parker #2-138,

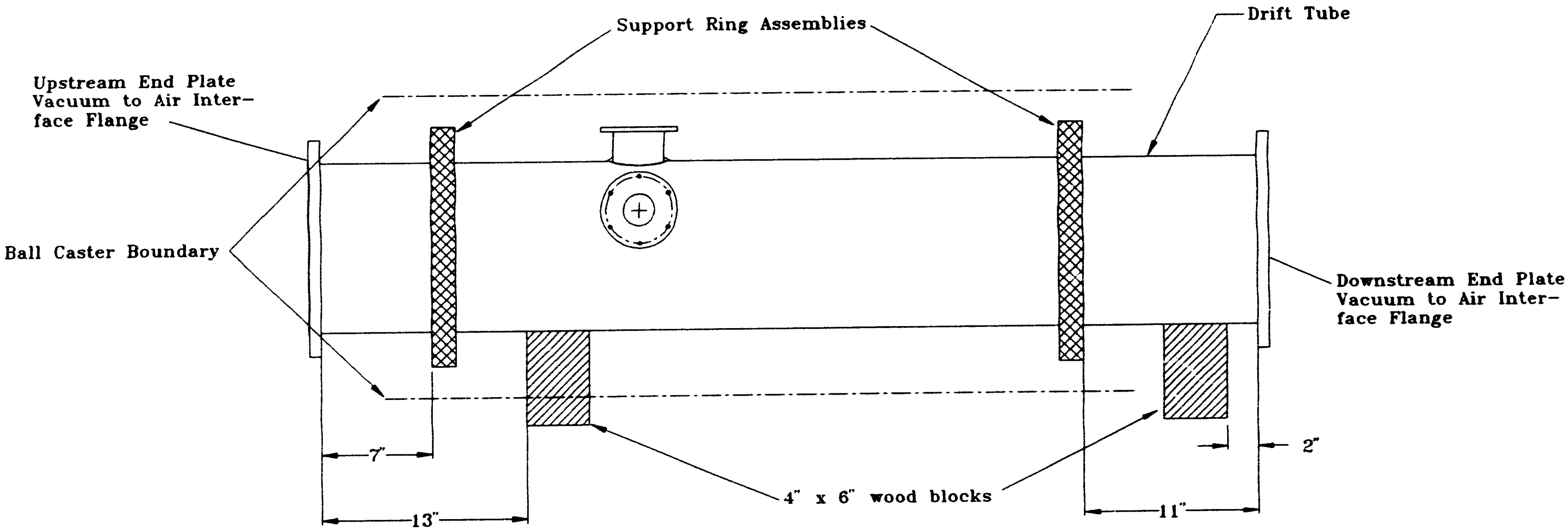
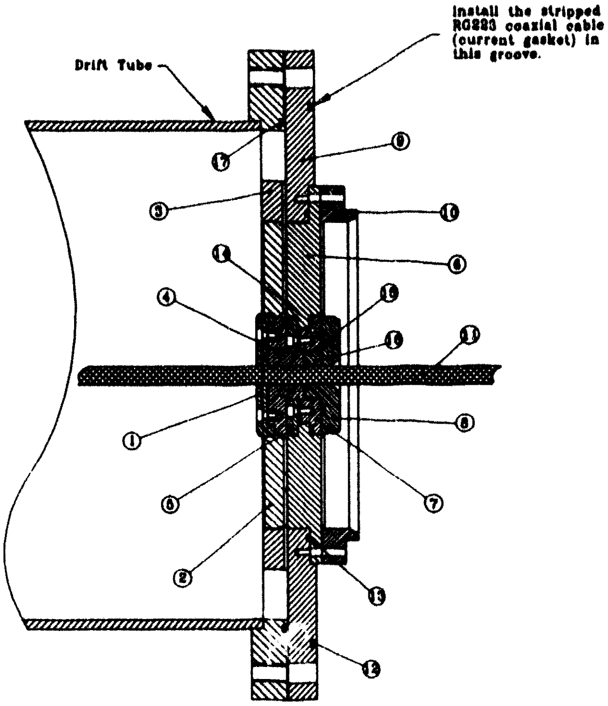


Figure 4: Placement of Wood Blocks on the Drift Tube to Allow Installation of the Support Ring Assemblies

d. 1 ea.- Parker #2-166,
e. 2 ea.- Parker #2-204,
f. 1 ea.- Parker #2-236,
g. 1 ea.- Parker #2-238,
h. 2 ea.- Parker #2-252,
i. 2 ea.- Parker #2-259,
j. 1 ea.- Parker #2-266, and
k. 3 ea.- Parker #2-275.

15. Lubricate all o-rings with vacuum grease designed for high vacuum applications, preferably Apiezon type L vacuum grease.
16. Place the lubricated o-rings aside in a clean location for installation at a later time.
17. Install a lubricated Parker #2-275 o-ring in the captive o-ring groove located on the One-piece Drift Tube's upstream vacuum to air interface flange, refer to figure 4.
18. Install a lubricated Parker #2-275 o-ring in the captive o-ring groove located on the drift tube's downstream vacuum to air interface flange, refer to figure 4.
19. Install the cable clamps and the Camloc® latches on the Electrical Ground Connection Plate and the High-Voltage Connection Plate, dwg# 3A3416.
20. Position the Electrical Ground Connection Plate so it is parallel to the drift tube's upstream vacuum to air interface flange and the surface with the counterbored holes is facing away from the One-piece Drift Tube flange.
21. Attach the Electrical Ground Connection Plate to the drift tube's upstream vacuum to air interface flange using eight (8) each 3/8"-16 x 1-1/8" steel socket head screws. Tighten the screws using a standard eight-hole flange tightening pattern until all screws are snug.
22. Install a lubricated Parker #2-275 o-ring in the captive o-ring groove on the Electrical Ground Connection Plate.
23. Screw the eight (8) High-Voltage Plate Support Rods, dwg# 3A3330, into the eight (8) 1/2-13 holes on the Ø16.00" BC on the Electrical Ground Connection Plate. Make certain the ends of the rods with the shortest thread lengths are screwed into the plate. (*note- Do not overtighten the support rods as stripping of the threads may result.*)
24. Position the High-Voltage Connection Plate so it is parallel to the Electrical Ground Connection Plate and the surface with the current contact groove is facing away from the Electrical Ground Connection Plate.
25. Align the eight (8) thru holes on the Ø16.00" BC on the High-Voltage Connection Plate with the High Voltage Plate Support Rods.
26. Install the High-Voltage Connection Plate on the support rods.
27. Secure the High-Voltage Connection Plate to the support rods using eight (8) each 1/2-13 G10 fiberglass nuts. Tighten nuts until snug. (*note- Do not overtighten the G10 nuts as stripping of the threads may result.*)
28. Lay the Downstream Outer End Plate on a clean flat surface with the grooved-side of the end plate facing up.
29. Install a lubricated Parker #2-166 o-ring in the inner-most groove of the Downstream Outer End Plate.
30. Install the Downstream End Plate Window in the Downstream Outer End Plate with the Ø6.495" o.d. section of the Downstream End Plate Window inserted into the i.d. of the Downstream Outer End Plate.
31. Align the eight (8) thru holes on the Ø7.50" BC on the Downstream End Plate Window with the eight (8) threaded holes on the Ø7.50" BC on the Downstream Outer End Plate.
32. Lay the Light Pipe Guide on top of the Downstream End Plate Window with the flange-side of the Light Pipe Guide in contact with the top surface of the Downstream End Plate Window.
33. Align the eight (8) thru holes on the Ø7.50" BC on the flange of the Light Pipe Guide with the eight (8) thru holes on the Downstream End Plate Window.

34. Secure the Light Pipe Guide and the Downstream End Plate Window to the Downstream Outer End Plate using eight (8) each 6-32 x 1" steel socket head screws and eight (8) each Ø7/16" o.d. #6 screw steel flat washers. Tighten the screws using a standard eight-hole flange tightening pattern until all screws are snug.
35. Turn the Downstream Outer End Plate Assembly over and lay the assembly down resting on the Light Pipe Guide.
36. Lay the Scintillator Support Ring, slotted-side down, on the Downstream Outer End Plate, refer to figure 5.
37. Align the eight (8) thru holes on the Ø7.75" BC on the Scintillator Support Ring with the eight (8) threaded holes on the Ø7.75" BC on the Downstream Outer End Plate.
38. Attach the Scintillator Support Ring to the Downstream Outer End Plate using eight (8) each 6-32 x 3/4" steel socket head screws and eight (8) each Ø7/16" o.d. #6 screw steel flat washers. **Just start the screws in the threaded holes at this time!**
39. Install a lubricated Parker #2-138 o-ring in the o-ring groove on one of the Feedthru Adapters.
40. Place the Downstream Outer End Plate Assembly on edge.
41. Insert the Feedthru Adaptor into the center of the Downstream End Plate Window from the Light Pipe Guide side of the Downstream Outer End Plate Assembly with the o-ring facing the Downstream End Plate Window. Hold the adaptor in place with one hand.
42. Insert the Feedthru Adaptor Clamp into the center of the Downstream End Plate Window from the Scintillator Support Ring side of the Downstream Outer End Plate Assembly with the surface with the four (4) counterbored holes facing away from the Downstream End Plate Window, refer to figure 5.
43. Slightly tilt the Downstream Outer End Plate Assembly toward the side with the Feedthru Adaptor while holding the Feedthru Adaptor and the Feedthru Adaptor Clamp.
44. Align the four (4) counterbored holes on the Ø1.70" BC on the Feedthru Adaptor Clamp with the four (4) threaded holes on the Ø1.70" BC on the Feedthru Adaptor.
45. Secure the Feedthru Adaptor Clamp to the Feedthru Adaptor using four (4) each 6-32 x 1/4" steel socket head screws. Tighten the screws using a standard four-hole flange tightening pattern until all screws are snug. (*note- Make certain the Feedthru Assembly will not rotate in the center of the Downstream Vacuum Window Endplate after the screws have been tightened.*)
46. Lay the Downstream Outer End Plate Assembly down resting on top of the Scintillator Support Ring.
47. Install a lubricated Parker #2-124 o-ring in the outer o-ring groove on the Light Pipe Centering Feedthru.
48. Install a lubricated Parker #2-204 o-ring in the inner o-ring groove on the Light Pipe Centering Feedthru.
49. Install the Light Pipe Centering Feedthru in the center of the Downstream Outer End Plate Assembly with the surfaces containing the o-rings facing the assembly, refer to figure 5.
50. Align the four (4) counterbored holes on the Ø1.80" BC on the Light Pipe Centering Feedthru with the four (4) threaded holes on the Ø1.80" BC on the Feedthru Adaptor.
51. Attach the Light Pipe Centering Feedthru to the Feedthru Adaptor using four (4) each 6-32 x 5/16" steel socket head screws. **Just start the screws in the threaded holes at this time!**
52. Turn the Downstream Outer End Plate Assembly over and lay the assembly down resting on the Light Pipe Guide.
53. Install the Scintillator Centering Feedthru in the center of the Downstream Outer End Plate Assembly with the surface containing the counterbored holes facing away from the assembly, refer to figure 5.
54. Align the four (4) counterbored holes on the Ø1.70" BC on the Scintillator Centering Feedthru with the four (4) threaded holes on the Ø1.70" BC on the Feedthru Adaptor Clamp.



Item#	Description/Part Name	Part#
1	Clamp, Scintillator Center	3A3393
2	Scintillator	3A3312
3	Ring Scintillator Support	3A3395
4	Feedthru, Scintillator Centering	3A3394
5	Clamp, Adaptor, Feedthru	3A3402
6	Window, Downstream End Plate	3A3397
7	Adaptor, Feedthru	3A3398
8	Feedthru, Light Pipe Centering	3A3399
9	End Plate, Outer, Downstream	3A3396
10	Guide, Light Pipe	3A3400
11	Center Rod	3A3426
12	Current Gasket (stripped RG223)	N/A
13	Parker o-ring	2-166
14	Parker o-ring	2-138
15	Parker o-ring	2-124
16	Parker o-ring	2-204
17	Parker o-ring	2-276

Figure 5: Downstream Vacuum Interface Subassembly

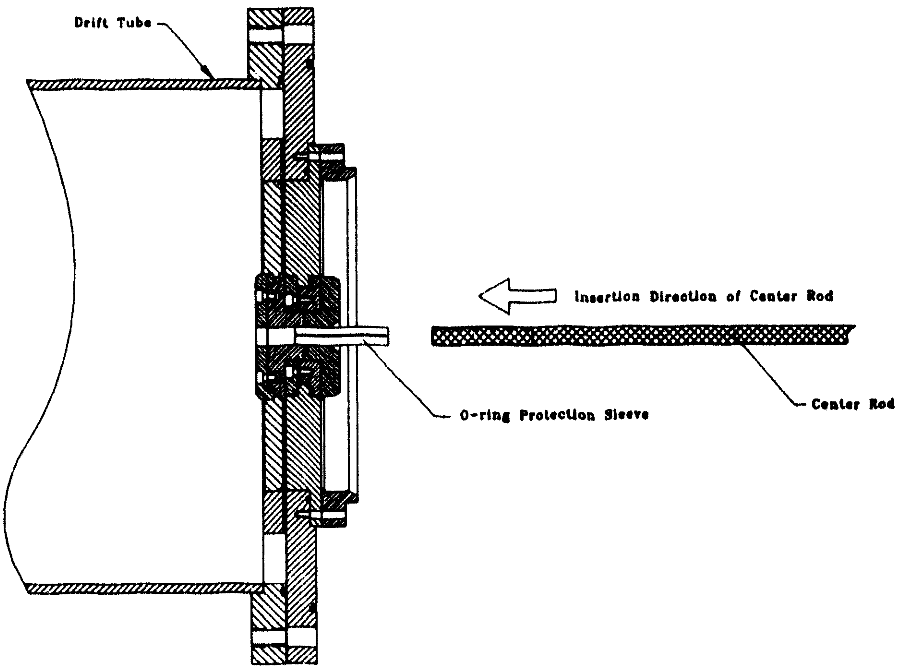


Figure 6: Position of the O-ring Protection Sleeve in the Downstream End Plate Subassembly

55. Attach the Scintillator Centering Feedthru to the Feedthru Adaptor Clamp using four (4) each 8-32 x 3/8" steel socket head screws. **Just start the screws in the threaded holes at this time!**
56. Position the Scintillator so the surface with the aluminum coating is parallel to the Downstream Outer End Plate and facing away from the Downstream End Plate Window.
57. Install the Scintillator in the space between the Scintillator Support Ring and the Scintillator Centering Feedthru, refer to figure 5. (*note- Make sure the Scintillator is firmly seated in the Downstream Outer End Plate Assembly.*)
58. Tighten the four (4) screws in the Scintillator Centering Feedthru using a standard four-hole flange tightening pattern until all screws are snug.
59. Tighten the eight (8) screws in the Scintillator Support Ring using a standard eight-hole flange tightening pattern until all screws are snug.
60. Position the Scintillator Center Clamp so the surface with the four (4) counterbored holes is parallel to the Scintillator and facing away from the Scintillator Centering Feedthru.
61. Install the Scintillator Center Clamp on the Scintillator Centering Feedthru, refer to figure 5.
62. Align the four (4) counterbored holes on the Ø1.70" BC on the Scintillator Center Clamp with the four (4) threaded holes on the Ø1.70" BC on the Scintillator Centering Feedthru.
63. Attach the Scintillator Center Clamp to the Scintillator Centering Feedthru using four (4) each 6-32 x 7/16" steel socket head screws. Tighten the screws using a standard four-hole flange tightening pattern until all screws are snug.
64. Install the Downstream Outer End Plate Assembly on the One-piece Drift Tube's downstream vacuum to air interface flange with the scintillator side facing the drift tube, refer to figure 5.
65. Align the eight (8) thru holes on the Ø12.625" BC on the Downstream Outer End Plate Assembly with the eight (8) threaded holes on the Ø12.625" BC on the downstream vacuum to air interface flange.
66. Attach the Downstream Outer End Plate Assembly to the downstream vacuum to air interface flange using eight (8) each 3/8"-16 x 1-3/8" steel socket head screws. Tighten the screws using a standard eight-hole flange tightening pattern until all screws are snug.
67. Cut a piece of RG-223 coaxial cable ~ 35.7" long.
68. Remove the PVC outer jacket from the cable.
69. Install the stripped RG-223 cable in the Ø11.23" i.d. groove on the Downstream Outer End Plate, refer to figure 5.
70. Position the Current Return Tube, dwg# 3A3315, so the end flange having 16 thru holes is parallel to and facing the Downstream Outer End Plate.
71. Align the larger diameter thru holes on the Current Return Tube flange with the heads of the 3/8" socket head screws that secure the Downstream Outer End Plate Assembly to the One-piece Drift Tube.
72. Install the Current Return Tube on the Downstream Outer End Plate.
73. Secure the Current Return Tube to the Downstream Outer End Plate using eight (8) each 1/4-20 x 3/4" steel socket head screws. Tighten the screws using a standard eight-hole flange tightening pattern until all screws are snug.
74. Insert the O-Ring Protection Sleeve, dwg# 3AXXXX into the i.d. of the Light Pipe Centering Feedthru. Compress the sleeve so that it slides just past the o-ring sandwiched between the Light Pipe Centering Feedthru and the Scintillator Centering Feedthru, refer to figure 6.
75. Insert the threaded end of the Center Rod, dwg# 3A3426, into the i.d. of the O-Ring Protection Sleeve, and slide the Center Rod/Current Return Plate Assembly forward ~ 1ft.

76. Slide the O-Ring Protection Sleeve back toward the Current Return Plate, dwg# 3A3415, and remove the sleeve from the Center Rod.
77. Cut a piece of RG-223 coaxial cable ~ 35.7" long.
78. Remove the PVC outer jacket from the cable.
79. Install the stripped RG-223 cable in the Ø11.23" i.d. groove of the Current Return Plate.
80. Slide the Center Rod/Current Return Plate Assembly forward until the Current Return Plate contacts the Current Return Tube flange.
81. Rotate the Current Return Plate so that the eight (8) 1/4-20 threaded holes on the Ø13.00" BC are aligned with the thru holes on the Current Return Tube and one of the spokes on the Current Return Plate is positioned 90° with respect to the horizon.
82. Attach the Current Return Tube flange to the Current Return Plate using eight (8) each 1/4-20 x 5/8" steel socket head screws. Tighten the screws using a standard eight-hole flange tightening pattern until snug.
83. Attach a 1' extension to a ball driver handle allowing access to the screws on the Light Pipe Centering Feedthru. Tighten the four (4) 6-32 socket head screws on the Light Pipe Centering Feedthru using a standard four-hole flange tightening pattern until all screws are snug.
84. Install one (1) Centering Ring Assembly, dwg# 3A3364, on the Current Return Tube positioned as indicated in figure 7. (*note- Ensure that part # 3A3369 is located on the bottom of the Current Return Tube.*)
85. Lay the Upstream End Plate on a flat surface with the counterbored holes facing down.
86. Install a lubricated Parker #2-138 o-ring in the o-ring groove on the remaining Feedthru Adaptor.
87. Insert the Feedthru Adaptor into the center of the Upstream End Plate with the o-ring facing the end plate. Hold the adaptor in place with one hand.
88. Place the Upstream End Plate on edge.
89. Position the Feedthru Adaptor Clamp so the surface having the four (4) counterbored holes parallel to and facing away from the Upstream End Plate.
90. Insert the Feedthru Adaptor Clamp into the center of the Upstream End Plate, refer to figure 8.
91. Slightly tilt the Upstream End Plate Assembly toward the side with the Feedthru Adaptor while holding the Feedthru Adaptor and the Feedthru Adaptor Clamp.
92. Align the four (4) counterbored holes on the Ø1.70" BC on the Feedthru Adaptor Clamp with the four (4) threaded holes Ø1.70" BC on the Feedthru Adaptor.
93. Secure the Feedthru Adaptor Clamp to the Feedthru Adaptor using four (4) each 6-32 x 5/16" steel socket head screws. Tighten the screws using a standard four-hole flange tightening pattern until all screws are snug. Make certain the feedthru assembly will not rotate in the center of the Upstream End Plate Assembly after the screws have been tightened.
94. Lay the Upstream End Plate Assembly down with the counterbored holes on the end plate facing down.
95. Install a lubricated Parker #2-124 o-ring in the outer o-ring groove on the Upstream End Plate O-Ring Retaining Feedthru.
96. Install a lubricated Parker #2-204 o-ring in the inner o-ring groove on the Upstream End Plate O-Ring Retaining Feedthru.
97. Position the Upstream End Plate O-Ring Retaining Feedthru so the surfaces having the o-rings are parallel to and facing the Feedthru Adaptor.
98. Install the Upstream End Plate O-Ring Retaining Feedthru in the center of the Upstream End Plate Assembly, refer to figure 8.
99. Align the four (4) counterbored holes on the Ø1.80" BC on the Upstream End Plate O-Ring Retaining Feedthru with four (4) threaded holes on the Ø1.80" BC on the Feedthru Adaptor.

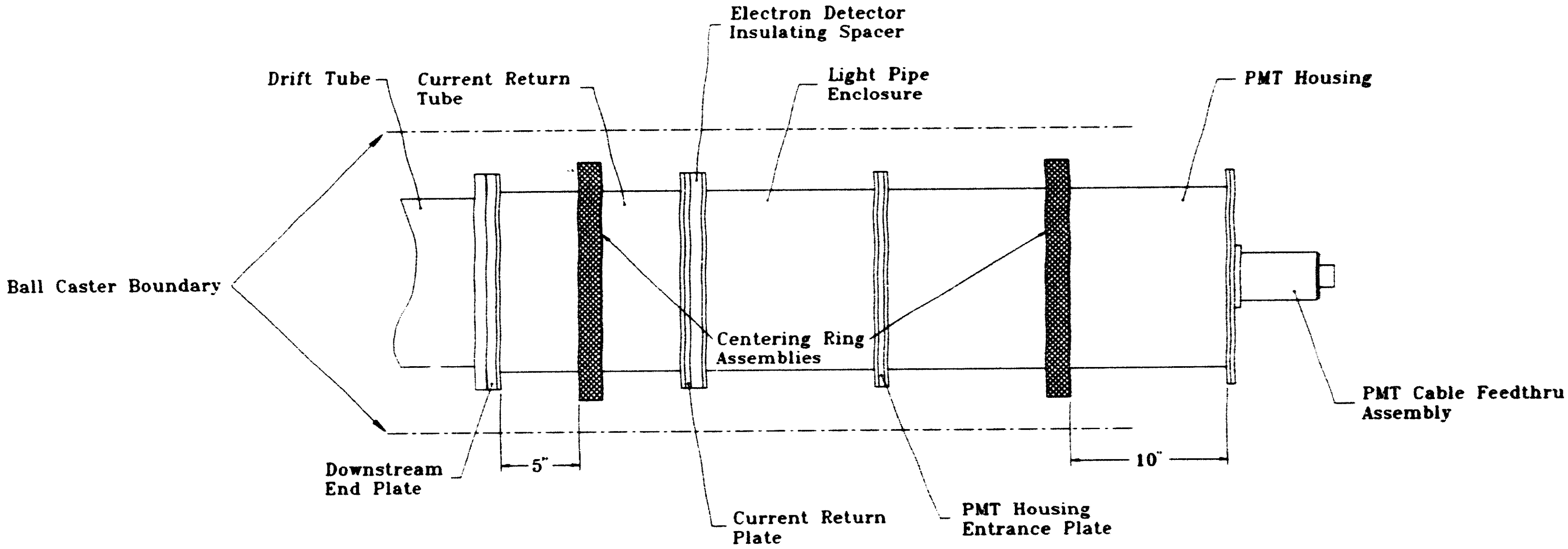
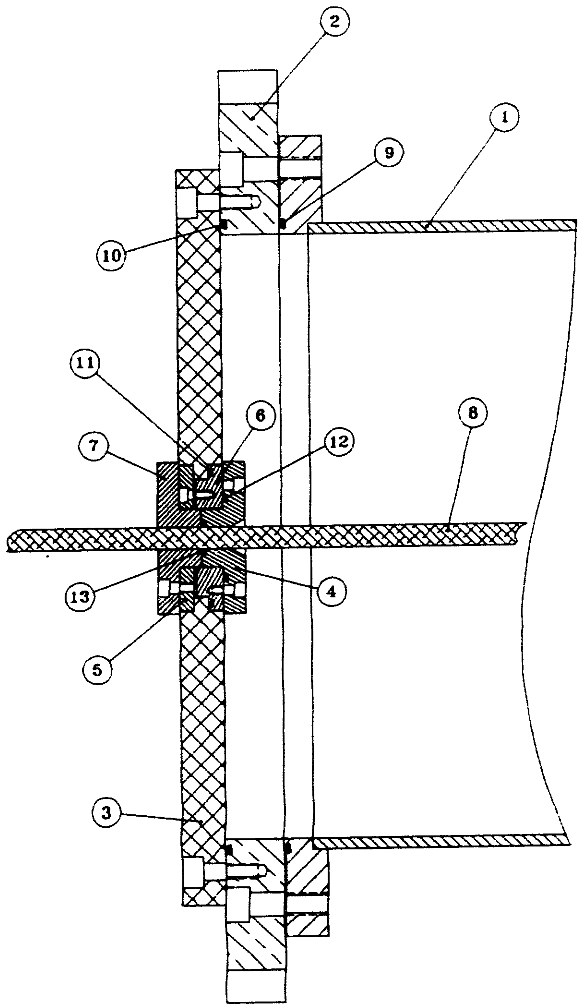


Figure 7: Electron Detector Subassembly

100. Secure the Upstream End Plate O-Ring Retaining Feedthru to the Feedthru Adaptor using four (4) each 6-32 x 5/16" steel socket head screws. Tighten the screws using a standard four-hole flange tightening pattern until all screws are snug.
101. Turn the Upstream End Plate Assembly over and lay the assembly down resting on top of the Upstream End Plate O-Ring Retaining Feedthru.
102. Position the Upstream End Plate O-Ring Compression Clamp so the surface having the four (4) counterbored holes is parallel to and facing away from the Upstream End Plate.
103. Install the Upstream End Plate O-Ring Compression Clamp in the center of the Upstream End Plate Assembly , refer to figure 8.
104. Align the four (4) counterbored holes on the Ø1.70" BC on the Upstream End Plate O-Ring Compression Clamp with the threaded holes on the Ø1.70" BC on the Feedthru Adaptor Clamp.
105. Attach the Upstream End Plate O-Ring Compression Clamp to the Feedthru Adaptor Clamp using four (4) each 8-32 x 3/8" steel socket head screws. **Just start the screws in the threaded holes at this time!**
106. Stand the Upstream End Plate Assembly on edge.
107. Insert the O-Ring Protection Sleeve into the i.d. of the Upstream End Plate O-Ring Compression Clamp. Compress the sleeve so that it slides just past the o-ring sandwiched between the Upstream End Plate O-Ring Compression Clamp and the Upstream End Plate O-Ring Retaining Feedthru.
108. Position the Upstream End Plate Assembly so the surface having the eight (8) counterbored holes on the Ø11.50" BC is parallel to and facing away from the Electrical Ground Connection Plate.
109. Insert the Center Rod into the i.d. of the O-Ring Protection Sleeve and slide the Upstream End Plate Assembly toward the Electrical Ground Connection Plate until the assembly contacts the Electrical Ground Connection Plate.
110. Align the eight (8) counterbored thru holes on the Ø11.50" BC on the Upstream End Plate with the eight (8) threaded holes on the Ø11.50" BC on the Electrical Ground Connection Plate.
111. Attach the Upstream End Plate Assembly to the Electrical Ground Connection Plate using eight (8) each 1/4-20 x 1" steel socket head screws and eight (8) each Ø0.625" o.d. 1/4" screw steel flat washers. Tighten the screws using a standard eight-hole flange tightening pattern until all screws are snug.
112. Slide the O-Ring Protection Sleeve toward the High-Voltage Connection Plate and remove it from the Center Rod.
113. Tighten the four (4) 8-32 socket head screws on the Upstream End Plate O-Ring Compression Clamp using a standard four-hole flange tightening pattern until all screws are snug.
114. Install eight (8) each 3/8-16 x 2" G-10 studs in the eight (8) 3/8" tapped holes on the Current Return Plate. Screw the studs into the Current Return Plate until they bottom out in the hole.
115. Install the Electron Detector Insulating Spacer, dwg# 3A3316 on the G-10 studs protruding from the Current Return Plate.
116. Slide the Electron Detector Insulating Spacer on the G-10 studs until it is flush with the Current Return Plate.
117. Clean all surfaces of the six (6) Light Pipes, dwg# 3A3314, using ethanol or methanol and a clean lint-free cloth. Place them aside in a clean location.
118. Insert the tapered (large) end of one of the Light Pipes into the bottom-most unoccupied pie-shaped slot on the Current Return Plate.
119. Slide the Light Pipe gently toward the Downstream End Plate Window until the tapered end of the Light Pipe contacts the Light Pipe Guide or Light Pipe Centering Feedthru. (*note- Try not to let the Light Pipe drag against the Current Return Plate when sliding as this will lead to scratching of the device resulting in increased transmission losses.*)



Item#	Description/Part Name	Part#
1	Drift Tube, One-Piece	3A3425
2	Plate, Electrical Ground Connection	3A3427
3	End Plate, Upstream	3A3403
4	Adaptor, Feedthru	3A3398
5	Clamp, Adaptor, Feedthru	3A3402
6	Feedthru, O-ring, Retaining, Upstream End Plate	3A3404
7	Clamp, Compression, O-ring Upstream End Plate	3A3401
8	Center Rod	3A3426
9	Parker o-ring	2-275
10	Parker o-ring	2-275
11	Parker o-ring	2-138
12	Parker o-ring	2-124
13	Parker o-ring	2-204

Figure 8: Upstream End Plate Subassembly

120. Adjust the position of the Light Pipe's tapered end so that it can slide into the space between the Light Pipe Guide and the Light Pipe Centering Feedthru. Once the Light Pipe enters this space, slide the Light Pipe toward the Downstream End Plate Window until the Light Pipe bottoms out in the space.
121. Repeat steps 4.1.118 - 4.1.120 for the remaining five (5) Light Pipes.
122. Assemble the Light Pipe Alignment Tool Ring, dwg# 3A3329, using two (2) each 8-32 x 1" steel socket head screws. Tighten the screws until there is a gap of ~ 1/16" between both halves of the Light Pipe Alignment Tool Ring.
123. Slide the Light Pipe Alignment Tool Ring onto the o.d. of the six (6) Light Pipes until it is positioned ~ 6" from the Current Return Plate.
124. Position the Light Pipe Enclosure, dwg# 3A3317, so the end flange with the thru holes for the 3/8" G-10 studs is facing the Current Return Plate.
125. Install the Light Pipe Enclosure on the 3/8" G-10 studs protruding from the Electron Detector Insulating Spacer.
126. Attach the Light Pipe Enclosure to the G-10 studs using eight (8) each 3/8-16 square G-10 nuts. Tighten the nuts until snug. (*caution- Do not overtighten the G-10 nuts as stripping of the stud threads will result.*)
127. Screw an additional G-10 nut on each of the G-10 studs to act as lock nuts. Tighten the nuts until snug. (*caution- Do not overtighten the G-10 nuts as stripping of the stud threads will result.*)
128. Position the PMT Housing Entrance Plate, dwg# 3A3318, so one of the three (3) threaded holes on the Ø9.0" BC is at bottom dead center.
129. Install the PMT Housing Entrance Plate on the six (6) Light Pipes and slide it toward the Current Return Plate until it is flush with the flange on the Light Pipe Enclosure.
130. Attach the Light Pipe Enclosure to the PMT Housing Entrance Plate using eight (8) each 1/4-20 x 5/16" steel socket head screws. Start the first screw into the top thru hole on the Light Pipe Enclosure flange. Skip a thru hole on the Light Pipe Enclosure flange and start the second screw. Repeat the above step for the remaining six (6) screws. Tighten the eight (8) screws using a standard eight-hole flange tightening pattern until all screws are snug.
131. Install the Light Pipe Grouping Ring, dwg# 3A3424, on the six (6) Light Pipes.
132. Slide the Light Pipe Grouping Ring toward the PMT Housing Entrance Plate until it is in contact with the entrance plate.
133. Clean the ends of the Light Pipes using ethanol or methanol and a clean lint-free cloth.
134. Apply a layer of Nye® Optical Coupling Gel ~ 1/16" thick to the end of the Light Pipes using a tongue depressor or similar item. Make sure the coupling gel is uniformly spread across the end of each Light Pipe.
135. Clean all surfaces of the Sum Coupler, dwg# 3A3353, using ethanol or methanol and a clean lint-free cloth.
136. Apply a layer of Nye® Optical Coupling Gel ~ 1/16" thick to the surface of the largest diameter end of the Sum Coupler using a tongue depressor or similar item. Make sure the coupling gel is uniformly spread across the entire end surface except for the region that is elevated at the center.
137. Position the coupler so the largest diameter end is parallel to and faces the PMT Housing Entrance Plate.
138. Insert the elevated region on the large end of the coupler in the i.d. of the Light Pipes.
139. Slide the Sum Coupler toward the PMT Housing Entrance Plate until it is flush with the end of the Light Pipes.
140. Rotate the coupler gently to allow the coupling gel on the coupler to mix with the coupling gel on the Light Pipes.
141. Position the Sum Coupler Securing Clamp, dwg# 3A3320, so the largest i.d. faces the Sum Coupler.

142. Align the six (6) thru holes on the Ø7.25" BC on the Sum Coupler Securing Clamp with the six (6) threaded holes on the Ø7.25" BC on the PMT Housing Entrance Plate
143. Attach the securing clamp to the PMT Housing Entrance Plate using six (6) each 1/4-20 x 1-3/4" steel socket head screws and six (6) each Ø0.625" o.d. 1/4" screw steel flat washers. Tighten the screws using a standard six-hole flange tightening pattern. (*note- Since the Sum Coupler Securing Clamp is fabricated from Teflon®, the securing clamp can easily flex when force is applied by the screws. It is, therefore, necessary to tighten the securing clamp in gradual steps to prevent excessive distortion to the part. The screws on the securing clamp should be tightened just enough so there are no noticeable bubbles in the coupling gel at the Light Pipe-Sum Coupler interface.*)
144. Clean the small end of the Sum Coupler using ethanol or methanol and a clean lint-free cloth.
145. Assemble the ND Filter Holder Assembly as per figure 9 if it is not already assembled.
146. Install two (2) 1/4-20 hex head nuts on the end opposite the end with the screwdriver slot of each of the three (3) PMT Mounting Rods, dwg# 3A3319.
147. Screw the nuts onto the PMT Mounting Rod so there is ~ 3/8" thread between the bottom nut and the end of the rod.
148. Hold the bottom nut in place with a 7/16" wrench while tightening the upper nut against the bottom nut.
149. Install one (1) PMT Mounting Rod in the threaded hole at bottom dead center of the Ø9.0" BC on the PMT Housing Entrance Plate with the nuts facing the entrance plate. Tighten the rod until snug.
150. Install one (1) of the PMT Mounting Rods in one of the threaded holes that is 120° away from the PMT Mounting Rod in step 4.1.149. Tighten the rod until snug.
151. Install the remaining PMT Mounting Rod in the other threaded hole that is 120° away from the PMT Mounting Rod in step 4.1.149. Tighten the rod until snug.
152. Position the ND Filter Holder Assembly so the nontapered i.d is parallel to and facing the PMT glass input window.
153. Insert the ND Filter Holder Assembly into the i.d. of the PMT shield.
154. Slide the ND Filter Holder Assembly toward the PMT glass input window until it contacts the plastic PMT alignment ring.
155. Install the PMT/ND Filter Holder Assembly on the PMT Mounting Rods.
156. Slide the assembly toward and onto the Sum Coupler.
157. Install one (1) 1/4" screw flat washer and one (1) 1/4-20 wing nut on each of the PMT Mounting Rods. **Screw the wing nuts onto the PMT Mounting Rods until they just contact the plastic support bracket on the PMT.**
158. Rotate the ND Filter Holder Assembly so the ND Filter Frame can be removed through the
top two (2) PMT Mounting Rods.
159. Tighten the 1/4-20 wing nuts on the PMT Mounting Rods just enough to prevent the easy rotation of the ND Filter Holder. (*note- The wing nuts securing the PMT Assembly should not be overtightened as breakage of the PMT envelope may result, destroying the tube!!!*)
160. Position the PMT Housing, dwg# 3A3322, so the end flange nearest the ND filter access port is parallel to and facing the PMT, and the ND filter access port is located at top dead center.
161. Slide the PMT Housing over the PMT Assembly and PMT Mounting Rods toward the PMT Housing Entrance Plate.
162. Align the thru holes on the PMT Housing end flange with the threaded holes on the PMT Housing Entrance Plate.

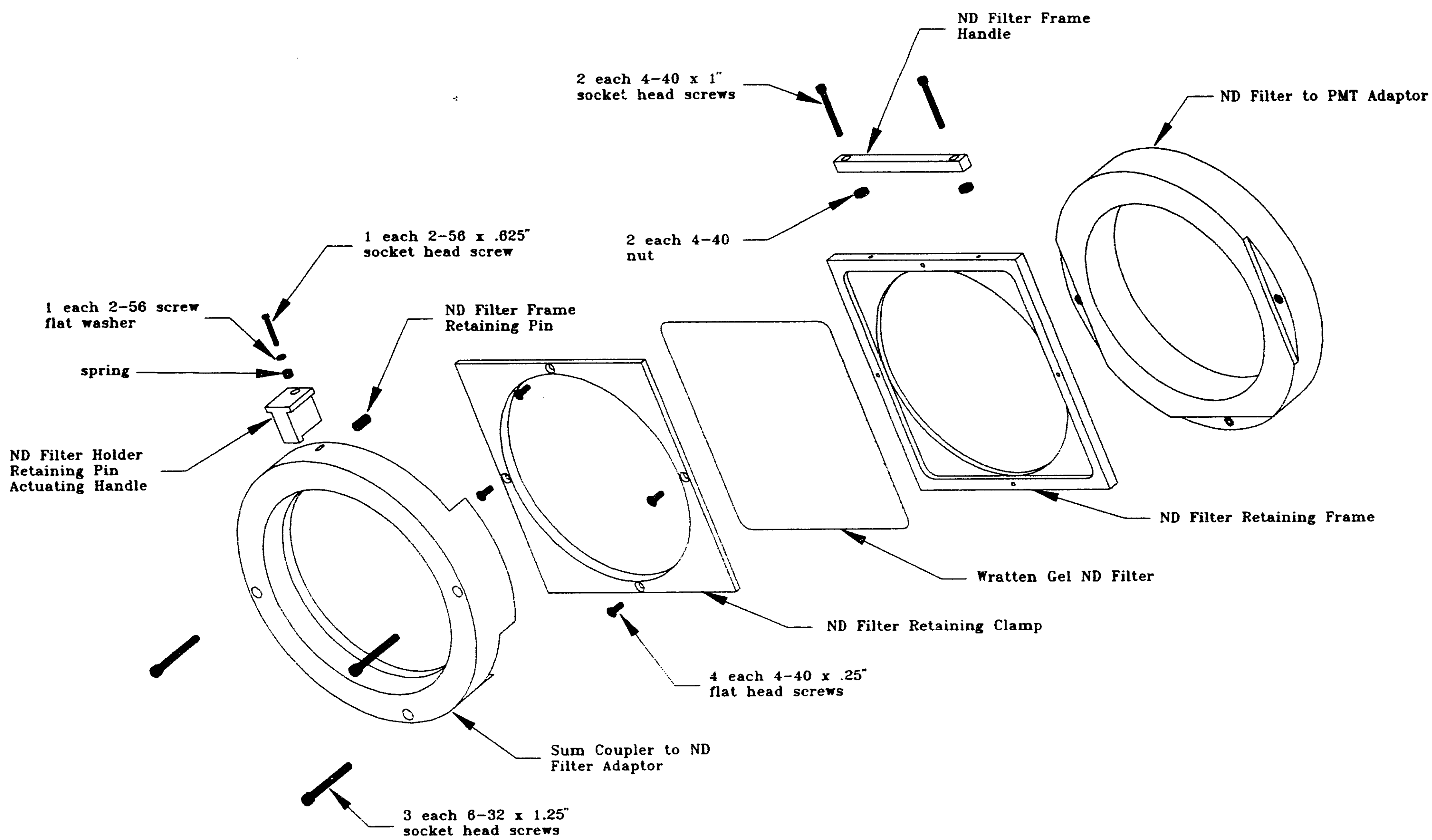


Figure 9: Neutral Density Filter Holder Assembly

163. Attach the PMT Housing to the PMT Housing Entrance Plate using eight (8) each 1/4-20 x 5/8" steel socket head screws and eight (8) each Ø0.625" o.d. 1/4" screw steel flat washers. Tighten the screws using a standard eight-hole flange tightening pattern until all screws are snug.
164. Stand the PMT Housing End Plate, dwg# 3A3422, on edge and positioned close to the end flange on the PMT Housing.
165. Align the eight (8) thru holes on the Ø13.00" BC on the PMT Housing End Plate with the eight (8) threaded holes on the Ø13.00" BC on the end flange of the PMT Housing.
166. Attach the PMT Housing End Plate to the PMT Housing using eight (8) each 1/4-20 x 1/2" steel socket head screws and eight (8) each Ø0.625" o.d. 1/4" screw steel flat washers. Tighten the screws using a standard eight-hole flange tightening pattern until all screws are snug.
167. Attach a 5-6' RG223 cable terminated in type-N connectors on both ends to the type-N output connector on the PMT.
168. Attach a 5-6' RG223 cable terminated with an SHV connector on one end and a type-HN connector on the other end to the SHV input connector on the PMT.
169. Position the PMT Cable Feedthru Tube, dwg# 3A3418, so the flange end is parallel to and facing the PMT Housing End Plate.
170. Insert the ends of the two (2) PMT coaxial cables through the hole in the center of the cable feedthru tube.
171. Align the four (4) thru holes on the Ø3.50" BC on the cable feedthru tube flange with the four (4) threaded holes on the Ø3.50" BC on the PMT Housing End Plate.
172. Attach the cable feedthru tube to the PMT Housing End Plate using four (4) each 1/4-20 x 5/8" steel socket head screws. Tighten the screws using a standard four-hole flange tightening pattern until all screws are snug.
173. Fill the cable feedthru opening on the cable feedthru tube with an opaque putty, preferably Apiezon type-Q, making a light tight seal for the PMT.
174. Cut a piece of Ø1 1/2" tinned copper braid, i.e. Alpha #2182, ~ 4' long.
175. Slide the two (2) PMT coaxial cables thru the i.d. if the tinned copper braid.
176. Slide the Ø1 1/2" braid over the nipple extending from end of the cable feedthru tube.
177. Attach the Ø1 1/2" braid to the nipple using a radiator/cable clamp or a nylon cable tie.
178. Cut two (2) pieces of Ø1" tinned copper braid, i.e. Alpha #2178, ~ 1 long.
179. Slide each of the PMT coaxial cables through a piece of the Ø1" braid.
180. Attach the braid to the stationary part of the each connector using a radiator/cable clamp or a nylon cable tie.
181. Slide the two (2) free ends of the Ø1" braid inside of the Ø1 1/2" braid.
182. Attach the Ø1 1/2" braid to the Ø1" braid using a nylon cable tie.
183. Tape or tie the PMT coaxial cables to the PMT Housing so they are not damaged during spectrometer installation in the radiation shield.
184. Install one (1) Centering Ring Assembly, dwg# 3A3364, on the PMT Housing positioned as indicated in figure 7. (*note- Ensure that part # 3A3369 is located on the bottom of the Current Return Tube.*)
185. Attach the Current Transformer Mounts, dwg# 3A3407, to the Pearson Current Transformer using four (4) each 1/-20 x 1" steel socket head screws. Make sure the thru hole on the bottom of the mount faces inboard toward the current transformer output connector, refer to figure 10.
186. Connect a UHF male to BNC female adaptor to the Pearson Current Transformer output connector.
187. Connect a BNC elbow adaptor to the UHF to BNC adaptor.
188. Connect a BNC 10X-50Ω in-line attenuator on the BNC elbow.
189. Position the Pearson Current Transformer so the electron direction arrow on the label on top of the current transformer is facing the Upstream End Plate.

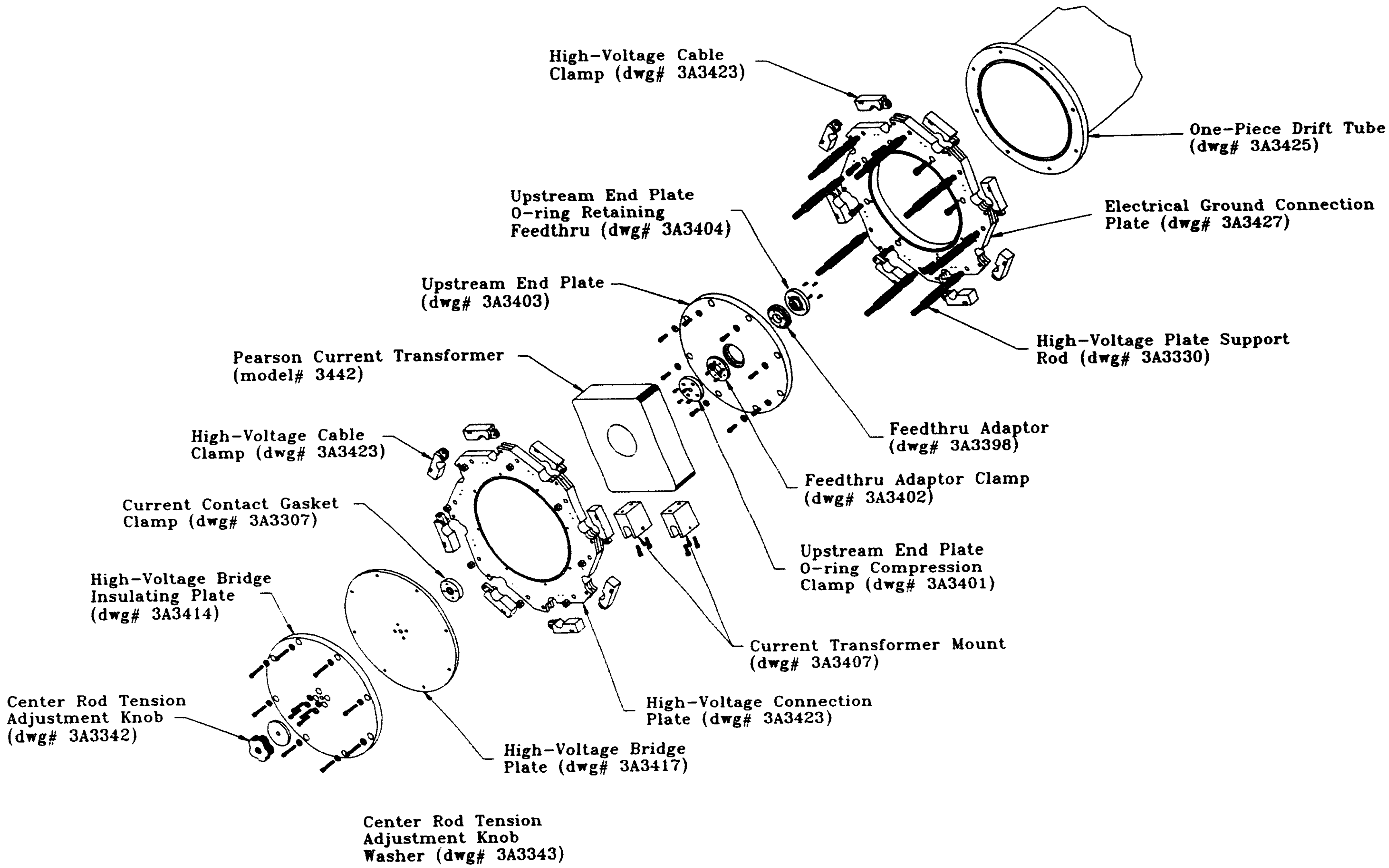


Figure 10: Exploded View of the High-Voltage End of the TPCS

190. Insert the Pearson Current Transformer into the space between the High-Voltage Connection Plate and the Electrical Ground Connection Plate. The grooves on the Current Transformer Mounts should slide over the two (2) High-Voltage Plate Support Rods on the bottom.
191. Secure the Pearson Current Transformer to the High-Voltage Plate Support Rods by screwing in two (2) 1/4-20 x 1-1/2" steel socket head screws into the holes located at the bottom of the Current Transformer Mounts [one (1) screw per Current Transformer Mount]. Finger tighten the screws.
192. Connect a 14' long RG223 cable to the in-line attenuator attached to the Pearson Current Transformer. (*note- The RG223 cable should be terminated with a BNC male connector on end and a type-N male connector on the other end.*)
193. Insert the four (4) 20' long RG220 coaxial cables in the slots on the Electrical Ground Connection Plate and the High-Voltage Connection Plate located at positions 45°, 135°, 225°, and 315° (0° referenced on the horizontal and angles are taken as positive in the counterclockwise direction facing the High-Voltage Connection Plate). (*note- The end of the RG220 coaxial cable **without** a nut attached to the shield is the end that connects to the Electrical Ground Connection Plate and the High-Voltage Connection Plate.*)
194. Clamp the coaxial cables to the Electrical Ground Connection Plate and the High-Voltage Connection Plate by engaging the Camloc® latches. Adjust the latches as required to ensure positive clamping of the cables to the connection plates.
195. Secure the RG220 cables and the RG223 cable from the Pearson Current Transformer to the spectrometer using cable ties at ~ four (4) places along the length of the spectrometer.
196. Cut a piece of RG223 ~ 2.36" long.
197. Remove the PVC outer jacket from the cable.
198. Stand the High Voltage Bridge Plate, dwg# 3A3417, on edge.
199. Insert a 12" long Ø3/8" rod through the hole located in the center of the High Voltage Bridge Plate with ~ equal lengths of the rod protruding from both sides of the plate.
200. Wrap the 2.36" long piece of RG223 around the Ø3/8" rod close to the tapered side of the thru hole on the High Voltage Bridge Plate.
201. Position the Current Contact Gasket Clamp, dwg# 3A3307, so the side with the elevated surface is parallel to and facing the surface on the High Voltage Bridge Plate with the tapered i.d.
202. Slide the Current Contact Gasket Clamp onto the Ø3/8" rod protruding from the High Voltage Bridge Plate until the elevated surface of the Current Contact Gasket Clamp contacts the RG223.
203. Align the four (4) threaded holes on the Ø1.50" BC on the Current Contact Gasket Clamp with the thru holes located on the Ø1.50" BC on the High Voltage Bridge Plate.
204. Attach the High Voltage Bridge Plate to the Current Contact Gasket Clamp using four (4) 1/4-20 x 1" steel socket head screws. Tighten the screws using a standard four-hole flange tightening pattern until the Current Contact Gasket Clamp is flush with the High Voltage Bridge Plate or as close to flush as possible. (*note- When initially tightening the screws, it will probably be necessary to push the ends of the RG223 together using the tip of a common screwdriver. This will be necessary until the RG223 starts to feed into the tapered i.d. on the High Voltage Bridge Plate and conforms to the tapered surface.*)
205. Remove the four (4) screws securing the Current Contact Gasket Clamp to the High Voltage Bridge Plate.
206. Remove the Ø3/8" rod from the High Voltage Bridge Plate and place the Current Contact Gasket Clamp and RG223 aside.
207. Cut a piece of RG223 coaxial cable ~ 35.4" long.
208. Remove the PVC outer jacket from the RG223 cable.
209. Insert the stripped RG223 cable in the Ø11.12" i.d. current contact gasket groove on the High-Voltage Connection Plate.

210. Stand the High Voltage Bridge Plate and the High Voltage Bridge Insulating Plate, dwg# 3A3414, on edge next to one another.
211. Position the High Voltage Bridge Insulating Plate so the surface without the counterbored holes is parallel to and facing the surface of the High Voltage Bridge Plate without the tapered i.d.
212. Align the eight (8) and four (4) hole bolt circles on the High Voltage Bridge Insulating Plate with the eight and four hole bolt circles on the High Voltage Bridge Plate.
213. Insert a 12" long Ø3/8" rod through the holes located in the center of the High Voltage Bridge Insulating Plate and the High Voltage Bridge Plate with ~ equal lengths of the rod protruding from both sides of the plates.
214. Slide the RG223 current gasket, that conforms to the tapered hole in the High Voltage Bridge Plate, onto the Ø3/8" rod protruding from the surface of the High Voltage Bridge Plate having the tapered hole.
215. Slide the Current Contact Gasket Clamp onto the Ø3/8" rod protruding from the surface of the High Voltage Bridge Plate having the tapered hole, with the elevated side of the Current Contact Gasket Clamp facing the High Voltage Bridge Plate, until it contacts the RG223.
216. Align the four (4) threaded holes on the Ø1.50" BC on the Current Contact Gasket Clamp with the thru holes located on the Ø1.5" BC on the High Voltage Bridge Plate.
217. Attach the High Voltage Bridge Insulating Plate and the High Voltage Bridge Plate to the Current Contact Gasket Clamp using four (4) each 1/4-20 x 1-1/4" steel socket head screws and four (4) each Ø0.625" o.d. 1/4" screw steel flat washers. Tighten the screws until there is a gap of ~ .125" between the High Voltage Bridge Plate and the Current Contact Gasket Clamp.
218. Remove the Ø3/8" rod from the High Voltage Bridge Insulating Plate/High Voltage Bridge Plate Assembly.
219. Position the High Voltage Bridge Insulating Plate/High Voltage Bridge Plate Assembly so the Current Contact Gasket Clamp is facing the Upstream End Plate.
220. Insert the Center Rod into the hole in the center of the Current Contact Gasket Clamp.
221. Slide the High Voltage Bridge Insulating Plate/High Voltage Bridge Plate Assembly toward the Upstream End Plate until it contacts the High-Voltage Connection Plate.
222. Align the eight (8) thru holes on the Ø12.00" BC on the High Voltage Bridge Insulating Plate/High Voltage Bridge Plate Assembly with the eight (8) threaded holes on the Ø12.00" BC on the High-Voltage Connection Plate.
223. Attach the High Voltage Bridge Insulating Plate/High Voltage Bridge Plate Assembly to the High-Voltage Connection Plate using eight (8) each 1/4-20 x 1-1/2" steel socket head screws and eight (8) each Ø0.625" o.d. 1/4" screw steel flat washers. Tighten the screws using a standard eight-hole flange tightening pattern until snug.
224. Tighten the four (4) screws securing the Current Contact Gasket Clamp to the High Voltage Bridge Insulating Plate/High Voltage Bridge Plate Assembly using a standard four-hole flange tightening pattern until the Current Contact Gasket Clamp is flush with the High Voltage Bridge Plate or as close as possible.
225. Install the Center Rod Tension Adjustment Knob Washer, dwg# 3A3343, on the Center Rod protruding from the High Voltage Bridge Insulating Plate. Slide the Center Rod Tension Adjustment Knob Washer toward the High Voltage Bridge Insulating Plate until the surfaces make contact.
226. Position the Center Rod Tension Adjustment Knob, dwg# 3A3342, so the Ø1.5" o.d. end is parallel to and facing the High Voltage Bridge Insulating Plate.
227. Screw the Center Rod Tension Adjustment Knob on the Center Rod until it contacts the Center Rod Tension Adjustment Knob Washer. Tighten the Center Rod Tension Adjustment Knob until it is hand tight, removing the droop from the Center Rod.
228. Clean the flange surface and the o-ring groove on the drift tube collimator port using ethanol or methanol and a clean lint-free cloth.

229. Install a lubricated Parker #2-238 o-ring in the captive o-ring groove on the collimator port flange.
230. Clean all surfaces of the Collimator Port Vacuum Window, dwg# 3A3311, using ethanol or methanol and a clean lint-free cloth.
231. Clean all surfaces of the Collimator Shielded Port Insulating Adaptor Ring, dwg# 3A3357, using ethanol or methanol and a clean lint-free cloth.
232. Place the Collimator Shielded Port Insulating Adaptor Ring on a clean flat surface with the recessed side facing down.
233. Apply a very thin film of vacuum grease to the surface between the six (6) thru holes and the edge of the Collimator Port Vacuum Window. Apply the vacuum grease to only one side of the Collimator Port Vacuum Window. (*note- The film of vacuum grease allows for temporary adhesion of the Collimator Port Vacuum Window to the Collimator Shielded Port Insulating Adaptor Ring during assembly.*)
234. Lay the Collimator Port Vacuum Window on top of the Collimator Shielded Port Insulating Adaptor Ring with the side having the film of vacuum grease facing the Collimator Shielded Port Insulating Adaptor Ring.
235. Align the six (6) thru holes on the Collimator Port Vacuum Window with the six (6) thru holes on the Collimator Shielded Port Insulating Adaptor Ring.
236. Position the Collimator Shielded Port Insulating Adaptor Ring/Collimator Port Vacuum Window Assembly so the Collimator Port Vacuum Window is parallel to and facing the collimator port flange.
237. Align the six (6) thru holes on the Collimator Shielded Port Insulating Adaptor Ring/Collimator Port Vacuum Window Assembly with the six (6) threaded holes on the collimator port flange.
238. Attach the Collimator Shielded Port Insulating Adaptor Ring/Collimator Port Vacuum Window Assembly to the collimator port flange using six (6) each 1/4-20 x 3/4" nylon flat head screws. Tighten the screws using a standard six-hole flange tightening pattern until the Collimator Shielded Port Insulating Adaptor Ring/Collimator Port Vacuum Window is flush with the collimator port flange. (*note- Do not overtighten the nylon screws as failure of the screw threads may result.*)
239. Screw the Center Rod Insulating End Cap, dwg# 3A3441, onto the end of the Center Rod.

4.2 Initial Radiation Shield Assembly

This procedure details the steps required to assemble the three (3) main TPCS Radiation Shield Modules. It is assumed that each module is loaded onto its respective cart, and the casters on the carts are aligned with the edges of the cart that are parallel to the axis of the Radiation Shield Module. (*note- Each of the Radiation Shield Modules weighs ~ 7tons; therefore, positioning a module as called for in a step can be a nontrivial task.*)

1. Place Radiation Shield Module One (RSM1), dwg# 3A3345, in a location close to the accelerator having an unobstructed line-of-sight between RSM1 and the source of the X-rays. (*note- The completed TPCS Radiation Shield Assembly occupies a space having dimensions of ~ 4' x 12' and the TPCS Capacitor Bank occupies a space having dimensions of ~ 3 1/2' x 5'. Ensure sufficient space is allocated to accommodate both the TPCS Radiation Shield Assembly and the TPCS Capacitor Bank "footprints" as well as sufficient space around the Radiation Shield Assembly to maneuver the RBC2000 during loading and unloading of Radiation Shield Hardware.*)
2. Position RSM1 so the thickest section of the shield is toward the X-ray source.

3. Turn the two (2) casters on the RSM1 Cart that are on the side opposite the X-ray source 90° using the TPCS Cart Caster Positioning Tee Handles as required. (*note- This locks RSM1 in place so it does not move during the coupling of the remaining Radiation Shield Modules.*)
4. Position Radiation Shield Module Two (RSM2), dwg# 3A3346, so the thickest section of the shield is toward the X-ray source. This will make the end of RSM2 having the recessed step face the end of RSM1 having the protruding step.
5. Align RSM2 to RSM1 so the recessed step in RSM2 mates with the protruding step on RSM1. (*note- This step will involve translating RSM2 so that it is in line with RSM1. A come along-type device anchored to the base of RSM1's Cart and attached to RSM2's Cart 's base can be used to pull RSM2 toward RSM1. Direction changes for RSM2 can be made by adjusting the position of the casters on RSM2's Cart using the TPCS Cart Caster Positioning Tee Handles as required.*)
6. Pull RSM2 toward RSM1, using the come along-type device, until the protruding step on RSM1 fully mates with the recessed step in RSM2.
7. Join the Ø40.0" o.d. flanges of RSM1 and RSM2 together using 12 each 1/2-13 x 2" steel hex head bolts, 24 each Ø1.25" o.d. 1/2" bolt steel flat washers, and 12 each 1/2-13 hex nuts. There should be a washer between the head of the bolt and the mating flange on RSM1 and between the nut and the mating flange on RSM2. Tighten the bolt/nut combination until snug and the mating flanges are flush with one another.
8. Turn the two (2) casters on the RSM2 Cart that are on the side opposite the X-ray source 90° using the TPCS Cart Caster Positioning Tee Handles as required. (*note- This locks RSM1/RSM2 in place so they do not move during the coupling of the remaining Radiation Shield Module.*)
9. Position Radiation Shield Module Three (RSM3), dwg# 3A3347, so the thickest section of the shield is toward the X-ray source. This will make the end of RSM3 having the recessed step face the end of RSM2 having the protruding step.
10. Align RSM3 to RSM2 so the recessed step in RSM3 mates with the protruding step on RSM2. (*note- This step will involve translating RSM3 so that it is in line with RSM1/RSM2. A come along-type device anchored to the base of RSM2's Cart and attached to RSM3's Cart 's base can be used to pull RSM3 toward RSM1/RSM2. Direction changes for RSM3 can be made by adjusting the position of the casters on RSM3's Cart using the TPCS Cart Caster Positioning Tee Handles as required.*)
11. Pull RSM3 toward RSM2, using the come along-type device, until the protruding step on RSM2 fully mates with the recessed step in RSM2.
12. Join the Ø40.0" o.d. flanges of RSM2 and RSM3 together using 12 each 1/2-13 x 2" steel hex head bolts, 24 each Ø1.25" o.d. 1/2" bolt steel flat washers, and 12 each 1/2-13 hex nuts. There should be a washer between the head of the bolt and the mating flange on RSM2 and between the nut and the mating flange on RSM3. Tighten the bolt/nut combination until snug and the mating flanges are flush with one another.
13. Position the RSM3 Liner, dwg# 3A3373, so the end nearest the semi-circular cutouts is facing the end of RSM3.
14. Curl the RSM3 Liner lengthwise into a cylinder with the longest edges overlapping ~ 2".
15. Insert the end of the liner nearest the semi-circular cutouts into the i.d. of RSM3 with the semi-circular facing skyward.
16. Slide the liner into RSM3 until the semi-circular cutouts are aligned horizontally with the ND Filter Access Port on RSM3.
17. Rotate the liner within RSM3 until one (1) of the semi-circular cutouts matches the i.d. of the hole on the NF Filter Access Port on RSM3.
18. Slide inside of RSM3 on your back until your head is near the joint between RSM2 and RSM3.
19. Reach up and grab hold of the end of the RSM3 Liner having one hand on each side of the overlapping sheet.
20. Bend the liner edges toward the center of RSM?.

21. Bring the edges of the liner together forming a V-shape.
22. Release the ends of the liner allowing it to conform to the i.d. of RSM3 providing a nonoverlapping seam on the top of the i.d. of RSM3. (*note- It will probably be necessary to bend the RSM3 Liner into a V-shape at several locations along the length of RSM3 before the RSM3L seats into place with a nonoverlapping seam. There may be sections that do not fully seat into place when the RSM3L is released from the V-shape. These sections can be seated by tapping the section not fully seated using the side of your hand as a soft mallet to pound the edges into place.*)
23. Curl the RSM2 Liner, dwg# 3A3372, lengthwise into a cylinder with the longest edges overlapping ~ 2".
24. Insert one end of the RSM2 Liner into the i.d. of RSM1.
25. Slide the RSM2 Liner into RSM1 until the far end contacts the end of RSM3 Liner.
26. Rotate the RSM2 Liner within RSM2 until the overlapping edges are at the top of the i.d. of RSM2.
27. Slide inside of RSM1 on your back until your head is near the joint between RSM2 and RSM3.
28. Reach up and grab hold of the end of the RSM2 Liner having one hand on each side of the overlapping sheet.
29. Bend the RSM2 Liner edges toward the center of RSM2.
30. Release the ends of the RSM2 Liner allowing it to conform to the i.d. of RSM2 providing a nonoverlapping seam on the top of the i.d. of RSM2. (*note- It will probably be necessary to bend the RSM2 Liner into a V-shape at several locations along the length of RSM2 before the liner seats into place with a nonoverlapping seam. There may be sections that do not fully seat into place when the liner is released from the V-shape. These sections can be seated by tapping the section not fully seated using the side of your hand as a soft mallet to pound the edges into place.*)
31. Position the RSM1 Liner, dwg# 3A3371, so the end nearest the semi-circular cutouts is facing the end of RSM1.
32. Curl the RSM1 Liner lengthwise into a cylinder with the longest edges overlapping ~ 2".
33. Insert the end of the RSM1 Liner nearest the semi-circular cutouts into the i.d. of RSM1 with the semi-circle formed at the edge of the overlap facing skyward.
34. Slide the RSM1 Liner into RSM1 i.d. until the semi-circular cutouts are aligned horizontally with the Vacuum Access, Target Foil Access, and Collimator Ports.
35. Rotate the RSM1 Liner within RSM1 until the semi-circular cutouts for the Vacuum Access and Collimator Ports match the holes for the Vacuum Access and Collimator Ports on RSM1, or as close as possible.
36. Slide inside of RSM1 on your back until your head is near the joint between RSM1 and RSM2.
37. Reach up and grab hold of the end of the RSM1 Liner having one hand on each side of the overlapping sheet.
38. Bend the RSM1 Liner edges toward the center of RSM1.
39. Bring the edges of the RSM1 Liner together forming a V-shape.
40. Release the ends of the RSM1 Liner allowing it to conform to the i.d. of RSM1 providing a nonoverlapping seam on the top of the i.d. of RSM1. (*note- It will probably be necessary to bend the RSM1 Liner into a V-shape at several locations along the length of RSM1 before the liner seats into place with a nonoverlapping seam. There may be sections that do not fully seat into place when the RSM3 Liner is released from the V-shape. These sections can be seated by tapping the section not fully seated using the side of your hand as a soft mallet to pound the edges into place.*)
41. Position the Hydraulic Fluid Containment Pan, dwg# 3A3442, near the side of the RSM3 Spectrometer Cart with the open side of the pan facing skyward, and the longest edge of the pan parallel to the edge of the RSM3 Spectrometer Cart.

42. Insert the edge of the Hydraulic Fluid Containment Pan nearest the RSM3 Spectrometer Cart into the space between RSM3 and the RSM3 Spectrometer Cart. (*note- When seated properly, the bottom corners of the Hydraulic Fluid Containment Pan will rest on top of the RSM3 Spectrometer Cart caster mounting plates and the bottom of the Hydraulic Fluid Containment Pan will be parallel to the floor.*)
43. Position the Vacuum Pump Oil Containment Pan, dwg# 3A3443, near the side of the RSM2 Spectrometer Cart with the open side of the containment pan facing skyward, and the longest edge of the containment pan parallel to the edge of the RSM2 Spectrometer Cart.
44. Insert the edge of the containment pan nearest the RSM2 Spectrometer Cart into the space between RSM2 and the RSM2 Spectrometer Cart. (*note- When seated properly, the bottom corners of the Vacuum Pump Oil Containment Pan will rest on top of the RSM2 Spectrometer Cart caster mounting plates and the bottom of the containment pan will be parallel to the floor.*)
45. Place the Electrohydraulic Pump in the High-Voltage Connection Plate.
46. Install the Hydraulic Actuator on RSM3 as shown in figure 11.
47. Connect the hydraulic hoses from the Hydraulic Actuator to the Electrohydraulic Pump connectors.
48. Plug the 120VAC, 20A power cord, from the Electrohydraulic Pump, in the wall receptacle.
49. Place the Vacuum Roughing Pump in the Vacuum Pump Oil Containment Pan with the inlet port facing toward RSM1.
50. Clean the KF-25 inlet port flange on the D25B Vacuum Roughing Pump using ethanol or methanol and a clean lint-free cloth.
51. Clean a KF-40 centering ring/o-ring assembly using ethanol or methanol and a clean lint-free cloth.
52. Lubricate the o-ring on the centering ring/o-ring assembly using vacuum grease, preferably Apiezon type L.
53. Clean a KF-25 centering ring/o-ring assembly using ethanol or methanol and a clean lint-free cloth.
54. Lubricate the o-ring on the centering ring/o-ring assembly using vacuum grease, preferably Apiezon type L.
55. Clean a KF-40 to KF-25 reducing adaptor using ethanol or methanol and a clean lint-free cloth.
56. Clean the KF-40 flanges on the ends of the flexible vacuum hose that will be used to connect the D25B Vacuum Roughing Pump to the TMP1000 Turbomolecular Vacuum Pump.
57. Connect the KF-25 side of the KF-40 to KF-25 reducing adaptor to the KF-25 inlet port flange on the D25B Vacuum Roughing Pump using a KF-25 centering ring/o-ring assembly and a KF-25 clamp.
58. Connect the KF-40 side of the KF-40 to KF-25 reducing adaptor to one end of the flexible vacuum hose using a KF-40 centering ring/o-ring assembly and a KF-40 clamp.
59. Insert the Eight Cable Shield, dwg# 3A3386, into the end of RSM3.
60. Align the four (4) thru holes on the four (4) mounting brackets of the Eight Cable Shield with the four (4) threaded holes on the bottom of the i.d. of RSM3 near the end flange.
61. Attach the Eight Cable Shield to RSM3 using four (4) each 1/4-20 x 3/8" steel hex head screws.
62. Position the RSM3 LOS Shield Insert, dwg# 3A3381, so the mounting plate with the three (3) thru holes is facing and is parallel to the RSM3 end flange.
63. Place the LOS insert mounting flange against the RSM3 end flange near the bottom of the i.d. of RSM3.
64. Align the three (3) thru holes on the LOS insert with the three (3) threaded holes on the RSM3 end flange.

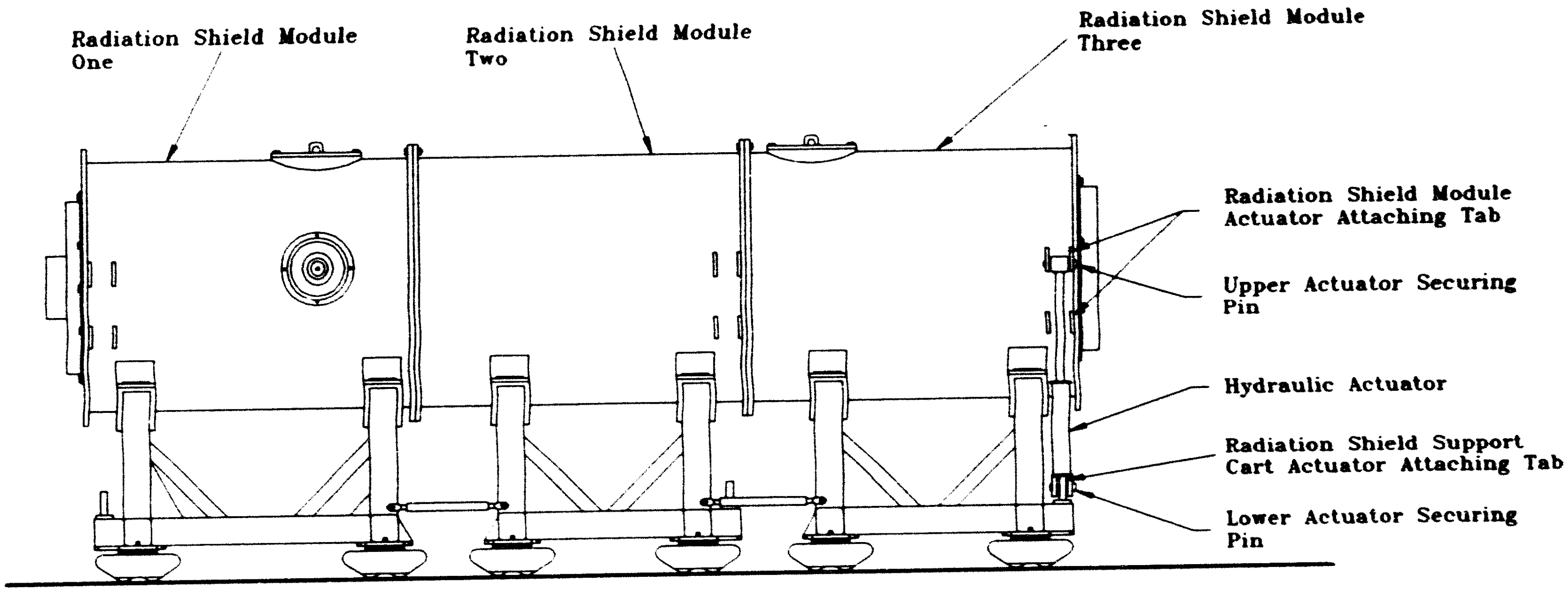


Figure 11: Hydraulic Actuator Placement

65. Attach the LOS insert to RSM3 using three (3) each 3/8-16 x 3/4" steel hex head screws. Tighten the screws until snug.
66. Position one of the RSM3 Cable Shield Inserts, dwg# 3A3382, so the end with the thru holes is facing away from the RSM3 end flange and the counterbored holes are facing skyward.
67. Insert the RSM3 Cable Shield Insert into the space underneath the Eight Cable Shield.
68. Align the two (2) thru holes on the RSM3 Cable Shield Insert with the two (2) threaded holes on top of the LOS insert. (*note- There are two (2) sets of threaded holes on the top of the RSM3 LOS Shield Insert. The RSM3 Cable Shield Inserts are interchangeable, so either set of threaded holes may be used.*)
69. Attach the RSM3 Cable Shield Insert to the LOS insert using two (2) each 1/4-20 x 1-1/2" steel socket head screws. Tighten the screws until snug.
70. Repeat steps 66-69 for the remaining RSM3 Cable Shield Insert.
71. Screw the two (2) RSM3 End Plug Alignment Pins, dwg# 3A3376, into the leftmost and rightmost threaded holes on the RSM3 end flange's Ø26.5" BC.
72. Rotate the Radiation Shield Module Assembly counterclockwise, as seen facing the RSM3 end flange, as far as possible using steps detailed in procedure 4.7 of this manual.
73. Insert the Instrumentation Cables Shield, dwg# 3A3385, into the end of RSM3 and to the left of the Eight Cable Shield.
74. Align the four (4) thru holes on the mounting brackets of the Instrumentation Cables Shield with the four (4) threaded holes on the RSM3 i.d.
75. Attach the Instrumentation Cables Shield to RSM3 using four (4) each 1/4-20 x 3/8" steel hex head screws. Tighten the screws until snug.
76. Rotate the Radiation Shield Module Assembly back to the drift tube loading position using steps detailed in procedure 4.7 of this manual.

4.3 Spectrometer Installation in the Radiation Shield

This procedure details the steps required to install the spectrometer inside of the Radiation Shield Module Assembly. This procedure assumes that the spectrometer is positioned on the TPCS Spectrometer Loading Fixture, and the Radiation Shield Module Assembly is rotated so the Collimator Access and Vacuum Access Port's centerline axes are parallel to the floor.

1. Move the TPCS Spectrometer Loading Fixture/spectrometer from the spectrometer assembly area to the RSM1 end of the Radiation Shield Module Assembly.
2. Position the loading fixture/spectrometer so the end flange on the TPCS Spectrometer Loading Fixture loading tube is parallel to and facing RSM1's end flange.
3. Insert the ends of the four (4) RG220 and the one (1) RG223 coaxial cables into the i.d. of RSM1.
4. Push the loading fixture/spectrometer toward RSM1until the end flange on the TPCS Spectrometer Loading Fixture loading tube contacts the RSM1 end flange.
5. Align the loading fixture so that loading tube axis centerline is coincident, albeit vertically displaced, with the axis centerline of the Radiation Shield Module Assembly i.d.
6. Raise the loading fixture/spectrometer until the bottom-most point of the i.d. of the TPCS Spectrometer Loading Fixture loading tube is level with the bottom-most point of the i.d. of RSM1.
7. Set the brake and close the hydraulic jack valve on the loading fixture lift table.

8. Bolt the TPCS Spectrometer Loading Fixture flange to the RSM1 end flange using two (2) each 3/8-16 x 5/8" steel hex head screws and two (2) Ø1.0" o.d. 3/8" screw steel flat washers. Tighten the screws until the TPCS Spectrometer Loading Fixture flange is flush against RSM1. (*note- It may be necessary to push the TPCS Spectrometer Loading Fixture sideways slightly to get the thru holes on the loading fixture to line up with the threaded holes on RSM1.*)
9. Push the spectrometer into the i.d. of the Radiation Shield Module Assembly until the Collimator and Vacuum Access Ports on the spectrometer are aligned with the Collimator and Vacuum Access Ports on RSM1. (*note- It will be necessary to occasionally pull the coaxial cables toward RSM3 to avoid buckling of the cables inside the Radiation Shield Module Assembly. Also, the coaxial cable ends must be guided through the space underneath the Eight Cable Shield at the end of RSM3.*)
10. Remove the two (2) 3/8-16 x 5/8" steel hex head screws and the two (2) Ø1.0" o.d. 3/8" screw steel flat washers that secure the TPCS Spectrometer Loading Fixture flange to RSM1.
11. Lower the loading fixture and disengage the brake on the fixture.
12. Move the TPCS Spectrometer Loading Fixture to the spectrometer assembly area.
13. Rotate the spectrometer inside of the Radiation Shield Module Assembly until the three (3) ports on the spectrometer are aligned with the three (3) ports on RSM1. (*note- The spectrometer can be rotated within the Radiation Shield Module Assembly by grabbing hold of the High-Voltage Connection Plate by the edges and turning as required. The alignment process can be speeded up if there are two (2) persons performing the alignment; one (1) person to rotate and slide the spectrometer and one (1) person to monitor the alignment of the ports.*)
14. Clean the mating surface and the o-ring groove on the Vacuum Connection Port flange on the spectrometer.
15. Install a lubricated Parker #2-252 o-ring in the captive o-ring groove on the Vacuum Connection Port flange on the spectrometer.
16. Screw one (1) each 1/4-20 x 2' all thread rod into the top threaded hole on the Ø4.375" BC on the Vacuum Connection Port flange on the spectrometer.
17. Screw one (1) each 1/4-20 x 2' all thread rod into the bottom threaded hole on the Ø4.375" BC on the Vacuum Connection Port flange on the One-piece Drift Tube.
18. Clean all surfaces on the Vacuum Interface Insulating Ring, dwg# 3A3358, using ethanol or methanol and a clean lint-free cloth.
19. Insert the two (2) 1/4-20 rods into two (2) opposing holes on the Vacuum Interface Insulating Ring.
20. Slide the Vacuum Interface Insulating Ring on the 1/4-20 rods toward the Vacuum Connection Port flange on the spectrometer until contact is made.
21. Clean all surfaces on the Vacuum Feedthru Port, dwg# 3A3388, using ethanol or methanol and a clean lint-free cloth.
22. Clean eight (8) each Vacuum Feedthru Port Screw Insulating Inserts, dwg# 3A3438, using ethanol or methanol and a clean lint-free cloth.
23. Place the Vacuum Feedthru Port on a clean flat surface resting on the face of the four-hole flange.
24. Install the eight (8) insulating inserts into the eight-hole flange on the Vacuum Feedthru Port. (*note- The Vacuum Feedthru Port Screw Insulating Inserts are press fit into the eight-hole flange on the Vacuum Feedthru Port. A hammer and a block of wood or Lexan® can be used to drive the insulating inserts into the holes. Place the Wood or Lexan® on top of the Vacuum Feedthru Port Screw Insulating Insert and hit the wood or Lexan® with the hammer until the insulating insert is flush with the flange face or it is slightly recessed. Make sure none of the Vacuum Feedthru Port Screw Insulating Inserts are protruding above the flange face surface as this may create problems for the vacuum seal.*)

25. Position the Vacuum Feedthru Port so the end flange with the eight (8) thru holes faces and is parallel to the Vacuum Interface Insulating Ring, and the flange with the four (4) counterbored holes has two (2) holes parallel to the floor.
26. Slide the Vacuum Feedthru Port on the 1/4-20 rods toward the Vacuum Interface Insulating Ring until contact is made.
27. Clean the Screw Insulating Ring, dwg# 3A3440, using ethanol or methanol and a clean lint-free cloth.
28. Position the Screw Insulating Ring so it is parallel to the eight-hole flange on the Vacuum Feedthru Port.
29. Align the thru holes on the Screw Insulating Ring with the thru holes on the eight-hole flange on the Vacuum Feedthru Port.
30. Slide the Screw Insulating Ring on the 1/4-20 rods toward the Vacuum Feedthru Port until contact is made.
31. Attach the Screw Insulating Ring/Vacuum Feedthru Port/Vacuum Interface Insulating Ring to the Vacuum Connection Port flange on the spectrometer using two (2) each 1/4-20 x 1-3/4" steel socket head screws and two (2) each Ø0.625" o.d. 1/4" screw steel flat washers. Tighten the screws until snug.
32. Remove the two (2) 1/4-20 rods from the Vacuum Connection Port flange on the One-piece Drift Tube.
33. Screw six (6) each 1/4-20 x 1-3/4" steel socket head screws and six (6) each Ø0.625" o.d. 1/4" screw steel flat washers into the six (6) remaining holes on the Vacuum Connection Port flange on the spectrometer . Tighten the screws using a standard eight-hole flange tightening pattern until snug.
34. Attach the Vacuum Feedthru Port to RSM1 using four (4) 3/8-16 x 1" steel socket head screws. Tighten the screws using a standard four-hole flange tightening pattern until snug.
35. Rotate the Radiation Shield Assembly so the centerline axis of the RSM1 Collimator Port is perpendicular to the floor using steps detailed in procedure 4.7 of this manual.
36. Rig the Collimator Shielded Port, dwg# 3A3350, so that it can be lifted by its mounting flange using the RBC2000. (*note- Make sure that any straps or other lifting appliances attached to the Collimator Shielded Port flange will not be caught between the underside of the flange and RSM1 when the Collimator Shielded Port is seated in the port.*)
37. Lift the Collimator Shielded Port using the RBC2000 and lower into place in the RSM1 Collimator Port. (*note- Make sure the bottom of the Collimator Shielded Port is fully seated in the Collimator Shielded Port Insulating Adaptor Ring.*)
38. Remove the rigging and the RBC2000 from the Collimator Shielded Port.
39. Align the four (4) thru holes on the Collimator Shielded Port flange with the four (4) threaded holes on the RSM1 Collimator Port.
40. Attach the Collimator Shielded Port to RSM1 using four (4) each 3/8-16 x 2-1/4" steel hex head bolts and four (4) each Ø1.0" o.d. 3/8" screw steel flat washers. Tighten the screws using a four-hole flange tightening pattern until snug.
41. Rotate the Radiation Shield Assembly so the centerline axis of the RSM1 Collimator Port is parallel with the floor using steps detailed in procedure 4.7 of this manual.
42. Clean all surfaces and o-ring grooves on the Vacuum Tee, dwg# 3A3437, using ethanol or methanol, Q-tips, and a clean lint-free cloth.
43. Install a lubricated Parker #2-252 o-ring in the captive o-ring groove on the Vacuum Feedthru Port mounting flange.
44. Position the Vacuum Tee so the 9" o.d. rotatable ASA flange is facing and is parallel to the Vacuum Feedthru Port mounting flange.
45. Align the thru hole on the Vacuum Tee 9" o.d. rotatable ASA flange with the threaded holes on the Vacuum Feedthru Port mounting flange.
46. Attach the Vacuum Tee to the Vacuum Feedthru Port mounting flange using eight (8) each 5/8-11 x 1-1/4" steel hex head screws and eight (8) each Ø1.75" o.d. 5/8" screw steel flat washers. (*note- Do not tighten the screws too much at this time.*)

47. Rotate the Vacuum Tee so the 11" rotatable ASA flange is facing toward the right with the centerline axis of the 11" rotatable flange parallel to the floor.
48. Tighten the eight (8) 5/8-11 x 1-1/4" steel hex head screws on the 9" rotatable ASA flange on the Vacuum Tee using a standard eight-hole flange tightening pattern.
49. Clean all surfaces of the Get-Lost Port Window, dwg# 3A3421, using ethanol or methanol and a clean lint-free cloth. Lay the Get-Lost Port Window down on a flat clean surface.
50. Position the PIN Holder, dwg# 3A3408, so the surface without the 4-40 and 6-32 inserts is parallel to and facing the Get-Lost Port Window.
51. Lay the PIN Holder on top of the Get-Lost Port Window and align the eight (8) thru holes on the Ø7.50" BC on the PIN Holder with the eight (8) thru holes on the Ø7.50" BC on the Get-Lost Port Window.
52. Install a lubricated Parker #2-259 o-ring in the o-ring groove on the 9" non-rotatable ASA flange on the Vacuum Tee.
53. Position the PIN Holder/Get-Lost Port Window so the Get-Lost Port Window is to and faces the 9" non-rotatable ASA flange on the Vacuum Tee.
54. Align the eight (8) thru holes on the PIN Holder/Get-Lost Port Window with the eight (8) thru holes on the 9" non-rotatable ASA flange on the Vacuum Tee.
55. Attach the PIN Holder/Get-Lost Port Window to the 9" non-rotatable ASA flange on the Vacuum Tee using eight (8) each 5/8-11 x 2-1/2" steel hex head bolts, 16 each Ø1.75" o.d. 5/8" screw steel flat washers, and eight (8) each 5/8-11 hex nuts. Tighten the bolt/nut combinations using a standard eight-hole flange tightening pattern until snug.
56. Remove and clean the o-ring on the Vacuum Gate Valve using ethanol or methanol and a clean lint-free cloth.
57. Clean all surfaces and o-ring grooves of the Vacuum Gate Valve using ethanol or methanol, Q-tips and a clean lint-free cloth.
58. Lubricate the o-ring for the Vacuum Gate Valve with vacuum grease, preferably Apiezon type-L. Replace the o-ring in the groove on the Vacuum Gate Valve mounting flange.
59. Attach the four (4) support legs to the bottom of the Turbomolecular Vacuum Pump.
60. Set the Turbomolecular Vacuum Pump on the floor resting on the four (4) support legs.
61. Clean the mating surface of the Turbomolecular Vacuum Pump's mounting flange using ethanol or methanol and a clean lint-free cloth.
62. Position the Vacuum Gate Valve so the mounting flanges are parallel to the floor and the vent valves are directed skyward.
63. Lay the Vacuum Gate Valve on top of the Turbomolecular Vacuum Pump's mounting flange.
64. Align the eight (8) thru holes on the Turbomolecular Vacuum Pump's mounting flange with the eight (8) threaded holes on the Vacuum Gate Valve's mounting flange.
65. Attach the Turbomolecular Vacuum Pump to the Vacuum Gate Valve using eight (8) 3/4-10 x 1-1/4" steel hex head screws. Tighten the screws using a standard eight-hole flange tightening pattern until snug.
66. Rig the Turbomolecular Vacuum Pump Assembly so that it can be lifted by the RBSC2000 with the centerline axis of the Turbomolecular Vacuum Pump parallel to the floor.
67. Install a lubricated Parker #2-266 o-ring in the o-ring groove on the 11" rotatable ASA flange on the Vacuum Tee.
68. Lift the Turbomolecular Vacuum Pump Assembly using the RBC2000, and position the Vacuum Gate Valve mounting flange so it is parallel to and facing the 11" rotatable ASA flange on the Vacuum Tee.
69. Remove the four (4) support legs from the Turbomolecular Vacuum Pump.
70. Attach the Turbomolecular Vacuum Pump Cooling Fan Assembly to the bottom of the Turbomolecular Vacuum Pump.
71. Align the eight (8) thru holes on the 11" rotatable ASA flange on the Vacuum Tee with the threaded holes on the Vacuum Gate Valve.

72. Attach the 11" rotatable ASA flange on the Vacuum Tee to the Vacuum Gate Valve mounting flange using eight (8) each 3/4-10 x 1" steel hex head screws and eight (8) each Ø2.0" o.d. 3/4" screw steel flat washers. (*note- Do not tighten the screws too much at this time.*)
73. Facing the cooling fan end of the Turbomolecular Vacuum Pump, rotate the Vacuum Gate Valve clockwise as far as possible. (*note-This will position the vent valves and control solenoid on top of the Turbomolecular Vacuum Pump Assembly with the edge of the Vacuum Gate Valve resting against the side of RSM1.*)
74. Tighten the eight (8) screws on the 11" rotatable ASA flange on the Vacuum Tee using a standard eight-hole flange tightening pattern until snug.
75. Plug the Turbomolecular Vacuum Pump Cooling Fan Assembly power cord into a *switchable* 120VAC receptacle.
76. Clean the KF-40 foreline pump flange on the Turbomolecular Vacuum Pump using ethanol or methanol and a clean lint-free cloth.
77. Clean a KF-40 centering ring/o-ring assembly using ethanol or methanol and a clean lint-free cloth.
78. Lubricate the o-ring using vacuum grease, preferably Apiezon type-L.
79. Connect the KF-40 flange on the flexible vacuum hose to the KF-40 foreline pump flange on the Turbomolecular Vacuum Pump using a KF-40 centering ring/o-ring assembly and a KF-40 clamp. (*note- Make sure the flexible vacuum hose connected to the KF-40 foreline pump flange on the Turbomolecular Vacuum Pump is not routed underneath the frame of the RSM1 Spectrometer Cart.*)
80. Lay the PIN Detector Holder, dwg# 3A3310, on a flat surface with the counterbored side of the PIN Detector Holder facing skyward.
81. Position the PIN Detector so the electrical connector is facing the PIN Detector Holder. (*note- The PIN Detector should have an opaque light block covering the active area. If it does not have this light block, one can be fabricated from black opaque vinyl electrical tape. Cut a small piece of the electrical tape, just large enough to cover the window over the active area, and stick it to the window on the PIN Detector.*)
82. Install the PIN Detector in the PIN Detector Holder with the PIN Detector's electrical connector seated in the Ø0.190" nominal thru hole on the PIN Detector Holder.
83. Connect a BNC female to Microdot® male adaptor to the female Microdot® connector on the PIN Detector.
84. Connect a BNC elbow adapter to the female BNC connector.
85. Position the PIN Detector Holder/PIN Detector Assembly so the active area of the PIN faces and is parallel to the center of the PIN Holder.
86. Align the three (3) thru holes on the Ø0.94" BC on the PIN Detector Holder with the three (3) 4-40 inserts on the Ø0.94" BC on the PIN Holder.
87. Attach the PIN Detector Holder to the PIN Holder using three (3) 4-40 x 7/8" steel pan head screws. Tighten the screws until the PIN Detector Holder is flush with the surface of the PIN Holder.
88. Position the Type-N Bulkhead Feedthru Mounting Bracket, dwg# 3A3439, so the two (2) thru holes on the bracket are aligned with the two (2) 6-32 inserts on the PIN Holder.
89. Attach the mounting bracket to the PIN Holder using two (2) 6-32 x 3/8" steel socket head screws. Tighten the screws until the Type-N Bulkhead Feedthru Mounting Bracket is flush with the surface of the PIN Holder.
90. Install a type-N female to female bulkhead feedthru on the Type-N Bulkhead Feedthru Mounting Bracket.

91. Install a 5"-6" long RG223 coaxial cable terminate with a BNC male connector on one end and a type-N male connector on the other end. (*note- The outside of the coaxial cable should be covered with a conductive braid connected to each of the shields of the two (2) end connectors.*)
92. Tape over the area between the spokes of the PIN Holder using 1"-2" wide black opaque vinyl electrical tape. (*note- This will block any visible light from entering the Get-Lost Port .*)
93. Install a Target Foil in the spectrometer following steps 30-42 of procedure 5.8.2.1 or steps 16-28 of procedure 5.8.2.2 of this manual, as appropriate.
94. Connect the four (4) RG220 coaxial cables from the spectrometer to the TPCS Capacitor Bank High Voltage Bus.
95. Insert the three (3) coaxial cables from the spectrometer into the space between the i.d. of RSM3 and the Instrumentation Cables Shield.
96. Remove the slack from the cables leaving the excess cable lengths hanging outside of RSM3.

4.4 Final Radiation Shield Assembly

This procedure describes the steps necessary to install the Radiation Shield Module Assembly End Plugs and the Access Port Plugs on the Radiation Shield Module Assembly. It is assumed that the Radiation Shield Module Assembly is in the drift tube loading position with the Vacuum Access and Collimator Port centerline axes parallel to the floor. It is also assumed that the RSM1 End Plug Door has been installed on the RSM1 End Plug.

1. Attach rigging to the top lifting tab on the RSM1 End Plug, dwg# 3A3348, for lifting by the RBC2000. (*note- The top lifting tab on the RSM1 End Plug is the tab that is positioned equidistant between the thru holes on the Ø26.5" BC.*)
2. Lift the RSM1 End Plug using the RBC2000 to a level that places the center of the end plug at the center of the axis of the i.d. of the Radiation Shield Module Assembly.
3. Position the end plug so the side with the Ø18.75" step is parallel to and facing the RSM1 end flange.
4. Guide the Ø18.75" step on the RSM1 End Plug into the i.d. of RSM1 until the mounting flange of end plug contacts the end flange of RSM1.
5. Align the four (4) thru holes on the end plug mounting flange with the four (4) threaded holes on the RSM1 end flange.
6. Attach the end plug to RSM1 using four (4) each 3/8-16 x 3/4" steel hex head screws and four (4) each Ø1.0" o.d. 3/8" screw flat washers. Tighten the screws until snug.
7. Remove the rigging from the RSM1 End Plug.
8. Open the RSM1 End Plug Access Door, dwg# 3A3352, and insert the RSM1 Removable Insert Plug, dwg# 3A3356, into the i.d. of the RSM1 End Plug.
9. Slide the RSM1 Removable Insert Plug into the i.d. of end plug until the insert plug contacts the Center Rod Insulating End Cap.
10. Close and latch the RSM1 End Plug Access Door.
11. Attach rigging to the two (2) lifting tabs on the RSM3 End Plug, dwg# 3A3380, for lifting by the RBC2000.
12. Lift the RSM3 End Plug using the RBC2000 to a level that places the center of the end plug at the center of the axis of the i.d. of the Radiation Shield Module Assembly.
13. Position end plug so the side with the Ø18.75" step is parallel to and facing the RSM3 end flange.
14. Insert the three (3) coaxial cables hanging outside of RSM3 into the rectangular thru hole on RSM3 End Plug.

15. Guide the Ø18.75" step on the end plug into the i.d. of RSM3 until the mounting flange of end plug contacts the end flange of RSM3. Use the RSM3 End Plug Alignment Pins to assist with the centering of end plug with the i.d. of RSM3. (*note- Make sure the three (3) coaxial cables do not get pinched between RSM3 End Plug and RSM3.*)
16. Attach the RSM3 End Plug to the RSM3 end flange using five (5) each 3/8-16 x 7/8" steel hex head screws and five (5) each Ø1.0" o.d. 3/8" screw flat washers. Tighten the screws until snug.
17. Connect the three (3) coaxial cables to the appropriate connectors on the RSM3 Connector Feedthru Plate, dwg# 3A3384.
18. Slide the excess cable lengths back into RSM3.
19. Align the four (4) thru holes on the RSM3 Connector Feedthru Plate with the four (4) threaded holes on RSM3.
20. Attach the RSM3 Connector Feedthru Plate to the RSM3 End Plug using four (4) each 1/4-20 x 3/8" steel hex head screws and four (4) each Ø0.625" o.d. 1/4" screw flat washers. Tighten the screws until snug.
21. Remove the rigging from the end plug.
22. Attach rigging to the ND Filter Access Port Plug, dwg# 3A3349, for lifting by the RBC2000.
23. Insert the ND Filter Access Port Plug in the ND Filter Access Port on RSM3.

4.5 Control Monitor Interfacing

This procedure describes the steps necessary to link the spectrometer to the Facility Control Monitor System (CMS). All coaxial cables will be supplied by the Facility CMS.
This procedure assumes that the TPCS Capacitor Bank Controller, CVC GPT-450 Vacuum Gauge Controller, System Vacuum Gate Valve Control Panel, and TMP1000 Turbomolecular Vacuum Pump Controller are installed in a CMS instrument rack.

1. Request the Facility CMS to install the following RG223 coaxial cable links between the:
   a. CMS Cordin Trigger Delay Generator delayed output port to the external trigger input port on the TPCS Capacitor Bank Controller through a 10X in-line attenuator,
   b. TPCS Capacitor Bank Controller trigger output port to the TPCS Capacitor Bank trigger input port, and
   c. TPCS Capacitor Bank trigger monitor output port to the external trigger input port of the CMS Trigger Delay Generator through a 5X in-line attenuator.
2. Request the Facility CMS to install the following control cable links between the:
   a. TPCS Capacitor Bank Controller command and control connector port to the TPCS Capacitor Bank command and control connector port.
   b. TMP1000 Turbomolecular Vacuum Pump Controller and the TMP1000 Turbomolecular Vacuum Pump on the spectrometer,
   c. System Vacuum Gate Valve Control Panel to the System Vacuum Gate Valve actuating solenoid on the spectrometer,
   d. CVC GPT-450 Vacuum Gauge Controller thermistor station output to the Thermistor Gauge on the spectrometer,
   e. CVC GPT-450 Vacuum Gauge Controller Penning Gauge bias/signal port to the Penning Gauge on the spectrometer.

4.6 Data Acquisition System

This procedure describes the steps necessary to link the spectrometer to the Facility Data Acquisition System (DAS). The signal and bias cables, cable connectors and adapters, bias supplies, and recording instruments will be supplied by the Facility DAS.

1. Request a total of four (4) signal cables be run from the TPCS to the Facility DAS. These cables will be used to transmit the signal from the PMT, PIN Detector, Pearson Current Transformer, and the TPCS Capacitor Bank Crowbar Current Monitor. (*note- The PIN Detector signal cable will also act as the bias supply cable for the PIN Detector. A bias tee will be required to prevent the biasing voltage from being "seen" at the input to the recording instrument.*)
2. Request that the signal cables be TDR'd by the Facility DAS so that timing differences due to cable lengths can be accounted for.
3. Have the signal cables connected to the recording instruments as illustrated in the signal maps, refer to figure 12, by DAS personnel.
4. Request that a bias supply with an output of -2200V be provided by the Facility DAS for the biasing of the PMT.
5. Request that a bias supply with an output of -100V be provided by the Facility DAS for the biasing of the PIN Detector through a bias tee.
6. Connect the bias and signal cables to the appropriate connector ports on the RSM3 Connector Feedthru Plate.
7. Connect the PIN bias/signal cable to the Type-N Bulkhead Feedthru Mounting Bracket.

4.7 Rotation of the Radiation Shield Module Assembly

This procedure describes the steps required to rotate the TPCS Radiation Shield Assembly about its axis using the electrohydraulic rotation system. It is assumed that the electrohydraulic pump and hydraulic actuator have already been installed on the Radiation Shield Module Assembly and the turnbuckles are attached to the shield modules. (*note- Two (2) individuals will be required to perform this procedure. One person will operate the electrohydraulic pump, and the other person will act as a spotter to ensure cables, hardware, and personnel are not in any danger during rotation of the Radiation Shield Module Assembly.*)

1. Depress the MOTOR switch on the pendant switch box for the electrohydraulic pump.
2. Depress and quickly release the UP switch on the pendant switch box several times until the pin through the top of the hydraulic actuator just contacts the RSM3 tab.
3. Release the UP and MOTOR switches on the pendant switch box.
4. Remove the retaining pin at the top of the turnbuckle connected to each shield module.
5. Swing the top of the turnbuckles out, down, and away from the shield module tabs.
6. Depress the MOTOR switch on the pendant switch box to start the motor on the electrohydraulic pump.
7. Depress the UP (or DOWN) button on the pendant switch box as required to extend (or retract) the hydraulic actuator's cylinder. (*note- There is a manually-operated flow metering valve located on the electrohydraulic pump output port that allows the speed of the hydraulic actuator cylinder extension and retraction to be adjusted. Adjust the metering valve as required to obtain the appropriate rotational speed.*)
8. Release the UP (or DOWN) and the MOTOR switches on the pendant switch box when the hydraulic actuator's cylinder has reached its travel limit or the desired position for the Radiation Shield Module Assembly has been reached.

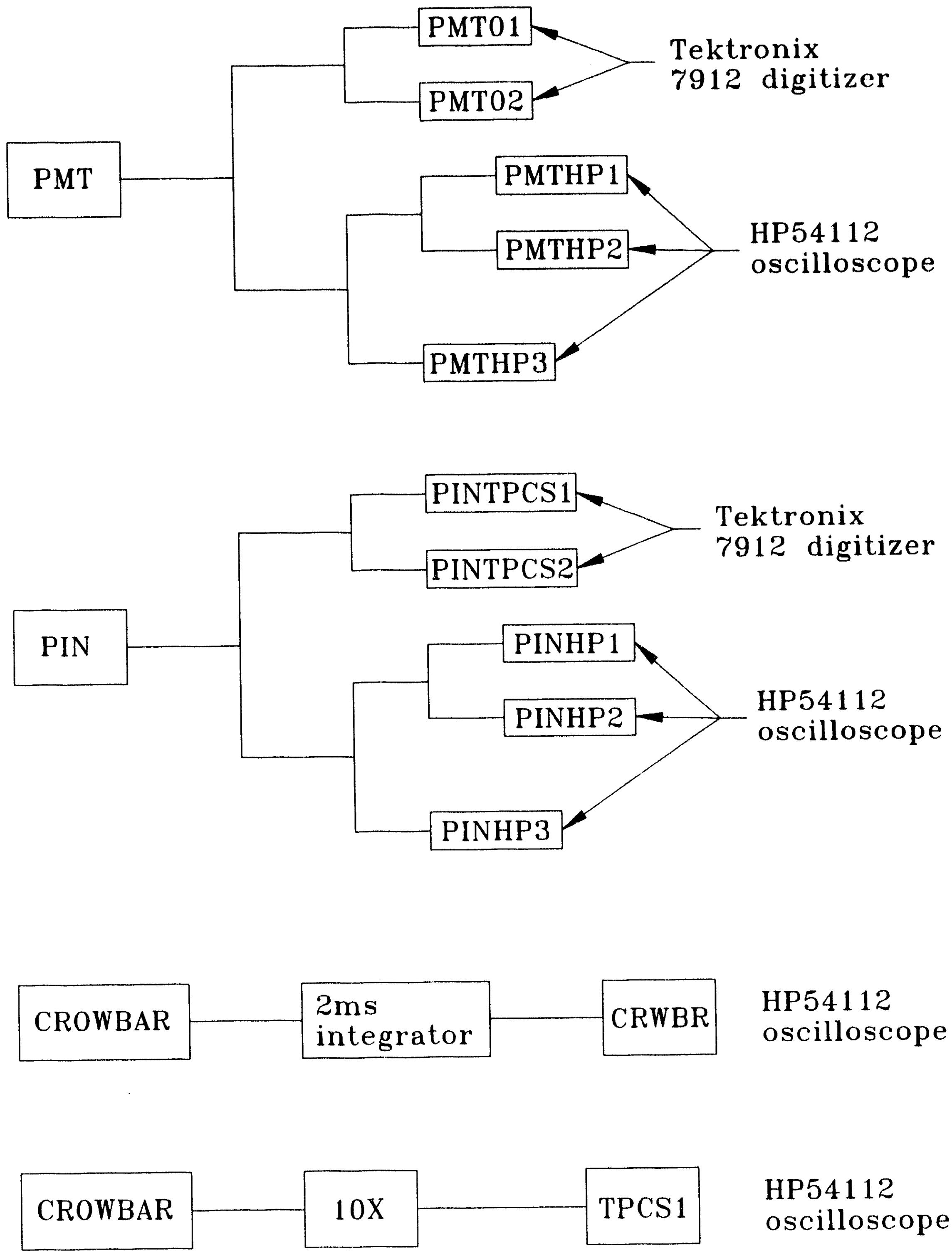


Figure 12: TPCS Signal Maps

9. Attach the top of the turnbuckles to each of the shield module tabs and tighten the turnbuckles so the turnbuckles are pulling down on the tabs. (*note- If the Radiation Shield Module Assembly is rotated to the desired position, there is no need to proceed further.*)
10. Depress the MOTOR switch on the pendant switch box.
11. Depress and quickly release the UP (or DOWN) switch on the pendant switch box several times until the retaining pin through the top of the hydraulic actuator can be removed from the RSM3 tab.
12. Remove the retaining pin from the top of the hydraulic actuator.
13. Depress the MOTOR and UP (or DOWN) switches on the pendant switch box to extend (or retract) the hydraulic actuator's cylinder so that it can be attached to the next higher (or lower) shield module tab.
14. Attach the top of the hydraulic actuator to the shield tab using the retaining pin.
15. Repeat steps 1-14 as required until the Radiation Shield Module Assembly is rotated to the desired position.

5.0 Routine Operations

5.1 Vacuum Gauge Connection to the System

This procedure details the proper steps that should be followed when connecting the vacuum gauges to the TPCS system. This procedure assumes the Penthervac Controller is mounted in the instrument rack and the power cord, thermistor gauge control cable, and the Penning gauge bias/signal cable are connected to the Penthervac Controller. Also it is assumed that the thermistor control cable and Penning bias/signal cable are already run to the remotely located spectrometer. (*note- Refer to the CVC GPT-450 Penthervac Vacuum Gauge Controller Operator's Manual for more detailed information concerning the CVC GPT-450 Penthervac Vacuum Gauge Controller.*)

1. Ensure that power is secured to the CVC GPT-450 Penthervac Vacuum Gauge Controller.
2. Install the thermistor and Penning vacuum sensors on the mounting ports located on the Target Foil Access Plate.
3. Connect the Penning bias/signal coaxial cable, terminated with an MHV-type connector, to the Penning gauge connector.
4. Connect the thermistor control cable to the thermistor. (*note- The connector on the thermistor is keyed alleviating any ambiguity as to the proper connector orientation.*)
5. Energize the Penthervac Vacuum Gauge Controller.
6. Depress the appropriate thermistor power switch depending on whether the thermistor is connected to station 1 or station 2 on the Penthervac Vacuum Gauge Controller.
7. Depress the Penning gauge power switch on the Penthervac Vacuum Gauge Controller. (*note- 1. The Penning gauge power switch being depressed does not necessarily mean there will be power supplied to the Penning gauge. The Penthervac Vacuum Gauge Controller automatically switches power to the Penning gauge, when the Penning gauge power switch is depressed, only after the thermistor senses a vacuum pressure < ~ 10mTorr. 2. On occasion, notably when the actual vacuum chamber pressure is in the 10^{-6}Torr range, the Penning gauge will not "light off" when the Penning gauge power switch is depressed, and the high vacuum pressure indicator will be "pegged" full left in the 10^{-7}Torr range. In this event, cycle the Penning power switch until the Penning gauge starts conducting current, at which time the high vacuum pressure indicator will deflect right and give the proper vacuum indication.*)

5.2 Evacuating the Spectrometer

This procedure outlines the steps required to place the spectrometer under vacuum. This procedure assumes that the One-piece Drift Tube has all of the necessary hardware in place, and the vacuum pumps are connected to the spectrometer, allowing the system to be placed under vacuum. Also, it is assumed that the Penning and thermistor vacuum gauges have previously been installed on the Target Foil Access Plate.

1. Fully open both of the vent valves located on the System Gate Valve.
2. Adjust the facility air supply pressure to ~ 60psig. (**note- Do not exceed 80psig!**)
3. Connect the air supply hose to the System Gate Valve and the facility air supply. (*note- Make sure the ends of the air supply hose are restrained to prevent whipping of the hose in the event of failure.*)
4. Connect the gate valve control cable to the gate valve control solenoid.
5. Connect the thermistor and Penning gauges to the spectrometer according section 5.1.
6. Place the System Gate Valve control switch in the OPEN position.
7. Energize the roughing pump.

8. Fully close the small Whitey vent valve located on the System Gate Valve. **(Do not overtighten the valve as valve seat damage may result jeopardizing the integrity of the valve.)**
9. Fully close the MDC bellows vent valve located on the System Gate Valve. **(Do not overtighten the valve as valve seat damage may result jeopardizing the integrity of the valve.)**
10. Allow the vacuum chamber pressure to drop bellow 100mTorr.
11. Energize the Turbomolecular pump frequency converter and depress the START switch. (*note- On occasion, the Turbomolecular Vacuum Pump Frequency Converter will indicate a failure after pump acceleration is complete. The failure is usually false, and a false failure indication should be suspected if the system pressure is in the* 10^{-5}*Torr range after pump acceleration. To get rid of the failure indication, depress the RESET button on the Turbomolecular Vacuum Pump Frequency Converter for ~ 5 seconds then release. The Turbomolecular Pump should accelerate momentarily and the RUN indicator should illuminate. The system may require several resets prior to the RUN indicator staying illuminated and no failure being indicated.*)
12. Energize the cooling fans on the Turbomolecular Pump.

5.3 Vacuum Gauge Disconnection from the System

The steps outlined in this procedure should be followed to properly disconnect the thermistor and Penning vacuum gauges located on the TPCS vacuum chamber from the CVC GPT-450 Penthervac Vacuum Gauge Controller prior to an accelerator shot or after the completion of a test series when the TPCS is being secured.

1. Secure the power to the CVC GPT-450 Penthervac Vacuum Gauge Controller.
2. Remove the control cable connected to the thermistor gauge located on the spectrometer. (*note- It is important that the thermistor gauge control cable be disconnected from the system prior to the removal of the Penning gauge bias/signal cable. The reason concerns safety and the fact that the Penning gauge power can only be delivered to the Penning gauge if 1) the Penthervac Vacuum Gauge Controller has power, 2) the Penning power switch on the Penthervac Vacuum Gauge Controller is depressed, and 3) the thermistor is sensing a pressure < ~ 10mTorr. If step 1 of section 5.3 was bypassed, this step would ensure no power was delivered to the Penning gauge.*)
3. Wind up the thermistor control cable and store it in a location out of the way.
4. Remove the Penning bias/control cable from the Penning gauge located on the spectrometer.
5. Wind up the Penning bias/signal cable and store it in a location out of the way.
6. Attach rigging to the Target Foil Access Port Plug, dwg# 3A3387, for lifting by the RBC2000.
7. Replace the Target Foil Access Port Plug on RSM1.

5.4 Venting the Spectrometer

The steps outlined in this procedure should be followed to properly take the spectrometer from a vacuum pressure state to an ambient air pressure state. This procedure assumes that the spectrometer is under an active vacuum with the vacuum pumps running and valved into the system.

1. Depress the STOP switch on the Turbomolecular Vacuum Pump Frequency Converter.
2. Secure power to the Turbomolecular Vacuum Pump Frequency Converter.
3. Place the System Gate Valve control switch in the CLOSED position. (This isolates the turbomolecular pump from the vacuum chamber allowing it to decelerate on its own.)
4. Secure power to the roughing vacuum pump.
5. Disconnect the vacuum gauges from the system following instructions detailed in section 5.3.
6. Fully open the MDC bellows vent valve located on the System Gate Valve.
7. Fully open the small Whitey vent valve located on the System Gate Valve.
8. When air can no longer be heard entering into the Whitey vent valve, the chamber is at equilibrium with the ambient air. At this point, fully close the small Whitey vent valve located on the System Gate Valve. **(Do not overtighten the valve as valve seat damage may result jeopardizing the integrity of the valve.)**

5.5 Safing the TPCS Capacitor Bank After a Routine Shot Sequence

This procedure should be followed to make the TPCS Capacitor Bank electrically safe following a routine shot series in which the energy stored in the capacitor bank was delivered to the TPCS load. **Do not use this procedure to safe the TPCS Capacitor Bank if energy is still stored in the capacitors or if it is suspected that energy is still stored in the capacitors. Do not allow any part of an individual's body to come into contact with the high voltage busplates prior to the completion of this procedure.** (*notes- 1. For orientation purposes, the left side of the capacitor bank enclosure is defined as the left side of the enclosure as viewed when facing the control panel on the TPCS Capacitor Bank. 2.* ***Always assume the Capacitors are charged when performing inspections or maintenance on the TPCS Capacitor Bank.***)

1. Look through the Lexan© inspection window on the TPCS Capacitor Bank to verify that the safing relay plunger is down and the contactor bar attached to the relay plunger is in contact with both terminals.
2. Turn off the 480V circuit breaker on the capacitor bank control panel and unplug the 480V supply cord from the wall receptacle.
3. Turn off the power to the Ignitron Trigger Generator and unplug the 120V supply cord from the wall receptacle.
4. Verify that there is a shorting strap connecting the capacitor bank enclosure to ground.
5. Verify that the shorting stick is connected to the capacitor bank enclosure.
6. Unlock the capacitor bank enclosure door on the left side of the TPCS Capacitor Bank located nearest the control panel.
7. Fully open the enclosure door.
8. Place the hook of the shorting stick, that is tied to the TPCS Capacitor Bank enclosure, on the top busplate.
9. Place the hook of the shorting stick on the bottom busplate.

10. Short the top and bottom busplates together with the shorting stick by placing the shorting stick between the busplates and rotating the shorting stick until the hook comes in contact with the top and bottom busplates.
11. Attach one of the shorting strap's spring clips to the top busplate.
12. Attach the other shorting strap spring clip to the bottom busplate.
13. Insert the end of the shorting stick's hook into the hole located on the top busplate near the high voltage power supply.
14. Position the shorting stick in a way that ensures good mechanical contact between the hook and the top busplate.
15. Unlock the three (3) remaining enclosure doors.
16. Open each of the enclosure doors and inspect the capacitor bank interior for signs of damage. **(note- Visually inspect the capacitors for damage first. If damage to any of the capacitors is evident, immediately terminate this procedure and follow the instructions detailed in section 5.6 beginning with step 7)** Repair or replace damaged hardware as required.
17. Remove the shorting stick from the top busplate and place it on top of the capacitor bank enclosure.
18. Close and lock the enclosure doors.

5.6 Manually Discharging the TPCS Capacitor Bank

Follow this procedure if energy is known to be stored, or is suspected to be stored, in the TPCS Capacitor Bank and can not be dumped using the built-in charge dump control circuitry. An example of a situation requiring the use of this procedure would be the following: The capacitor bank was charged and discharged but only part of the energy was delivered to the load. During the discharge, one of the resistors in series with the capacitors opened preventing the discharge of energy from the capacitor. The only way to discharge the capacitor bank in this situation is to manually discharge the charged capacitor through a resistive discharge circuit.

1. Turn off the 480V circuit breaker on the capacitor bank control panel and unplug the 480V supply cord from the wall receptacle.
2. Turn off the power to the Ignitron Trigger Generator and unplug the 120V supply cord from the wall receptacle.
3. Verify that there is a shorting strap connecting the capacitor bank enclosure to ground.
4. Unlock the capacitor bank enclosure door on the left side of the TPCS Capacitor Bank located nearest the control panel.
5. Fully open the enclosure door.
6. Visually inspect, from a distance, the capacitor bank and try to determine which capacitor probably still has charge stored in it. Look for any bulging in the capacitor casings as well as signs of an open series resistor on top of the capacitors.
7. Grasp the resistive grounding stick with both hands. (*note- Make sure both hands are placed behind the hand guard on the resistive grounding stick in order to prevent exposure of the hands to the terminals on the resistor.*)
8. Touch the hooked end of the resistive grounding stick to the top busplate.
9. Touch the resistive grounding stick to the bottom busplate.
10. Touch the hooked end of the resistive grounding stick to the center terminal on each capacitor. [*note- The RC time constant for the TPCS Capacitor Bank and through the resistive grounding stick is ~ 1 second (~ 5 seconds to discharge the complete bank). The RC time constant for a single capacitor through the resistive grounding stick is ~ 250ms (~ 1.25 seconds to fully discharge the capacitor).*]
11. After the capacitor(s) has/have been discharged, short the center terminal of each capacitor to its case.

12. Make the necessary repairs to the TPCS Capacitor Bank.

5.7 Operation of the TPCS

5.7.1 Operation of the TPCS Without the Accelerator

Follow this procedure when operating the TPCS without the accelerator in the trigger loop. In this mode of operation, the TPCS Capacitor Bank Controller is usually triggered manually using the Internal trigger mode and by depressing the FIRE button. The TPCS DAS oscilloscopes are triggered internally by the Pearson current transformer signal that is generated when the TPCS Capacitor Bank releases its charge to the TPCS load. The primary reasons for using the TPCS in this configuration are 1) to test the TPCS Capacitor Bank stand alone and 2) to fire the TPCS Capacitor Bank in order to determine the setpoint voltage required to obtain a desired current through the system.

1. Refer to figure 13 for the proper timing configuration.
2. Set the TPCS DAS oscilloscope that is recording the Pearson Current Transformer signal in the local mode.
3. Set the time base to **100**µs/div, refer to figure 14.
4. Terminate the Pearson Current Transformer signal channel in 50Ω on the oscilloscope.
5. Set the vertical amplifier sensitivity to 2V/div. (*note- For a 200kA pulse, the Pearson Current Transformer signal will be ~ 10V going through a 10X in line attenuator into 50Ω.*)
6. Set the trigger so the oscilloscope triggers off of the leading edge of the Pearson Current Transformer signal.
7. Set the oscilloscope delay so that it is referenced to the center graticule.
8. Complete the pre-shot portion of the Procedure Checklist for Operating the TPCS without the Accelerator, located in section 12.0 of this manual. (*note- **Always assume the Capacitors are charged when performing inspections or maintenance on the TPCS Capacitor Bank!***)
9. Turn the RUN/SAFE key switch on the TPCS Capacitor Bank Controller to the RUN position. (note- *The RUN/SAFE indicator should have the RUN section illuminated.*)
10. Depress the ARM switch on the TPCS Capacitor Bank Controller. (*note- The ARM/ARMED indicator should have the ARMED section illuminated.*)
11. Depress the CHARGE button on the TPCS Capacitor Bank Controller. (*note- The CHARGE/CHARGING indicator should have the CHARGING section illuminated. The analog current meter should indicate a charge current consistent with the charge rate dialed in on the TPCS Capacitor Bank. During the charge, the TPCS Capacitor Bank voltage should be displayed on the digital panel meter on the TPCS Capacitor Bank Controller. With a charge current of 600mA and a setpoint voltage of ~ -8.5kV, the charge cycle should take ~ 30s to complete. Upon completion of the charge cycle, the CHARGE COMPLETE and FIRE READY indicators should illuminate. Also the charge current meter needle should drop to zero.*)
12. Let the TPCS Capacitor Bank Voltage bleed off to the desired fire voltage level then depress the FIRE button on the TPCS Capacitor Bank Controller.
13. Complete the post-shot portion of the Procedure Checklist for Operating the TPCS without the Accelerator, located in section 12.0 of this manual. (*note- **Always assume the Capacitors are charged when performing inspections or maintenance on the TPCS Capacitor Bank!***)

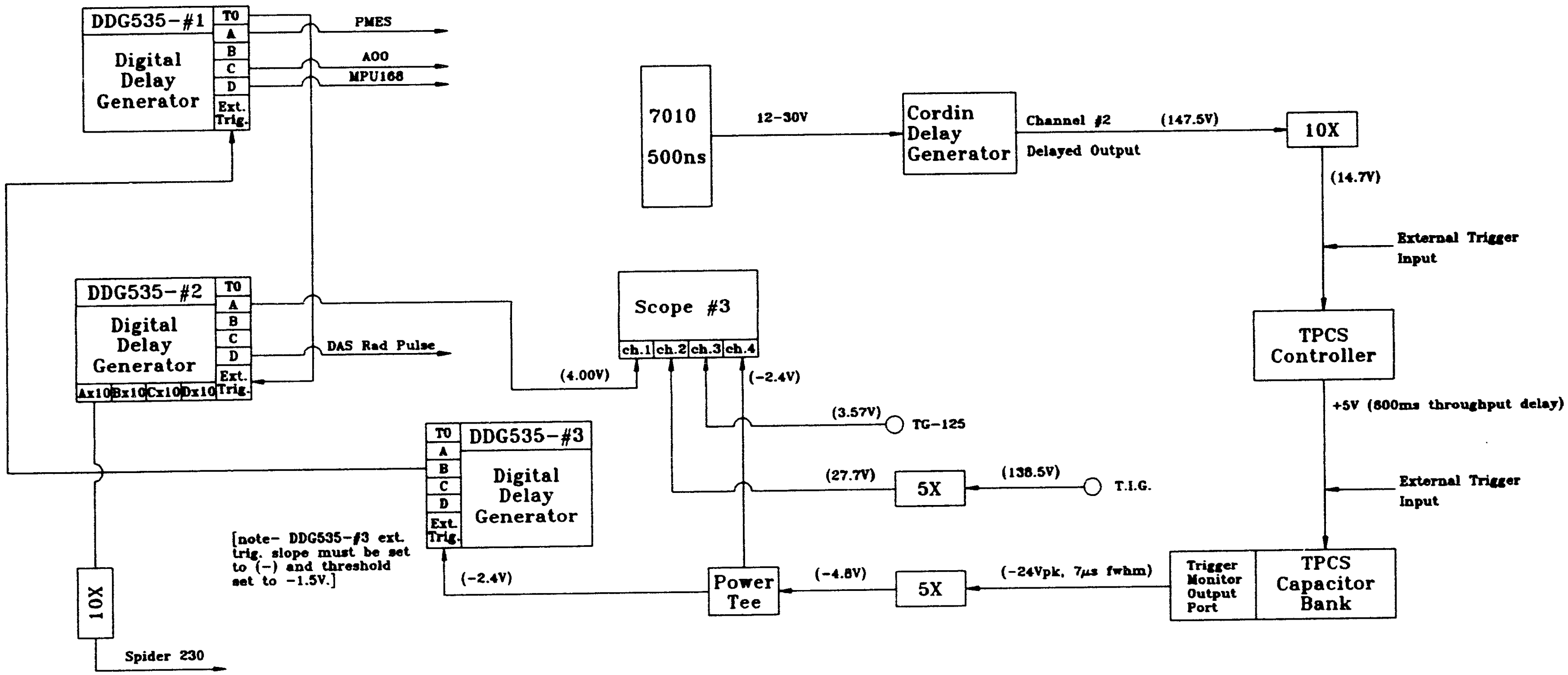


Figure 13: TPCS Triggering Scheme

HP54112D scope# _____ settings

1. **TPCSI** (ch. 1): (10X ext. at Pearson), 2V/div, +4V offset, DC coupling, 50Ω.
2. **CRWBR** (ch. 2): (2 ms integrator at cap bank), 1V/div, +1V offset, DC coupling, 1MΩ.
3. **PMTHP3** (ch. 3): 2X (power tee), 100 mV/div, -200mV offset, DC cplng, 50Ω, cable from other HP54112D ch. 2.
4. **Timebase**: 5 ms/div, delay ref left, -200 ms delay, triggered.
5. **Trigger**: edge, external, +1V level, +slope, external trigger off of TPCS1
6. Display cleared; awaiting trigger.

Figure 14- Scope Settings for TPCS Signals without the Accelerator

5.7.2 Operation of the TPCS With the Accelerator

There are two (2) configurations in which the TPCS is operated in conjunction with the accelerator: 1) the TPCS data is critical to the experiment and 2) the TPCS data is not critical to the experiment. This procedure should be followed for both configurations. The only difference between the two configurations is the machine trigger/timing setup. If the TPCS is a critical diagnostic, the accelerator will not fire unless it receives a trigger signal from the TPCS. When the TPCS is not a critical diagnostic, the machine has a redundant triggering path that triggers the accelerator in the event the TPCS does not send a trigger signal back within a specified amount of time.

1. Refer to figures 13 for the proper timing configuration. (*note- This is the only step in the procedure in which there is a difference between the two setup configurations.*)
2. Set the oscilloscope sensitivities according to the scope sensitivity matrix, refer to figure 15. (*note- All of the oscilloscopes recording TPCS data should be remotely controlled through the accelerator DAS, and all sensitivities will be changed through the DAS shot header. Oscilloscopes will be triggered by the machine trigger received by DAS from the Facility CMS.*)
3. Make sure to terminate the Pearson Current Transformer signal channel in 50Ω on the oscilloscope.
4. Set the oscilloscope delay so that it is referenced to the center graticule.
5. Complete the pre-shot portion of the Procedure Checklist for firing the TPCS with the Accelerator located in section 12.0 of this manual. (*note- **Always assume the Capacitors are charged when performing inspections or maintenance on the TPCS Capacitor Bank!***)
6. Turn the RUN/SAFE key switch on the TPCS Capacitor Bank Controller to the RUN position. (*note- The RUN/SAFE indicator should have the RUN section illuminated.*)
7. Depress the ARM switch on the TPCS Capacitor Bank Controller. (*note- The ARM/ARMED indicator should have the ARMED section illuminated.*)
8. When the Saturn accelerator has charged to ~ 60kV, depress the CHARGE button on the TPCS Capacitor Bank Controller. (*note- The CHARGE/CHARGING indicator should have the CHARGING section illuminated. The analog current meter should indicate a charge current consistent with the charge rate dialed in on the TPCS Capacitor Bank. During the charge, the TPCS Capacitor Bank voltage should be displayed on the digital panel meter on the TPCS Capacitor Bank Controller. With a charge current of **600mA** and a setpoint voltage of ~ -8.5kV, the charge cycle should take ~ 30s to complete. Upon completion of the charge cycle, the CHARGE COMPLETE and FIRE READY indicators should illuminate. Also the charge current meter needle should drop to zero.*)
9. Inform the Facility Control Monitor machine operator when the TPCS has reached full charge. (*note- This gives the machine operator the go ahead to fire the machine through the TPCS.*)
10. Complete the post-shot portion of the Procedure Checklist for firing the TPCS with the Accelerator located in section 12.0 of this manual. (*note- **Always assume the Capacitors are charged when performing inspections or maintenance on the TPCS Capacitor Bank!***)

Unit Type	Signal Name	Ext. Atten.	Prog. Atten.	Gauge Factor	Volts/ Div.	Vert. Pos.	Time Zero	Sweep (ns)
TD7912	PINTPCS1	4.00	1.0	1.0	0.01	1.0	371.0	20
TD7912	PINTPCS2	4.04	1.0	1.0	0.10	1.0	371.0	20
TD7912	PMT01	4.08	1.0	1.0	0.20	6.0	352.0	100
TD7912	PMT02	4.00	1.0	1.0	0.02	6.0	352.0	100
HP54112	PMTHP1	2.0	1.0	1.0	1.0	7.0	0.0	100
HP54112	PMTHP2	2.0	1.0	1.0	0.1	7.0	0.0	100
HP54112	PINHP1	2.0	1.0	1.0	1.0	1.0	0.0	100
HP54112	PINHP2	2.0	1.0	1.0	0.1	1.0	0.0	100
HP54112	TPCSI	10.0	1.0	2.0e+03	2.0	2.0	0.0	5000
HP54112	CRWBR	1.0	1.0	9.3e+04	1.0	3.0	0.0	5000
HP54112	PMTHP3	2.0	1.0	1.0	0.25	6.0	0.0	5000
HP54112	PINHP3	2.0	1.0	1.0	0.05	1.0	0.0	5000

note- Additional information can be obtained from the Saturn DAS shot header for shot #4192.

Figure 15- Scope Settings for TPCS Signals with the Accelerator

5.8 Routine System Parameter Changes

5.8.1 Cutting Target Foils

This procedure outlines the steps required to cut polypropylene targets for use on the TPCS. There are four (4) different polypropylene target geometries that can be used on the TPCS. The procedure is the same for all target geometries.

1. Select the appropriate thickness polypropylene foil. (*note- The polypropylene foil most commonly used is 12.7μm thick, and it is supplied on a roll 3" wide x 300' long.*)
2. Place the Target Foil Cutting Template Assembly, dwg# 3A3337, on a flat work surface.
3. Select the appropriate Target Foil Cutting Template, dwg# 3A3339, for the target to be cut.
4. Release the two (2) horizontal handle clamps securing the cutting template to the Target Foil Cutting Template Base Plate, dwg# 3A3338.
5. Remove the cutting template from the base plate. (*note- The Target Foil Cutting Template may need to be pried off of the Target Foil Cutting Template Base Plate using a common screwdriver. The screwdriver blade can be inserted between the tapered portion at the top of the cutting template and the base plate. Once inserted, the screwdriver can be twisted to pry off the cutting template.*)
6. Cut a piece of the polypropylene foil ~ 5.5" long from the roll of foil using a sharp pair of scissors. (*note- Make sure the ends of the cut foil are ~ parallel to one another and are ~ perpendicular to the edges of the foil.*)
7. Place the cut foil on the Target Foil Cutting Template Base Plate in the space between the two elevated sections on the base plate that was once occupied by the cutting template that was removed.
8. Position the foil as shown in figure 16.
9. Insert the Target Foil Cutting Template in its slot on the Target Foil Cutting Template Base Plate making sure the alignment pins on the cutting template are aligned with the alignment holes on the base plate.
10. Engage the horizontal handle clamps on the Target Foil Cutting Template Assembly, to lock the cutting template to the base plate and sandwiching the foil between the cutting template and the base plate.
11. Cut the foil by running a sharp blade, i.e. X-acto knife, razor, etc., along the outline of the base of the cutting template.
12. Remove the excess foil from the Target Foil Cutting Template Assembly, .
13. Insert the Target Foil Template Hole Punch, dwg# 3A3340, in the two (2) holes on the Target Foil Cutting Template.
14. Release the two (2) horizontal handle clamps securing the Target Foil Cutting Template to the Target Foil Cutting Template Base Plate.
15. Remove the cutting template from the base plate as in step 5.8.1.5.
16. Remove the foil from the base plate and store for use at a later time.
17. Insert the Target Foil Cutting Template in its slot on the Target Foil Cutting Template Base Plate making sure the alignment pins on the cutting template are aligned with the alignment holes on the base plate.
18. Engage the horizontal handle clamps on the Target Foil Cutting Template Assembly, to lock the Target Foil Cutting Template to the Target Foil Cutting Template Base Plate.

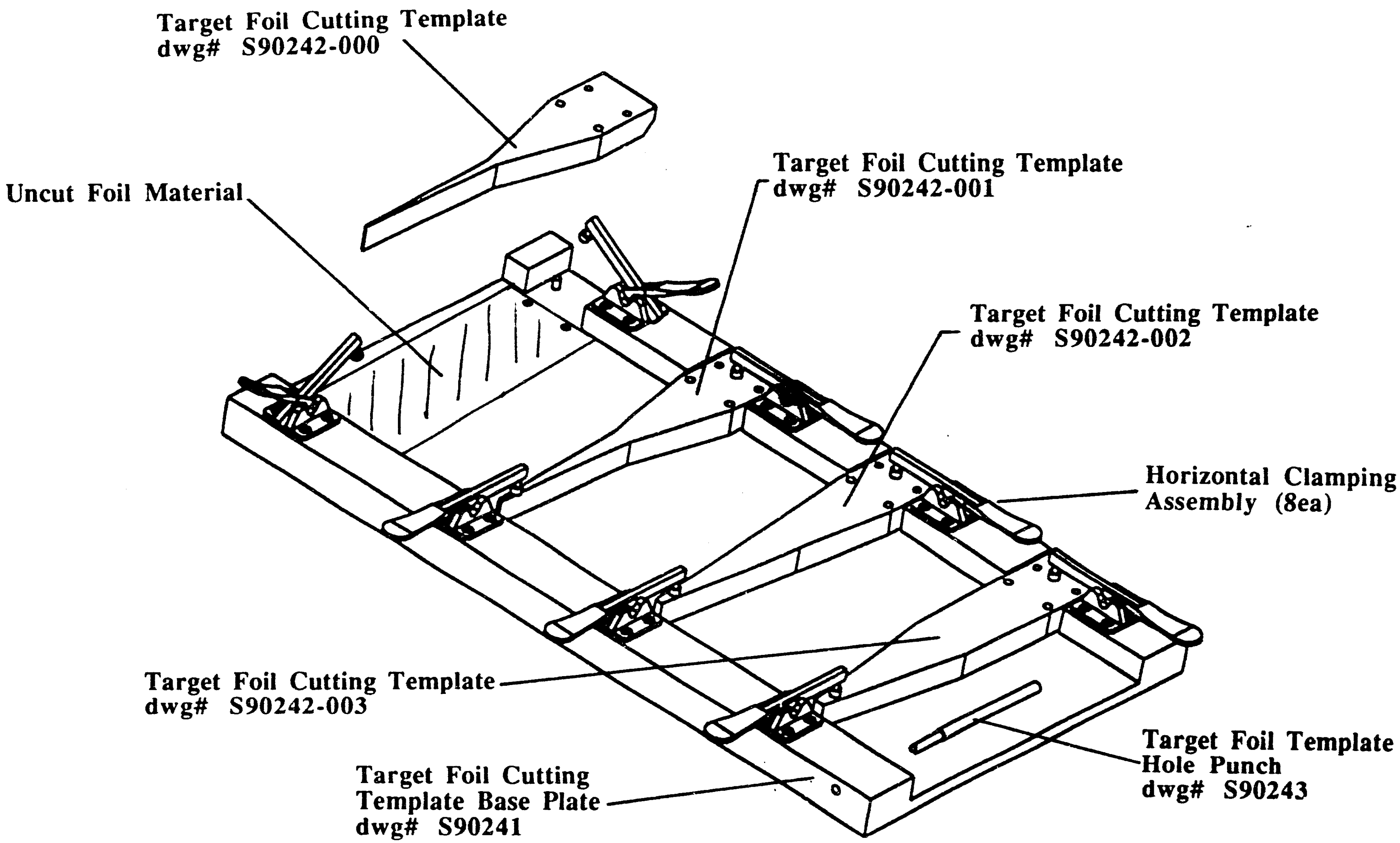


Figure 16: Target Foil Template Cutting Assembly

5.8.2 Loading/Replacing Target Foils

5.8.2.1 Polypropylene Target Foil

This procedure assumes that the TPCS system is loaded with a Target Foil Assembly containing a polypropylene Target Foil and that a different polypropylene Target Foil is to be installed in the TPCS, refer to figure 17. Also, it is assumed that the spectrometer is installed in the radiation shield, and the spectrometer Collimator Port is pointed toward the X-ray source.

1. Safe the TPCS Capacitor Bank following steps outlined in procedure 5.5.
2. Vent the TPCS vacuum chamber, if required, following steps outlined in procedure 5.4.
3. Attach rigging to the Target Foil Access Port Plug for lifting by the RBC2000.
4. Remove the access port plug from RSM1 using the RBC2000 boom crane and set aside and out of the way.
5. Remove seven (7) 8-32 x 5/8" stainless steel socket head screws from the Ø4.125" BC on the Target Foil Access Plate, dwg# 3A3430, and set them aside. (*note- Care should be taken to prevent the screws removed from the Target Foil Access Plate from dropping inside of the radiation shield. It is a good idea to drape a towel between the underside of the access plate port and the edge of the radiation shield to act as a catch net for the screws in the event they are dropped during removal.*)
6. Hold the Target Foil Access Plate with one hand while removing the final 8-32 x 5/8" screw from the plate.
7. Remove the Target Foil Access Plate and the 8-32 x 5/8" screw from the spectrometer and set aside in a clean dry location.
8. Remove the Target Foil Retaining Ring, dwg# 3A3360, from the spectrometer and set aside in a clean dry location.
9. Remove the Target Foil Assembly from the spectrometer by grabbing hold of the Target Foil Frame Mounting Bracket, dwg# 3A3336, and pulling the Target Foil Assembly straight out of the port. Set the assembly aside in a clean dry location.
10. Remove the two (2) 4-40 x 7/16" nylon pan head screws from the Target Foil Frame Mounting Bracket.
11. Lay the Target Foil Frame Assembly down on a flat work surface with the heads of the four (4) nylon screws facing skyward.
12. Remove the two (2) 4-40 x 3/8" nylon pan head screws from the Target Foil Bottom Clamp, dwg# 3A3335. Set the screws and the Target Foil Bottom Clamp aside.
13. Remove the two (2) 4-40 x 5/16" nylon pan head screws from the Top Target Foil Clamp, dwg# 3A3325. Set the screws and the top clamp aside.
14. Remove the Target Foil, dwg# 3A3308, from the Target Foil Holder, dwg# 3A3391, and store it for use at a later time if it is still usable.
15. Remove the two (2) 4-40 x 3/8" nylon pan head screws from the top of the Target Foil Frame, dwg# 3A3334. Set the screws and the frame aside.
16. Load the top of the new Target Foil into the Target Foil Holder making sure the thru holes on the Target Foil line up with the threaded holes on the Target Foil Holder.
17. Place the Top Target Foil Clamp on top of the Target Foil making sure all of the holes line up.
18. Insert the two (2) 4-40 x 5/16" nylon pan head screws in the holes in the Top Target Foil Clamp. Tighten the screws until the top clamp is securely held in place.
19. Insert the Target Foil Holder/Target Foil/Top Target Foil Clamp into the slot at the top of the Target Foil Frame.

20. Insert the two (2) 4-40 x 3/8" nylon pan head screws into the top thru holes on the Target Foil Frame and start threading the screws into the Target Foil Holder. (*note- Do not screw the screws into the Target Foil Holder too far at this time. The screws are used to remove the slack and wrinkles from the Target Foil after it is clamped to the bottom of the Target Foil Frame.*)
21. Straighten the Target Foil so that it stretches across the bottom cutout section of the Target Foil Frame.
22. Place the Target Foil Bottom Clamp, with the elevated side down toward the Target Foil, in position on the cutout section on the bottom of the Target Foil Frame.
23. Align the thru holes on the bottom clamp with the threaded holes on the cutout section on the bottom of the frame.
24. Insert the two (2) 4-40 x 3/8" nylon pan head screws in the holes in the bottom clamp and start threading the screws into the frame until the screws just touch the clamp surface.
25. Tighten the screws on top of the frame until the bottom of the Target Foil is flush with the bottom-most edge of the Target Foil Frame, also the Target Foil should be centered between the screws on the Target Foil Bottom Clamp.
26. Tighten the screws on the bottom clamp until they securely clamp the bottom of the Target Foil in place. (*note- It is necessary to tighten the screws on the Target Foil Bottom Clamp evenly so the top of the bottom clamp remains parallel with the surface of the Target Foil Frame. This ensures maximum surface contact of the Target Foil Bottom Clamp with the Target Foil increasing the clamping efficiency.*)
27. Tighten the screws on the top of the Target Foil Frame until the wrinkles and curling are removed from the Target Foil. (*note- Do not overtighten the screws as it will result in distortion or breakage of the Target Foil.*)
28. Insert the top of the frame into the slot provided on the Target Foil Frame Mounting Bracket.
29. Align the thru holes on the mounting bracket with the threaded holes on the frame.
30. Attach the mounting bracket to the Target Foil Frame using the two (2) 4-40 x 7/16" nylon pan head screws. Tighten the screws until the frame is held firmly in place. (*note- Do not overtighten the screws as they may be overstressed and break.*)
31. Position the Target Foil Assembly so the open part of the Target Foil Frame is facing downstream toward the electron detector which will make the Target Foil surface normal to the centerline of the Collimator Port on the TPCS.
32. Insert the Target Foil Assembly into the Target Foil Access Port on the One-piece Drift Tube.
33. Slide the Target Foil Assembly into the Target Foil Access Port while maintaining contact between the upstream edge of the Target Foil Frame and the upstream wall of the Target Foil Access Port. Make sure the grooves on the o.d. of the Target Foil Frame Mounting Bracket align with the alignment pins in the Target Foil Access Port and the Target Foil Assembly is seated in the port. (*note- The top surface of the Target Foil Frame Mounting Bracket should be parallel to the Center Rod if the assembly is seated properly.*)
34. Position the Target Foil Retaining Ring so the side with the springs protruding from it is parallel to and facing the top surface of the mounting bracket.
35. Insert the Target Foil Retaining Ring into the i.d. of the Target Foil Access Port making sure the springs contact the top surface of the mounting bracket.
36. Remove the Parker #2-236 o-ring from the groove on the Target Foil Access Port Flange.
37. Clean the o-ring using ethanol or methanol and a clean lint-free cloth.
38. Lubricate the o-ring using vacuum grease, preferably Apiezon Type L.
39. Clean the o-ring groove on the Target Foil Access Port Flange using ethanol or methanol, Q-tips, and a clean lint-free cloth.
40. Replace the lubricated o-ring in the groove on the Target Foil Access Port Flange.

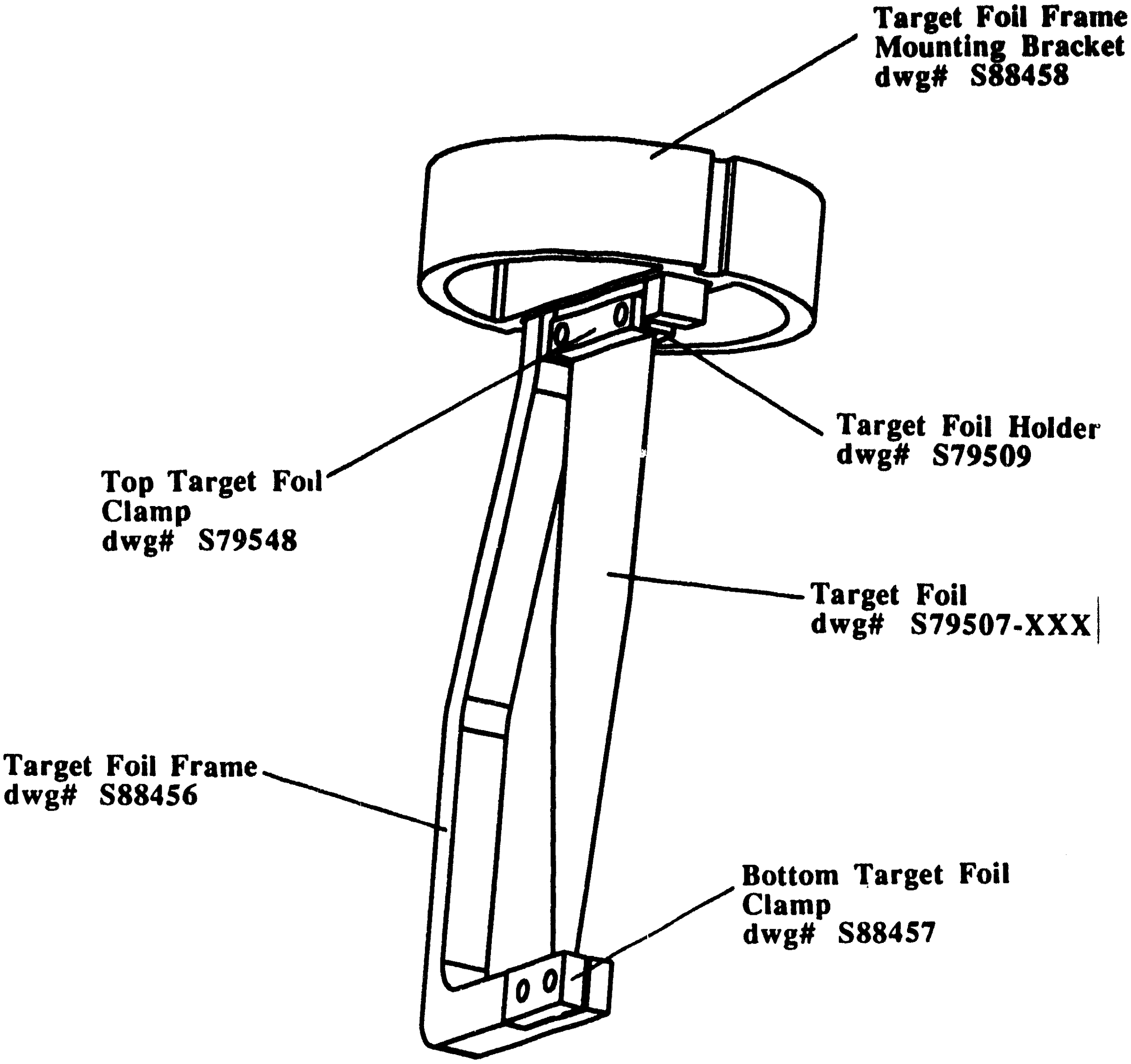


Figure 17: Polypropylene Target Foil Assembly

41. Clean the vacuum-side of the Target Foil Access Plate using ethanol or methanol and a clean lint-free cloth.
42. Position the access plate so the acrylic window is on the side of the get-lost port.
43. Attach the Target Foil Access Plate to the Target Foil Access Port Flange using eight (8) 8-32 x 5/8"steel socket head screws. Tighten the screws using a standard eight-hole flange tightening pattern until snug. (*note- Care should be taken to prevent the screws being installed into the Target Foil Access Plate from dropping inside of the radiation shield. It is a good idea to drape a towel between the underside of the access plate port and the edge of the radiation shield to act as a catch net for the screws in the event they are dropped during installation.*)
44. Evacuate the spectrometer following steps outlined in procedure 5.2 of this manual.
45. Disconnect the cables connected to the vacuum gauges following steps outlined in procedure 5.3 of this manual.
46. Replace the Target Foil Access Port Plug on RSM1.

5.8.2.2 <u>Gold Target Foil</u>

This procedure assumes that the TPCS system is loaded with a Target Foil Assembly containing a gold Target Foil and that a different gold Target Foil is to be installed in the TPCS, refer to figure 18. Also, it is assumed that the spectrometer is installed in the radiation shield, and the spectrometer collimator port is pointed toward the X-ray source.

1. Safe the TPCS Capacitor Bank following steps outlined in procedure 5.5.
2. Vent the TPCS vacuum chamber, if required, following steps outlined in procedure 5.4.
3. Attach rigging to the Target Foil Access Port Plug for lifting by the RBC2000.
4. Remove the access port plug from RSM1 following procedures outlined in section 6.2.1 of this manual.
5. Remove seven (7) 8-32 x 5/8" stainless steel socket head screws from the Ø4.125" BC on the Target Foil Access Plate, dwg# 3A3430, and set them aside. (*note- Care should be taken to prevent the screws removed from the Target Foil Access Plate from dropping inside of the radiation shield. It is a good idea to drape a towel between the underside of the access plate port and the edge of the radiation shield to act as a catch net for the screws in the event they are dropped during removal.*)
6. Hold the Target Foil Access Plate with one hand while removing the final 8-32 x 5/8" screw from the plate.
7. Remove the Target Foil Access Plate and the 8-32 x 5/8" screw from the spectrometer and set aside in a clean dry location.
8. Remove the Target Foil Retaining Ring, dwg# 3A3360, from the spectrometer and set aside in a clean dry location.
9. Remove the Target Foil Assembly from the spectrometer by grabbing hold of the Target Foil Frame Mounting Bracket, dwg# 3A3336, and pulling the Target Foil Assembly straight out of the port. Set the assembly aside in a clean dry location.
10. Remove the two (2) 4-40 x 7/16" nylon pan head screws from the Target Foil Frame Mounting Bracket.
11. Lay the Target Foil Frame Assembly down on a clean dry flat work surface.
12. Remove the two (2) 6-32 x 1/2" nylon pan head screws securing the Target Foil Mounting Frame, dwg# 3A3389, to the Target Foil Frame Mounting Bracket. Set the screws and the mounting frame aside.
13. Attach a blank Target Foil Mounting Frame to the Target Foil Frame Mounting Bracket using two (2) 6-32 x 1/2" nylon pan head screws.

14. Attach the Target Foil Mounting Frame containing the new gold Target Foil to the Target Foil Frame Mounting Bracket using two (2) 6-32 x 1/2" nylon pan head screws. Tighten the screws sufficiently to prevent the movement of the mounting frame in the mounting bracket.
15. Insert the top of the mounting frame into the slot provided on the mounting bracket.
16. Align the thru holes on the mounting bracket with the threaded holes on the mounting frame.
17. Attach the Target Foil Mounting Frame to the Target Foil Frame Mounting Bracket using the two (2) 4-40 x 7/16" nylon pan head screws. Tighten the screws until the Target Foil Frame is held firmly in place. (*note- Do not overtighten the screws as they may be overstressed and break.*)
18. Position the Target Foil Assembly so the gold Target Foil is facing downstream toward the electron detector which will make the Target Foil surface normal to the centerline of the Collimator Port on the TPCS.
19. Insert the Target Foil Assembly into the Target Foil Access Port on the One-piece Drift Tube.
20. Slide the Target Foil Assembly into the Target Foil Access Port while maintaining contact between the upstream edge of the Target Foil Frame Mounting Bracket and the upstream wall of the Target Foil Access Port. Make sure the grooves on the o.d. of the mounting bracket align with the alignment pins in the Target Foil Access Port and the Target Foil Assembly is seated in the port. (*note- The top surface of the Target Foil Frame Mounting Bracket should be parallel to the Center Rod if the assembly is seated properly.*)
21. Position the Target Foil Retaining Ring so the side with the springs protruding from it is parallel to and facing the top surface of the Target Foil Frame Mounting Bracket.
22. Insert the Target Foil Retaining Ring into the i.d. of the Target Foil Access Port making sure the springs contact the top surface of the Target Foil Frame Mounting Bracket.
23. Remove the Parker #2-236 o-ring from the groove on the Target Foil Access Port Flange.
24. Clean the o-ring on using ethanol or methanol and a clean lint-free cloth.
25. Lubricate the o-ring using vacuum grease, preferably Apiezon Type L.
26. Clean the o-ring groove on the Target Foil Access Port Flange using ethanol or methanol, Q-tips, and a clean lint-free cloth.
27. Replace the lubricated o-ring in the groove on the Target Foil Access Port Flange.
28. Clean the vacuum-side of the Target Foil Access Plate using ethanol or methanol and a clean lint-free cloth.
29. Position the access plate so the acrylic window is on the side of the get-lost port.
30. Attach the Target Foil Access Plate to the Target Foil Access Port Flange using eight (8) 8-32 x 5/8"steel socket head screws. Tighten the screws using a standard eight-hole flange tightening pattern until snug. (*note- Care should be taken to prevent the screws being installed into the Target Foil Access Plate from dropping inside of the radiation shield. It is a good idea to drape a towel between the underside of the access plate port and the edge of the radiation shield to act as a catch net for the screws in the event they are dropped during installation.*)
31. Evacuate the spectrometer following steps outlined in procedure 5.2 of this manual.
32. Disconnect the cables connected to the vacuum gauges following steps outlined in procedure 5.3 of this manual.
33. Replace the Target Foil Access Port Plug on RSM1.

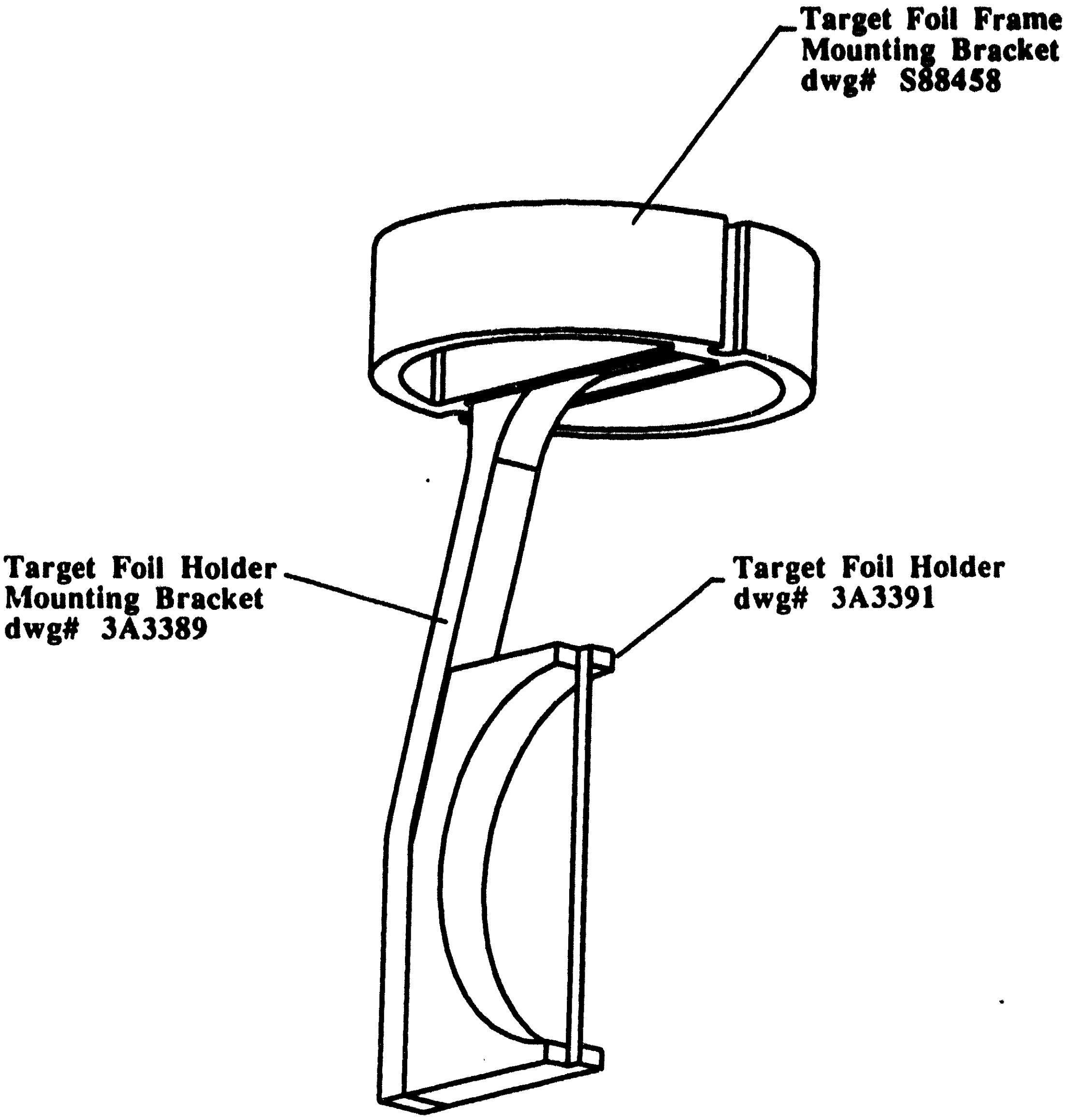


Figure 18: Gold Target Foil Assembly

5.8.2.3 Changing from a Polypropylene Target Foil to a Gold Target Foil

This procedure assumes that the TPCS system is loaded with a Target Foil Assembly containing a polypropylene Target Foil and that a gold Target Foil is to be installed in the TPCS. Also, it is assumed that the spectrometer is installed in the radiation shield, and the spectrometer collimator port is pointed toward the X-ray source.

1. Follow steps 1-14 of procedure 5.8.2.1.
2. Follow steps 12-29 of procedure 5.8.2.2.

5.8.2.4 Changing from a Gold Target Foil to a Polypropylene Target Foil

This procedure assumes that the TPCS system is loaded with a Target Foil Assembly containing a gold Target Foil and that a polypropylene Target Foil is to be installed in the TPCS. Also, it is assumed that the spectrometer is installed in the radiation shield, and the spectrometer collimator port is pointed toward the X-ray source.

1. Follow steps 1-11 of procedure 5.8.2.2.
2. Follow steps 15-43 of procedure 5.8.2.1.

5.8.2.5 Changing from a Polypropylene Target Foil to No Target Foil

This procedure assumes that the TPCS system is loaded with a Target Foil Assembly containing a polypropylene Target Foil and that the Target Foil Assembly will be reinstalled in the TPCS without a Target Foil in place to obtain background data. Also, it is assumed that the spectrometer is installed in the radiation shield, and the spectrometer collimator port is pointed toward the X-ray source.

1. Follow steps 1-14 of procedure 5.8.2.1.
2. Follow steps 27-43 of procedure 5.8.2.1

5.8.2.6 Changing from a Gold Target Foil to No Target Foil

This procedure assumes that the TPCS system is loaded with a Target Foil Assembly containing a gold Target Foil and that the Target Foil Assembly will be reinstalled in the TPCS without a Target Foil in place to obtain background data. Also, it is assumed that the spectrometer is installed in the radiation shield, and the spectrometer collimator port is pointed toward the X-ray source.

1. Follow the steps outlined in procedure 5.8.2.2 except for changing step 12 to read as follows: 12. Attach a blank Target Foil Mounting Frame to the Target Foil Frame Mounting Bracket using two (2) 6-32 x 1/2" nylon pan head screws. Tighten the screws sufficiently to prevent the movement of the mounting frame in the mounting bracket.

5.8.2.7 Changing from No Target Foil to a Polypropylene Target Foil

This procedure assumes that the TPCS system is loaded with a Target Foil Assembly containing no Target Foil and that a polypropylene Target Foil is to be installed in the TPCS. Also, it is assumed that the spectrometer is installed in the radiation shield, and the spectrometer collimator port is pointed toward the X-ray source.

1. Follow steps 1-9 of procedure 5.8.2.1.
2. Follow steps 15-43 of procedure 5.8.2.1.

5.8.2.8 Changing from No Target Foil to a Gold Target Foil

This procedure assumes that the TPCS system is loaded with a Target Foil Assembly containing no Target Foil and that a gold Target Foil is to be installed in the TPCS. Also, it is assumed that the spectrometer is installed in the radiation shield, and the spectrometer collimator port is pointed toward the X-ray source.

1. Follow steps outlined in procedure 5.8.2.2.

5.8.3 Changing ND Filters

This procedure should be followed to change the optical attenuation of the PMT input provided by the ND Filters. It is assumed that the spectrometer is installed in the radiation shield, and the spectrometer collimator port is pointed toward the X-ray source.

1. Attach rigging to the ND Filter Access Port Plug for lifting by the RBC2000.
2. Lift the ND Filter Access Port Plug from RSM1 using the RBC2000.
3. **Ensure the PMT bias supply is turned off!** (*note- The bias must be secured from the PMT to prevent overdriving and possibly permanent damage to the PMT when it is exposed to ambient light and biased.*)
4. Remove the PMT Housing ND Filter Access Port Lid, dwg# 3A3359, from the PMT Housing by holding the handle on the lid and turning counterclockwise until the lid is separated from the housing.
5. Slide the ND Filter Holder Retaining Pin Actuating Handle, dwg# 3A3436, so the ND Filter Frame Assembly is free to slide out of the ND Filter Holder Assembly.
6. Remove the ND Filter Frame Assembly from the ND Filter Holder Assembly by holding the ND Filter Frame Handle, dwg# 3A3354 and lifting the ND Filter Frame Assembly straight out of the ND Filter Holder Assembly. Set the ND Filter Frame Assembly on a flat clean dry work surface with the screws facing skyward.
7. Remove the four (4) 4-40 x 5/16" steel flat head screws from the ND Filter Retaining Clamp, dwg# 3A3433. Set the screws and the clamp aside.
8. Add or delete ND Filters as required for the experiment.
9. Replace the ND Filter Retaining Clamp on the ND Filter Retaining Frame, dwg# 3A3432.
10. Attach the clamp to the ND Filter Retaining Frame using the four (4) 4-40 x 5/16" flat head screws. Tighten the screws until snug.
10. Hold the ND Filter Frame Assembly by the ND Filter Frame Handle and install the assembly in the ND Filter Holder Assembly. (*note- Make sure the assembly is fully inserted into the ND Filter Holder Assembly so the ND Filter Holder Retaining Pin Actuating Handle can slide freely.*)
11. Slide the handle toward the PMT to lock the ND Filter Frame Assembly in position.
12. Replace the PMT Housing ND Filter Access Port Lid on the PMT Housing.
13. Replace the ND Filter Access Port Plug on the radiation shield using the RBC2000.
14. Disconnect the RBC2000 from the ND Filter Access Port Plug.

5.8.4 Changing PMTs

This procedure should be used when it is necessary to change or replace a PMT that is loaded into the spectrometer. It is assumed that the spectrometer is installed in the radiation shield, and the spectrometer collimator port is pointed toward the X-ray source.

1. Rotate the radiation shield assembly to the drift tube loading position with the Collimator Port and the Vacuum Port centerline axes parallel to the floor following steps detailed in procedure 4.7 of this manual.
2. Rig the RBC2000 boom crane to the RSM3 End Plug.
3. **Ensure the PMT bias supply is turned off!**
4. Disconnect the three (3) coaxial cables connected to the end plug. (*note- As each cable is removed, ensure that the cable is labeled with the corresponding signal designation.*)
5. Remove the four (4) 1/4-20 x 3/8 steel hex head screws and the four (4) Ø0.625" o.d. 1/4" screw steel flat washers from the RSM3 Connector Feedthru Plate.
6. Remove the connector feedthru plate from the radiation and disconnect the three (3) coaxial cables connected to the RSM3 End Plug. Push the cables inside of the radiation shield. (*note- As each cable is removed, ensure that the cable is labeled with the corresponding signal designation.*)
7. Remove the slack from the rigging connected to the RBC2000.
8. Remove the five (5) each 3/8-16 x 7/8" steel hex head screws and five (5) each Ø1.0 o.d. 3/8" screw steel flat washers from the RSM3 End Plug.
9. Remove the RSM3 End Plug from the radiation shield and set aside out of the way.
10. Remove the clamp attaching the Ø1 1/2" tinned copper braid to the nipple extending from the PMT Cable Feedthru Tube.
11. Remove the light blocking opaque putty filling the cable feedthru opening on the cable feedthru tube.
12. Remove the four (4) each 1/4-20 x 5/8" steel socket head screws from the cable feedthru tube.
13. Slide the cable feedthru tube away from the PMT Housing End Plate until the connectors on the end of the PMT are accessible.
14. Disconnect the two (2) connectors from the PMT. (*note- Leave the coaxial cables, braid, and PMT Cable Feedthru Tube together as an assembly.*)
15. Remove the eight (8) each 1/4-20 x 1/2" steel socket head screws and eight (8) each 1/4" screw steel flat washers from the PMT Housing End Plate. Set the end plate aside out of the way.
16. Remove the three (3) 1/4-20 wing nuts and Ø0.625"o.d. 1/4" screw steel flat washers from the PMT mounting rods.
17. Slide one arm underneath the PMT and grasp the underside of the PMT with one hand positioned near the optical input to the PMT.
18. Hold on to the o.d. of the housing containing the resistor string and the electrical connectors on the PMT with the free hand.
19. Pull the PMT straight out of the PMT Housing. (*note- Make sure the underside of the PMT/ND Filter Holder Assembly is supported sufficiently to prevent dropping of the optical input end when the assembly is separated from the Sum Coupler.*)
20. Position the ND Filter Holder Assembly so the nontapered i.d is parallel to and facing the PMT glass input window.
21. Insert the ND Filter Holder Assembly into the i.d. of the PMT shield.
22. Slide the ND Filter Holder Assembly toward the PMT glass input window until it contacts the plastic PMT alignment ring.
23. Install the PMT/ND Filter Holder Assembly on the PMT Mounting Rods.
24. Slide the assembly toward and onto the Sum Coupler.

25. Install one (1) 1/4" screw flat washer and one (1) 1/4-20 wing nut on each of the PMT Mounting Rods. **Screw the wing nuts onto the PMT Mounting Rods until they just contact the plastic support bracket on the PMT.**
26. Rotate the ND Filter Holder Assembly so the ND Filter Frame can be removed through the
top two (2) PMT Mounting Rods.
27. Tighten the 1/4-20 wing nuts on the PMT Mounting Rods just enough to prevent the easy rotation of the ND Filter Holder. (*note- The wing nuts securing the PMT Assembly should not be overtightened as breakage of the PMT envelope may result, destroying the tube!*)
28. Rotate the ND Filter Holder Assembly so the ND Filter Frame can be removed through the ND Filter Access Port.
29. Tighten the 1/4-20 wing nuts on the PMT Mounting Rods just enough to prevent the easy rotation of the ND Filter Holder. (*note- The wing nuts securing the PMT Assembly should not be overtightened as breakage of the PMT envelope may result!*)
30. Stand the PMT Housing End Plate on edge and positioned close to the end flange on the PMT Housing.
31. Align the thru holes on the PMT Housing End Plate with the threaded holes on the end flange of the PMT Housing.
32. Attach the PMT Housing End Plate to the PMT Housing using eight (8) each 1/4-20 x 1/2" steel socket head screws and eight (8) each 1/4" screw steel flat washers. Tighten the screws using a standard eight-hole flange tightening pattern until all screws are snug.
33. Reconnect the coaxial cables to the bulkhead connectors on the PMT.
34. Slide the PMT Cable Feedthru Tube toward the PMT Housing End Plate.
35. Align the four (4) thru holes on the Ø3.50" BC on the cable feedthru tube flange with the four (4) threaded holes on the Ø3.50" BC on the PMT Housing End Plate.
36. Attach the cable feedthru tube to the PMT Housing End Plate using four (4) each 1/4-20 x 5/8" steel socket head screws. Tighten the screws using a standard four-hole flange tightening pattern until all screws are snug.
37. Fill the cable feedthru opening on the cable feedthru tube with an opaque putty, preferably Apiezon type-Q, making a light tight seal for the PMT.
38. Slide the Ø1 1/2" braid over the nipple extending from the cable feedthru tube.
39. Attach the Ø1 1/2" braid to the nipple using a radiator/cable clamp or a nylon cable tie.
40. Position the RSM3 End Plug so it can be inserted into the RSM3 using the RBC2000.
41. Pull the three (3) coaxial cables inside the radiation shield through the rectangular hole in the end plug.
42. Install the end plug on the RSM3 end flange. Use the two (2) alignment pins on the RSM3 to guide the end plug into place.
43. Attach the end plug to the RSM3 using five (5) each 3/8-16 x 7/8" steel hex head screws and five (5) each Ø1.0 o.d. 3/8" screw steel flat washers. Tighten the screws until snug.
44. Disconnect the rigging and the RBC2000 from the RSM3 End Plug. Secure the RBC2000.
45. Connect the three (3) coaxial cables coming from the inside of the RSM3 to the RSM3 Connector Feedthru Plate.
46. Align the four (4) thru holes on the connector feedthru plate with the four (4) threaded holes around the rectangular thru hole on the RSM3.
47. Attach the connector feedthru plate to the RSM3 End Plug using four (4) 1/4-20 x 3/8 steel hex head screws and four (4) Ø0.625" o.d. 1/4" screw steel flat washers. Tighten the screws until snug.
48. Connect the three (3) signal and bias coaxial cables to the appropriate connectors on the end plug.

49. Align the Radiation Shield Module Assembly to the radiation source following procedure 5.9 of this manual.

5.9 Aligning the TPCS to the Radiation Source

This procedure details the steps necessary to align the TPCS collimator port to the radiation source using the HeNe alignment laser. It is assumed that the Radiation Shield Module Assembly needs to be rotated up so that the collimator port on the spectrometer points toward the source. (*note- Two (2) individuals will be required to perform this procedure. One person will operate the electrohydraulic pump, and the other person will act as a spotter to ensure cables, hardware, or personnel are not in danger during rotation of the Radiation Shield Module Assembly.*)

1. Remove the Collimator Element Stack from the spectrometer following steps detailed in procedure 6.3 of this manual.
2. Hold the handle of the HeNe Alignment Laser System and insert the assembly into the i.d. of the Collimator Shielded Port.
3. Slide the assembly into the Collimator Shielded Port until it fully seated in the Collimator Shielded Port.
4. Plug the cable from the laser tube into the Laser Power Supply.
5. Plug the power cord for the Laser Power Supply into a 120VAC receptacle.
6. Alert personnel in the area of the output of the alignment laser that Class II laser light will be emitted from the alignment laser during the TPCS alignment process.
7. Depress the MOTOR switch on the pendant switch box for the electrohydraulic pump.
8. Depress and quickly release the UP switch on the pendant switch box several times until the pin through the top of the hydraulic actuator just contacts the RSM3 tab.
9. Release the UP and MOTOR switches on the pendant switch box.
10. Remove the retaining pin at the top of the turnbuckle connected to each Radiation Shield Module.
11. Swing the top of the turnbuckles out, down, and away from the shield tabs.
12. Turn on the power switch for the Laser Power Supply.
13. Depress the MOTOR and UP switches on the pendant switch box to extend the hydraulic actuator's cylinder. (*note- There is a manually-operated flow metering valve located on the electrohydraulic pump output port that allows the speed of the hydraulic actuator cylinder extension and retraction to be adjusted. It is very useful to slow the extension or retraction of the hydraulic actuator cylinder when the alignment laser beam spot is close to the desired position.*)
14. Release the UP and MOTOR switches on the pendant switch box when the alignment laser's beam spot is in the desired position on the radiation source or the hydraulic actuator is extended fully.
15. Attach the top of the turnbuckles to the shield tabs and tighten the turnbuckles so the turnbuckles are pulling down on the shield tabs.
16. Go to step 5.9.23 if the Radiation Shield Module Assembly is rotated to the desired position.
17. Depress the MOTOR switch on the pendant switch box.
18. Depress and quickly release the DOWN switch on the pendant switch box several times until the retaining pin through the top of the hydraulic actuator can be removed from the RSM3 tab.
19. Remove the retaining pin from the top of the hydraulic actuator.
20. Depress the MOTOR and DOWN switches on the pendant switch box to retract the hydraulic actuator's cylinder so that it can be attached to the next lower shield tab.
21. Attach the top of the hydraulic actuator to the shield tab using the retaining pin.

22. Repeat steps 5.9.8-12 and steps 5.9.14-22 as required until the Radiation Shield Module Assembly is rotated to the desired position.
23. Verify that the position of the laser beam spot on the radiation source is as desired once the turnbuckles are locked in place.
24. Turn off the power switch for the Laser Power Supply.
25. Disconnect the power cord for the Laser Power Supply from the 120VAC receptacle.
26. Disconnect the cable from the laser tube from the Laser Power Supply.
27. Short the electrodes on the cable connected to the laser tube to some bare metal on the shield or on the Alignment Laser Assembly. (*note- The laser tube acts as a capacitor and stores charge while it is biased. Shorting the electrodes to one another ensures no charge is stored in the laser tube and eliminates the shock hazard associated with the stored charge and bare electrodes.*)
28. Hold the handle on the Alignment Laser Assembly and pull the assembly out of the Collimator Shielded Port.
29. Go to step 5.9.36 if this is not the first time the collimator stack is being assembled.
30. Lay the bottom Collimator Three, dwg# 3A3324, on a flat clean surface and apply a thin film of vacuum grease on one (1) face of the bottom Collimator #3.
31. Lay the bottom Collimator Two, dwg# 3A3323, on top of the layer of vacuum grease on Collimator #3.
32. Adjust the position of Collimator #2 so its i.d. is concentric with the i.d. of Collimator #3.
33. Apply a thin film of vacuum grease on the exposed face of the bottom Collimator #2.
34. Lay the bottom Collimator #1, dwg# 3A3309, on top of the layer of vacuum grease on Collimator #2.
35. Adjust the position of Collimator #1 so its i.d. is concentric with the i.d. of Collimator #2 and Collimator #3.
36. Insert the rubber washer end of the Collimator Element Removal and Replacement Tool into the i.d. of the bottom Collimator Assembly until it stops.
37. Tighten the wing nut on the Collimator Element Removal and Replacement Tool until the Collimator Assembly can be lifted without it sliding off the Collimator Element Removal and Replacement Tool.
38. Insert Collimator Assembly into the Ø3.02" i.d. of the Collimator Shielded Port.
39. Slide the Collimator Assembly into the Collimator Shielded Port until the bottom of the assembly is seated in the Collimator Shielded Port Insulating Adaptor Ring.
40. Loosen the wing nut on the Collimator Element Removal and Replacement Tool sufficiently to allow the Collimator Element Removal and Replacement Tool to be removed from the Collimator #1 i.d.
41. Remove the Collimator Element Removal and Replacement Tool from the i.d. of the bottom Collimator #1.
42. Insert the Collimator Stack Middle Spacer Tube, dwg# 3A3362, into the Ø3.02" i.d. of the Collimator Shielded Port.
43. Slide the Collimator Stack Middle Spacer Tube into the i.d. of the Collimator Shielded Port until it contacts the face of the bottom Collimator #1.
44. Insert the rubber washer end of the Collimator Element Removal and Replacement Tool into the i.d. of the top Collimator #2 and Collimator #3 collimator elements until the rubber washers are slid just beyond the i.d. of the top Collimator #3.
45. Hold the Collimator Element Removal and Replacement Tool off to one side so the i.d.s of the collimator elements are in contact with the aluminum barrel of the Collimator Element Removal and Replacement Tool.
46. Insert the top Collimator #2/Collimator #3 Assembly into the Ø3.02" i.d. of the Collimator Shielded Port.
47. Slide the top Collimator #2/Collimator #3 Assembly into the i.d. of the Collimator Shielded Port until the bottom face of the top Collimator #3 contacts the top surface of the Collimator Stack Middle Spacer Tube.

48. Remove the Collimator Element Removal and Replacement Tool from the i.d. of the top Collimator #2/Collimator #3 Assembly.
49. Insert the rubber washer end of the Collimator Element Removal and Replacement Tool into the i.d. of the top Collimator #1 until it stops.
50. Tighten the wing nut on the Collimator Element Removal and Replacement Tool until the top Collimator #1 can be lifted without it sliding off the Collimator Element Removal and Replacement Tool.
51. Insert top Collimator #1 into the Ø3.02" i.d. of the Collimator Shielded Port.
52. Slide the top Collimator #1 into the i.d. of the Collimator Shielded Port until its bottom face contacts the top face of the top Collimator #2.
53. Loosen the wing nut on the Collimator Element Removal and Replacement Tool sufficiently to allow the Collimator Element Removal and Replacement Tool to be removed from the Collimator #1 i.d.
54. Remove the Collimator Element Removal and Replacement Tool from the top Collimator #1.
55. Insert the Ø3.0" o.d. opaque light blocking sheet into the i.d. of the Collimator Shielded Port. (*note- The Ø3.0" o.d. opaque light blocking sheet should lay flat against the face of the top Collimator #1.*)
56. Insert the Collimator Spacer, dwg# 3A3390, into the Ø3.02" i.d. of the Collimator Shielded Port.
57. Slide the Collimator Spacer into the i.d. of the Collimator Shielded Port until it contacts the opaque light blocking sheet. (*note- At this point the top face of the Collimator Spacer should be slightly below the plane defined by the top of the Ø3.02" i.d. of the Collimator Shielded Port. If the Collimator Spacer extends above the plane, the collimator stack is not properly seated in the Collimator Shielded Port, and the collimator elements will have to be removed to correct the problem.*)
58. Position the Collimator Stack Retaining Slug, dwg# 3A3351, so the end with the chamfered opening is facing away from the Collimator Shielded Port.
59. Insert the Collimator Stack Retaining Slug into the Ø5.69" i.d. of the Collimator Shielded Port.
60. Slide the Collimator Stack Retaining Slug into the i.d. of the Collimator Shielded Port until it is fully seated into the Ø5.69" i.d. of the Collimator Shielded Port.

5.10 Zero kV Charge Sequence

This procedure should be followed to charge the TPCS Capacitor Bank to a 0kV charge voltage. A 0kV charge sequence will allow the TPCS triggering circuits to be checked for proper operation without the need to actually charge the capacitors. This procedure assumes that the TPCS will be triggered by Facility Control Monitor.
2. Turn the RUN/SAFE key switch on the TPCS Capacitor Bank Controller to the RUN position. (*note- The RUN/SAFE indicator should have the RUN section illuminated.*)

1. Complete the pre-shot portion of the Procedure Checklist for Operating the TPCS with the Accelerator, located in section 12.0 of this manual. (*note-* ***Always assume the Capacitors are charged when performing inspections or maintenance on the TPCS Capacitor Bank.***)
2. Set the Charge Voltage Set Vernier on the TPCS Capacitor Bank Controller to 0kV.
3. Turn the RUN/SAFE key switch on the TPCS Capacitor Bank Controller to the RUN position. (*note- The RUN/SAFE indicator should have the RUN section illuminated.*)
4. Depress the ARM switch on the TPCS Capacitor Bank Controller. (*note- The ARM/ARMED indicator should have the ARMED section illuminated.*)

5. Depress the CHARGE button on the TPCS Capacitor Bank Controller. (*note- The CHARGE/CHARGING indicator should have the CHARGING section illuminated and the CHARGE COMPLETE and FIRE READY indicators should illuminate.*)
6. Turn the RUN/SAFE key switch on the TPCS Capacitor Bank Controller to the SAFE position upon completion of tests. (*note- The RUN/SAFE indicator should have the SAFE section illuminated.*)
7. Complete the post-shot portion of the Procedure Checklist for Operating the TPCS with the Accelerator, located in section 12.0 of this manual. (*note-* ***Always assume the Capacitors are charged when performing inspections or maintenance on the TPCS Capacitor Bank.***)

5.11 Securing the TPCS System Following a Shot Series

This procedure should be followed to secure the TPCS system following a shot series.

1. Complete the post-shot portion of the Procedure Checklist for firing the TPCS with the Accelerator, located in section 12.0 of this manual.
2. Vent the spectrometer to atmosphere according to procedure 5.4.
3. Disconnect the vacuum gauges from the TPCS system following procedure 5.3.
4. Rotate the Radiation Shield Assembly to the drift tube loading position with the Collimator Port and the Vacuum Port centerline axes parallel to the floor following steps detailed in procedure 4.7 of this manual.
5. Unplug the 480VAC and the 120VAC power cords supplying the TPCS Capacitor Bank from the wall receptacles. Wind up the power cords and store them on top of the TPCS Capacitor Bank..
6. Disconnect the power cord supplying the Vacuum Roughing Pump from the wall receptacle. Wind up the power cord and store in the compartment under RSM2 with the Vacuum Roughing Pump.
7. Turn off the 120VAC to the Vacuum Turbomolecular Pump Cooling Fans.
8. Unplug the 120VAC power cord supplying the Vacuum Turbomolecular Pump Cooling Fans from the wall receptacle. Wind up the power cord and store in the compartment under RSM1 with the Vacuum Turbomolecular Pump.
9. Disconnect the control cable for the Vacuum Turbomolecular Pump from the pump. Wind up the control cable and store it next to the vacuum gauge cables.
10. Disconnect the control cable for the System Gate Valve. Wind up the control cable and store it next to the vacuum gauge cables and the Vacuum Turbomolecular Pump control cable.
11. Disconnect the air supply line for the System Gate Valve from the System Gate Valve and the facility air pressure regulator. Wind up the air line and store inside of the TPCS Capacitor Bank.
12. Disconnect the signal and bias cables connected to the Radiation Shield and the PIN.
13. Make sure all doors are secured and locked on the TPCS Capacitor Bank.
14. Secure power to the TPCS Capacitor Bank Controller.
15. Store the keys to the TPCS Capacitor Bank Controller and the RBC2000 in the Tool box located near the TPCS Capacitor Bank.

6.0 System Disassembly

6.1 Radiation Shield Plug Removal

6.1.1 Neutral Density Filter Access Port Plug Removal

This procedure describes the steps necessary to remove the Neutral Density Filter Access Port Plug from RSM3. Removal of the plug is more easily accomplished if the Radiation Shield Module Assembly is in the drift tube loading position; however, it is not necessary to be in this position to remove the ND Filter Access Port Plug.

1. Attach rigging to the ND Filter Access Port Plug for lifting by the RBC2000.
2. Lift the ND Filter Access Port Plug from the ND Filter Access Port on RSM3 using the RBC2000. (*note- If the Radiation Shield Module Assembly is rotated from the drift tube loading position, the RBC2000 boom will have to be lifted slightly and then retracted slightly for several cycles to remove the ND Filter Access Port Plug.*)
3. Lower the ND Filter Access Port Plug to the floor and remove the rigging.

6.1.2 Target Foil Access Port Plug Removal

This procedure describes the steps necessary to remove the Target Foil Access Port Plug from RSM1. Removal of the access port plug is more easily accomplished if the Radiation Shield Module Assembly is in the drift tube loading position; however, it is not necessary to be in this position to remove the Target Foil Access Port Plug.

1. Attach rigging to the Target Foil Access Port Plug for lifting by the RBC2000.
2. Lift the access port plug from the ND Filter Access Port on RSM1 using the RBC2000. (*note- If the Radiation Shield Module Assembly is rotated from the drift tube loading position, the RBC2000 boom will have to be lifted slightly and then retracted slightly for several cycles to remove the Target Foil Access Port Plug.*)
3. Lower the access port plug to the floor and remove the rigging.

6.1.3 Radiation Shield Module Three End Plug Removal

This procedure describes the steps necessary to remove the RSM3 End Plug from the RSM3 end flange.

1. Rotate the Radiation Shield Module Assembly to the drift tube loading position following steps detailed in procedure 4.7 of this manual.
2. Attach rigging to the two (2) lifting tabs on end plug for lifting by the RBC2000.
3. Attach the RBC2000 to the rigging on the end plug and remove the slack from the rigging by raising the boom on the RBC2000.
4. Disconnect the three (3) coaxial cables connected to the outside of the RSM3 Connector Feedthru Plate.
5. Remove the four (4) each 1/4-20 x 3/8" steel hex head screws and four (4) each Ø0.625" o.d. 1/4" screw flat washers that attach the connector feedthru plate to the end plug.
6. Disconnect the three (3) coaxial cables connected to the connector feedthru plate and place the plate out of the way.
7. Remove the five (5) each 3/8-16 x 7/8" steel hex head screws and five (5) each Ø1.0" o.d. 3/8" screw flat washers that attach the end plug to the RSM3 end flange.
8. Lift and remove the end plug using the RBC2000 from RSM3.

6.1.4 Radiation Shield Module One End Plug Removal

This procedure describes the steps necessary to remove the RSM1 End Plug from the RSM1 end plug.

1. Open the RSM1 End Plug Access Door and remove the RSM1 Removable Insert Plug.
2. Close and latch the access door.
3. Attach rigging to the top lifting tab on RSM1 End Plug for lifting by the RBC2000. (*note- The top lifting tab on the end plug is the tab that is positioned equidistant between the thru holes on the Ø26.5" BC.*)
4. Attach the rigging on the end plug to the RBC2000 and remove the slack from the rigging by raising the boom on the RBC2000.
5. Remove the four (4) each 3/8-16 x 3/4" steel hex head screws and four (4) each Ø1.0" o.d. 3/8" screw flat washers that attach the RSM1 End Plug to the RSM1 end flange.
6. Lift and remove the end plug using the RBC2000 from RSM1.

6.2 Vacuum Pump System Removal

This procedure details the steps required to remove the Turbomolecular Vacuum Pump, Vacuum Gate Valve, and associated hardware from the spectrometer.

1. Rotate the Radiation Shield Module Assembly to the drift tube loading position following steps detailed in procedure 4.7 of this manual.
2. Disconnect the coaxial cable connected between the PIN Diode Detector and the Type-N Bulkhead Feedthru Mounting Bracket. (*note- Make sure the bias has been secured from the PIN Diode Detector prior to disconnecting the coaxial cable!*)
3. Remove the two (2) 6-32 x 3/8" steel socket head screws that attach the Type-N Bulkhead Feedthru Mounting Bracket to the PIN Holder.
4. Remove the mounting bracket Assembly from the PIN Holder.
5. Remove the type-N bulkhead feedthru from the mounting bracket.
6. Remove the three (3) 4-40 x 7/8" steel pan head screws that attach the PIN Detector Holder to the PIN Holder.
7. Remove the PIN Detector Holder Assembly from the PIN Holder and disassemble.
8. Disconnect the power cord for the Turbomolecular Vacuum Pump Cooling Fan Assembly from the 120VAC receptacle.
9. Disconnect the flexible vacuum hose from the foreline port on the Turbomolecular Vacuum Pump.
10. Rig the Turbomolecular Vacuum Pump and Vacuum Gate Valve so they can be lifted by the RBC2000.
11. Attach the RBC2000 to the rigging and raise the boom until the slack is removed.
12. Remove the eight (8) each 3/4-10 x 1" steel hex head screws and eight (8) each Ø2.0" o.d. 3/4" screw steel flat washers that attach the 11" rotatable ASA flange on the Vacuum Tee to the Vacuum Gate Valve mounting flange.
13. Remove the Turbomolecular Vacuum Pump/Vacuum Gate Valve from the spectrometer.
14. Remove the Turbomolecular Vacuum Pump Cooling Fan Assembly from the bottom of the Turbomolecular Vacuum Pump.
15. Attach the four (4) support legs to the Turbomolecular Vacuum Pump.
16. Set the Turbomolecular Vacuum Pump/Vacuum Gate Valve on the floor resting on the four (4) support legs.
17. Remove the Vacuum Gate Valve from the Turbomolecular Vacuum Pump.
18. Remove the eight (8) each 5/8-11 x 2-1/2" steel hex head bolts, 16 each Ø1.75" o.d. 5/8" screw steel flat washers, and eight (8) each 5/8-11 hex nuts that attach the PIN Holder/Get-Lost Port Window to the 9" non-rotatable ASA flange on the Vacuum Tee.

19. Remove the PIN Holder/Get-Lost Port Window from the Vacuum Tee.
20. Remove the eight (8) each 5/8-11 x 1-1/4" steel hex head screws and eight (8) each Ø1.75" o.d. 5/8" screw steel flat washers that attach the Vacuum Tee to the Vacuum Feedthru Port mounting flange.
21. Remove the Vacuum Tee from the spectrometer.
22. Remove six (6) of the eight (8) 1/4-20 x 1-5/8" steel socket head screws and six (6) each Ø0.625" o.d. 1/4" screw steel flat washers that attach the Vacuum Feedthru Port to the Vacuum Connection Port flange.
23. Insert two (2) 1/4-20 x 2' rods into two (2) of the holes left vacant in the above step.
24. Remove the four (4) 3/8-16 x 1" steel socket head screws that attach the Vacuum Feedthru Port to RSM1.
25. Remove the two (2) remaining 1/4-20 x 1-5/8" steel socket head screws and two (2) each Ø0.625" o.d. 1/4" screw steel flat washers that attach the Vacuum Feedthru Port to the Vacuum Connection Port flange.
26. Remove the Vacuum Feedthru Port along with the Screw Insulating Ring from the spectrometer.
27. Remove the Vacuum Interface Insulating Ring from the spectrometer.
28. Remove the two (2) 1/4-20 rods screwed into the Vacuum Connection Port flange.

6.3 Collimator Element Stack Removal

This procedure describes the steps necessary to remove the collimator elements from the Radiation Shield Module Assembly.

1. Rotate the Radiation Shield Assembly so the centerline axis of the RSM1 Collimator Port is perpendicular to the floor following steps detailed in procedure 4.7 of this manual.
2. Remove the Collimator Stack Retaining Slug from the i.d. of the Collimator Shielded Port.
3. Remove the Collimator Spacer from the i.d. of the Collimator Shielded Port.
4. Remove the Ø3.0" o.d. opaque light blocking sheet from the i.d. of the Collimator Shielded Port.
5. Insert the rubber washer end of the Collimator Element Removal and Replacement Tool into the i.d. of the top Collimator #1 until it stops.
6. Tighten the wing nut on the Collimator Element Removal and Replacement Tool until the Collimator #1 can be lifted without it sliding off the Collimator Element Removal and Replacement Tool.
7. Remove the top Collimator #1 from the i.d. of the Collimator Shielded Port.
8. Loosen the wing nut on the Collimator Element Removal and Replacement Tool and remove the Collimator Element Removal and Replacement Tool from the i.d. of the top Collimator #1.
9. Insert the rubber washer end of the Collimator Element Removal and Replacement Tool into the i.d. of the top Collimator #2 and Collimator #3 collimator elements until the rubber washers are slid just beyond the i.d. of the top Collimator #3.
10. Hold the Collimator Element Removal and Replacement Tool off to one side so the i.d.s of the collimator elements are in contact with the aluminum barrel of the Collimator Element Removal and Replacement Tool.
11. Remove the top Collimator #2 and Collimator #3 collimator elements from the i.d. of the Collimator Shielded Port while holding the Collimator Element Removal and Replacement Tool against the side of the i.d. of the collimator elements.
12. Remove the Collimator Element Removal and Replacement Tool from the i.d. of the collimator elements.
13. Insert the rubber washer end of the Collimator Element Removal and Replacement Tool into the i.d. of the bottom Collimator #1 until it stops.

14. Tighten the wing nut on the Collimator Element Removal and Replacement Tool until the Collimator #1 can be lifted without it sliding off the Collimator Element Removal and Replacement Tool.
15. Remove the bottom collimator element stack containing Collimator #1, Collimator #2, Collimator #3, and the Collimator Spacer Tube from the i.d. of the Collimator Shielded Port.

6.4 Spectrometer Removal from the Radiation Shield Module Assembly

This procedure details the steps required to remove the spectrometer from the Radiation Shield Module Assembly. It is assumed that the Radiation Shield End Plugs, Access Plugs, and vacuum pump system have already been removed from the Radiation Shield Module Assembly.

1. Rotate the Radiation Shield Module Assembly so the centerline axis of the RSM1 collimator port is perpendicular to the floor following steps detailed in procedure 4.7 of this manual.
2. Remove the four (4) each 3/8-16 x 2-1/4" steel hex head bolts and four (4) each Ø1.0" o.d. 3/8" screw steel flat washers that attach the Collimator Shielded Port to RSM1.
3. Rig the Collimator Shielded Port so that it can be lifted by its mounting flange using the RBC2000.
4. Remove the Collimator Shielded Port from RSM1 using the RBC2000.
5. Rotate the Radiation Shield Module Assembly to the drift tube loading position following steps detailed in procedure 4.7 of this manual.
6. Move the TPCS Spectrometer Loading Fixture from the spectrometer assembly area to the RSM1 end of the Radiation Shield Module Assembly.
7. Position the loading fixture/spectrometer so the end flange on the TPCS Spectrometer Loading Fixture loading tube is parallel to and facing RSM1's end flange.
8. Insert the ends of the four (4) RG220 and the one (1) RG223 coaxial cables into the i.d. of RSM1.
9. Push the loading fixture/spectrometer toward RSM1 until the end flange on the TPCS Spectrometer Loading Fixture loading tube contacts the RSM1 end flange.
10. Align the loading fixture so that loading tube axis centerline is coincident, albeit vertically displaced, with the axis centerline of the Radiation Shield Module Assembly i.d.
11. Raise the loading fixture/spectrometer until the bottom-most point of the i.d. of the TPCS Spectrometer Loading Fixture loading tube is level with the bottom-most point of the i.d. of RSM1.
12. Set the brake and close the hydraulic jack valve on the loading fixture lift table.
13. Bolt the TPCS Spectrometer Loading Fixture flange to the RSM1 end flange using two (2) each 3/8-16 x 5/8" steel hex head screws and two (2) Ø1.0" o.d. 3/8" screw steel flat washers. Tighten the screws until the loading fixture flange is flush against RSM1. (*note- It may be necessary to push the TPCS Spectrometer Loading Fixture sideways slightly to get the thru holes on the loading fixture to line up with the threaded holes on RSM1.*)
14. Disconnect the four (4) RG220 coaxial cables from the TPCS Capacitor Bank.
15. Pull the spectrometer from the i.d. of the Radiation Shield Module Assembly. (*note- Make sure the spectrometer is fully loaded on the TPCS Spectrometer Loading Fixture.*)
16. Remove the two (2) 3/8-16 x 5/8" steel hex head screws and the two (2) Ø1.0" o.d. 3/8" screw steel flat washers that secure the TPCS Spectrometer Loading Fixture flange to RSM1.
17. Open the valve on the hydraulic jack on the loading fixture to lower the fixture.
18. Disengage the brake on the TPCS Spectrometer Loading Fixture.

19. Move the TPCS Spectrometer Loading Fixture/spectrometer to the spectrometer assembly/disassembly area.

6.5 Spectrometer Disassembly

This procedure describes the steps required to disassemble the spectrometer. The procedure assumes that the spectrometer has been unloaded from the Radiation Shield Module Assembly and is resting on the TPCS Spectrometer Loading Fixture in the spectrometer assembly/disassembly area.

1. Remove the Center Rod Insulating End Cap from the end of the Center Rod.
2. Remove the six (6) each 1/4-20 x 3/4" nylon flat head screws that attach the Collimator Shielded Port Insulating Adaptor Ring/Collimator Port Vacuum Window Assembly to the collimator port flange and remove the assembly from the One-piece Drift Tube.
3. Remove the Center Rod Tension Adjustment Knob from the Center Rod.
4. Remove the Center Rod Tension Adjustment Knob Washer from the Center Rod.
5. Loosen the four (4) screws that secure the Current Contact Gasket Clamp to the High Voltage Bridge Insulating Plate/High Voltage Bridge Plate Assembly. (*note- It is not necessary to remove the four (4) screws at this time.*)
6. Remove the eight (8) each 1/4-20 x 1-1/2" steel socket head screws and eight (8) each Ø0.625" o.d. 1/4" screw steel flat washers that attach the High Voltage Bridge Insulating Plate/High Voltage Bridge Plate Assembly to the High-Voltage Connection Plate.
7. Remove the High Voltage Bridge Insulating Plate/High Voltage Bridge Plate from the Center Rod.
8. Remove the four (4) screws that secure the Current Contact Gasket Clamp to the High Voltage Bridge Insulating Plate/High Voltage Bridge Plate Assembly and separate the assembly.
9. Remove the cable ties that secure the RG220 cables and the RG223 cable to the One-piece Drift Tube.
10. Release the eight (8) Camloc® latches that clamp the RG220 coaxial cables to the Electrical Ground Connection Plate and the High-Voltage Connection Plate.
11. Remove the four (4) 20' long RG220 coaxial cables from the spectrometer.
12. Remove the RG223 coaxial cable from the 10X-50Ω in-line attenuator connected to the Pearson Current Transformer.
13. Remove the two (2) 1/4-20 x 1-1/2" steel socket head screws from the holes located at the bottom of the Current Transformer Mounts.
14. Remove the current transformer from the space between the High-Voltage Connection Plate and the Electrical Ground Connection Plate.
15. Remove the BNC 10X-50Ω in-line attenuator and the BNC elbow adaptor from the UHF to BNC adaptor connected to the current transformer.
16. Remove the cable clamps or cable ties securing the braid that is covering the signal and bias coaxial cables connected to the PMT.
17. Remove the braid covering the coaxial cables.
18. Remove the opaque putty filling the cable feedthru opening on the PMT Cable Feedthru Tube .
19. Remove the four (4) each 1/4-20 x 5/8" steel socket head screws that attach the cable feedthru tube to the PMT Housing End Plate.
20. Remove the cable feedthru tube from the spectrometer.
21. Remove the two (2) coaxial cables connected to the PMT.

22. Remove the eight (8) each 1/4-20 x 1/2" steel socket head screws and eight (8) each Ø0.625" o.d. 1/4" screw steel flat washers that attach the PMT Housing End Plate to the PMT Housing.
23. Remove the PMT Housing End Plate from the PMT Housing.
24. Remove the eight (8) each 1/4-20 x 5/8" steel socket head screws and eight (8) each Ø0.625" o.d. 1/4" screw steel flat washers that attach the PMT Housing to the PMT Housing Entrance Plate.
25. Remove the PMT Housing from the spectrometer.
26. Remove the Centering Ring Assembly from the PMT Housing.
27. Remove the three (3) 1/4-20 wing nuts and three (3) Ø0.625" o.d. 1/4" screw flat washers from the PMT Mounting Rods.
28. Remove the PMT/ND Filter Holder Assembly from the spectrometer.
29. Remove the ND Filter Holder Assembly from the PMT. (*note- Cap the optical input end of the PMT with and opaque cover and store the PMT in a dark location positioned horizontally.*)
30. Remove the three (3) PMT Mounting Rods from the PMT Housing Entrance Plate.
31. Remove the six (6) each 1/4-20 x 1-3/4" steel socket head screws and eight (8) each Ø0.625" o.d. 1/4" screw steel flat washers that attach the Sum Coupler Securing Clamp to the PMT Housing Entrance Plate.
32. Remove the Sum Coupler/Sum Coupler Securing Clamp from the spectrometer.
33. Remove the Sum Coupler Securing Clamp from the coupler.
34. Clean all surfaces of the coupler and the end of the six (6) Light Pipes using ethanol or methanol and a lint-free cloth.
35. Wrap the coupler in protective wrapping to prevent scratching of the surface and store in a clean dry location.
36. Remove the Light Pipe Grouping Ring from the o.d. of the Light Pipes.
37. Remove the eight (8) each 1/4-20 x 5/16" steel socket head screws that attach the Light Pipe Enclosure to the PMT Housing Entrance Plate.
38. Remove the PMT Housing Entrance Plate from the spectrometer.
39. Remove the 16 each 3/8-16 square G-10 nuts that attach the Light Pipe Enclosure to the G-10 studs.
40. Remove the Light Pipe Enclosure from the spectrometer.
41. Remove the Light Pipe Alignment Tool Ring from the o.d. of the Light Pipes.
42. Remove the six (6) Light Pipes from the spectrometer.
43. Clean all surfaces of the Light Pipes using ethanol or methanol and a lint-free cloth.
44. Wrap the Light Pipes in protective wrapping to prevent scratching of the surface and store in a clean dry location.
45. Remove the Electron Detector Insulating Spacer from the spectrometer.
46. Remove the eight (8) each 3/8-16 x 2" G-10 studs from the Current Return Plate.
47. Remove the four (4) each 8-32 x 3/8" socket head screws that attach the Upstream End Plate O-Ring Compression Clamp to the Feedthru Adaptor Clamp.
48. Remove the Upstream End Plate O-Ring Compression Clamp from the Upstream End Plate Assembly.
49. Remove eight (8) each 1/4-20 x 1" steel socket head screws and eight (8) each Ø0.625" o.d. 1/4" screw steel flat washers that attach the Upstream End Plate Assembly to the Electrical Ground Connection Plate.
50. Remove the Upstream End Plate Assembly from the spectrometer.
51. Lay the Upstream End Plate Assembly down on the surface having the eight (8) counterbored holes.
52. Remove the four (4) each 6-32 x 5/16" steel socket head screws that secure the Upstream End Plate O-Ring Retaining Feedthru to the Feedthru Adaptor.
53. Remove the Upstream End Plate O-Ring Retaining Feedthru from the Upstream End Plate Assembly.
54. Turn the Upstream End Plate Assembly over so it is resting on the opposite surface.

55. Remove the four (4) each 6-32 x 5/16" steel socket head screws that secure the Feedthru Adaptor Clamp to the Feedthru Adaptor.
56. Remove the Feedthru Adaptor Clamp from the Upstream End Plate.
57. Turn the Upstream End Plate over on the opposite face and remove the Feedthru Adaptor from the end plate.
58. Attach a 1' extension to a ball driver handle allowing access to the screws on the Light Pipe Centering Feedthru. Loosen the four socket head screws on the Light Pipe Centering Feedthru.
59. Remove the eight (8) each 1/4-20 x 5/8" steel socket head screws that attach the Current Return Plate to the Current Return Tube flange.
60. Remove the Center Rod/Current Return Plate Assembly from the spectrometer.
61. Remove the eight (8) each 1/4-20 x 3/4" steel socket head screws that secure the Current Return Tube to the Downstream Outer End Plate.
62. Remove the Current Return Tube from the spectrometer.
63. Remove the Centering Ring Assembly from the Current Return Tube.
64. Remove the eight (8) each 3/8"-16 x 1-3/8" steel socket head screws that attach the Downstream Outer End Plate Assembly to the downstream vacuum to air interface flange.
65. Remove the Downstream Outer End Plate Assembly from the spectrometer.
66. Lay the Downstream Outer End Plate Assembly down on a clean flat surface resting on top of the Light Pipe Guide.
67. Remove the four (4) each 6-32 x 7/16" steel socket head screws that attach the Scintillator Center Clamp to the Scintillator Centering Feedthru.
68. Remove the Scintillator Center Clamp from the Downstream Outer End Plate Assembly.
69. Remove the eight (8) each 6-32 x 3/4" steel socket head screws and eight (8) each Ø7/16" o.d. #6 screw steel flat washers that attach the Scintillator Support Ring to the Downstream Outer End Plate.
70. Remove the Scintillator Center Clamp/Scintillator from the Downstream Outer End Plate Assembly.
71. Remove the Scintillator and wrap it in protective wrapping to prevent scratching of the surface. Store in a clean dry location.
72. Remove the four (4) each 8-32 x 3/8" socket head screws that attach the Scintillator Centering Feedthru to the Downstream Outer End Plate.
73. Remove the Scintillator Centering Feedthru from the Downstream Outer End Plate Assembly.
74. Turn the Downstream Outer End Plate Assembly over and lay the assembly down resting on the face of the end plate.
75. Remove the four (4) each 6-32 x 5/16" steel socket head screws that attach the Light Pipe Centering Feedthru to the Feedthru Adaptor.
76. Remove the Light Pipe Centering Feedthru from the Downstream Outer End Plate Assembly.
77. Remove the eight (8) each 6-32 x 1" steel socket head screws and eight (8) each Ø7/16" o.d. #6 screw steel flat washers that secure the Light Pipe Guide and the Downstream End Plate Window to the Downstream Outer End Plate.
78. Remove the Light Pipe Guide from the Downstream Outer End Plate Assembly.
79. Remove the Downstream End Plate Window, Feedthru Adaptor, and Feedthru Adaptor Clamp from the Downstream Outer End Plate Assembly.
80. Lay the Downstream End Plate Window, Feedthru Adaptor, and Feedthru Adaptor Clamp down on a clean flat surface with the Ø6.495" o.d. side facing skyward and preferably on top of a clean soft cloth to prevent scratching of the Downstream End Plate Window face.
81. Remove the four (4) each 6-32 x 1/4" steel socket head screws that secure the Feedthru Adaptor Clamp to the Feedthru Adaptor.
82. Remove the Feedthru Adaptor Clamp from the Downstream End Plate Window i.d.

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Centimeter

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 mm

1 2 3 4 5

Inches

1.0 1.1 1.25 1.4 1.6 1.8 2.0 2.2 2.5 2.8 3.2 3.6 4.0 4.5 5.0 5.6 6.3

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83. Lift the Downstream End Plate Window from the surface allowing the Feedthru Adaptor to remain on the surface.
84. Wrap the Downstream End Plate Window in protective wrapping to prevent scratching of the surface. Store in a clean dry location.
85. Remove the eight (8) each 1/2-13 G10 fiberglass nuts that secure the High-Voltage Connection Plate to the High-Voltage Plate Support Rods.
86. Remove the High-Voltage Connection Plate from the High-Voltage Plate Support Rods.
87. Remove the eight (8) High-Voltage Plate Support Rods from the Electrical Ground Connection Plate.
88. Remove the eight (8) each 3/8"-16 x 1-1/8" steel socket head screws that attach the Electrical Ground Connection Plate to the upstream vacuum to air interface flange of the One-piece Drift Tube.
89. Remove the Electrical Ground Connection Plate from the drift tube.
90. Remove the Target Foil from the spectrometer following steps 4-8 of procedure 5.8.2.1 or steps 4-8 of procedure 5.8.2.2 of this manual, as appropriate.
91. Attach rigging to the drift tube for lifting by the RBC2000.
92. Lift the drift tube from the TPCS Spectrometer Loading Fixture and place it on two (2) 4" x 4" x 2' blocks located on the ground, or similar support, to allow the removal of the Centering Ring Assemblies. Refer to figure 4.
93. Remove the two (2) Centering Ring Assemblies from the drift tube.

6.6 <u>Radiation Shield Disassembly</u>

This procedure details the steps required to disassemble the three (3) TPCS Radiation Shield Module Assembly. The Radiation Shield Modules will not be removed from the support carts. Also, the vacuum roughing pump, electrohydraulic pump, and hydraulic actuator will not be removed from the Radiation Shield Module Assembly. It is assumed that the Radiation Shield Module Assembly is in the drift tube loading position and that the spectrometer has been removed from the Radiation Shield Module Assembly. (*note- Each of the Radiation Shield Modules weighs ~ 7tons; therefore, positioning a module as called for in a step can be a nontrivial task.*)

1. Remove the four (4) each 1/4-20 x 3/8" steel hex head screws that attach the Instrumentation Cables Shield to RSM3.
2. Remove the Instrumentation Cables Shield from the id. of RSM3.
3. Remove the three (3) each 3/8-16 x 3/4" steel hex head screws that attach the RSM3 LOS Shield Insert to RSM3.
4. Remove the RSM3 LOS Shield Insert/RSM3 Cable Shield Insert assembly from RSM3.
5. Remove the two (2) each 1/4-20 x 1-1/2" steel socket head screws that attach the left RSM3 Cable Shield Insert to the RSM3 LOS Shield Insert.
6. Remove the left RSM3 Cable Shield Insert from the LOS insert.
7. Remove the two (2) each 1/4-20 x 1-1/2" steel socket head screws that attach the right RSM3 Cable Shield Insert to the LOS insert.
8. Remove the right RSM3 Cable Shield Insert from the LOS insert.
9. Remove the four (4) each 1/4-20 x 3/8" steel hex head screws that attach the Eight Cable Shield to RSM3.
10. Remove the Eight Cable Shield from RSM3.
11. Remove the flexible vacuum hose from the roughing pump.
12. Remove the RSM1 Liner from RSM1.
13. Remove the RSM2 Liner from RSM2.
14. Remove the RSM3 Liner from RSM3.

15. Remove the 12 each 1/2-13 x 2" steel hex head bolts, 24 each Ø1.25" o.d. 1/2" bolt steel flat washers, and 12 each 1/2-13 hex nuts that join the Ø40.0" o.d. flanges of RSM2 and RSM3 together.
16. Position the four (4) casters on the RSM3 Cart so it can be rolled in a direction parallel to the longitudinal axis of RSM3.
17. Separate RSM3 from RSM2 using the come along-type device. (*note- One end of the come along is attached to the RSM3 Cart and the other end is attached to a wall or floor anchor.*)
18. Remove the 12 each 1/2-13 x 2" steel hex head bolts, 24 each Ø1.25" o.d. 1/2" bolt steel flat washers, and 12 each 1/2-13 hex nuts that join the Ø40.0" o.d. flanges of RSM1 and RSM2 together.
19. Position the four (4) casters on the RSM2 Cart so it can be rolled in a direction parallel to the longitudinal axis of RSM2.
20. Separate RSM2 from RSM1 using the come along-type device. (*note- One end of the come along is attached to the RSM2 Cart and the other end is attached to a wall or floor anchor.*)

7.0 Environment, Safety, & Health Considerations

7.1 Electrical

The voltages used on the TPCS range from 120VAC, powering the Ignitron Trigger Generator, to 10kV, across the output bus of the energy storage capacitors of the TPCS capacitor bank. All levels of voltage encountered on the TPCS are capable of delivering electric shock to personnel; however, reasonable effort has been made to limit access to these voltages by personnel working on or near the TPCS.

The voltage that poses the greatest risk to personnel on the TPCS is the voltage across the output bus of the TPCS energy storage capacitors. At full charge, the capacitors have 10kV of potential developed across their terminals storing 100kJ of energy. Due to the lethal nature of this voltage, extra precautions have been taken to reduce the possibility of personnel exposure to the voltage. A charge dump relay, incorporated into the high voltage circuit, automatically closes if 1) power is lost to the capacitor bank, 2) one or more of the capacitor bank access doors is opened, 3) the run switch on the TPCS Capacitor Bank Controller is turned off, or 4) the emergency shut down switch on the TPCS Capacitor Bank Controller is pushed. In the event the capacitor bank fails to discharge automatically or there is a failure that prevents the discharge of the energy storage capacitors, a resistive discharging stick is available to safely discharge the full energy stored in the capacitor bank. For additional precautions and safety procedures, refer to the current TPCS SOP and the TPCS Capacitor Bank Operation and Maintenance Manual (PIMM-3851, June 1988).

7.2 Mechanical

The TPCS is comprised of many heavy and awkward to handle lead and steel parts. Routine operation and maintenance requirements for the TPCS necessitate the removal and replacement of many of these parts resulting in the increased possibility of encountering crush and pinch hazards during such operations. The most frequent operations involve parts associated with the radiation shield. The radiation shield weighs ~ 22 tons, and it is designed to allow the omnidirectional travel of the TPCS on the floor of the exposure cell and rotation of the TPCS about its axis. Access to pertinent parts of the TPCS is accomplished by removing shield access plugs (ranging in weight from 20lbs to >750lbs).

Operations involving the translation of the radiation shield, rotation of the radiation shield, or removal/replacement of shield access plugs, and/or other TPCS hardware, present situations in which personnel are exposed to crush and pinch hazards. The radiation shield, by design, is asymmetric with ~ two (2) times more shielding on the side of the shield facing the radiation source than the side facing away from the source. This makes the rotation of the shield a more hazardous operation than would be encountered with a symmetric shield, because the center of gravity of the radiation shield changes as the shield is rotated. This shift in the center of gravity creates a situation in which the shield will want to rotate in the direction that will place the center of gravity as close to the ground as possible, in order to equilibrate forces acting on the shield and minimize the energy level. As long as the hydraulic actuator is connected to the radiation shield, and the hydraulic system is pressurized, no free movement of the radiation shield will occur. To prevent free rolling of the radiation shield during change over of the hydraulic actuator to another jacking position, turnbuckles are used to lock down the radiation shield. FFor additional precautions and safety procedures, refer to the current TPCS SOP.

A two (2) ton capacity electrohydraulic reversible boom crane[8] is available for use in handling the radiation shield plugs, as well as other TPCS hardware, during removal/replacement operations. The crane offers electrohydraulically powered boom movement facilitating easy vertical and horizontal positioning of the TPCS hardware. The crane is also equipped with an electric drive unit allowing easy movement of TPCS hardware within the work area. Refer to the Reversible Boom Crane's RBC2000 Owner's Manual concerning specifications and operating instructions.

7.3 Chemical

A wide variety of chemicals are encountered on and around the TPCS. These include vacuum pump oil (roughing pump), vacuum grease (o-ring seals), optical coupling gel (light guide interfaces), PCB-free transformer oil (high energy storage capacitors), hydraulic fluid (hydraulic actuator system), solvents (isopropanol, ethanol, and methanol used during part cleaning operations), lead (radiation shield hardware), cadmium (collimator elements), and mercury (ignitron current switches).

During routine operations, personnel working on or around the TPCS will not be exposed to the transformer oil or mercury since they are contained within sealed units. For additional precautions and safety procedures, refer to the current TPCS SOP and literature from the manufacturer accompanying the capacitors and ignitrons.

Personnel performing alignment of the TPCS will come into contact with collimator elements, some of which are solid cadmium, and radiation shield parts, some of which are solid lead. According to published data, lead and cadmium are not absorbed through the skin; however, it is recommended that personnel handling the lead and cadmium parts wear disposable rubber gloves during handling operations. For additional precautions and safety procedures, refer to the current TPCS SOP and the appropriate Material Safety Data Sheet.

During maintenance, assembly, and disassembly operations on the TPCS, personnel will come into contact with vacuum oil, hydraulic fluid, optical coupling gel, and common solvents. All rags and gloves used by personnel during the handling of equipment/parts containing these oils, gel, or solvents should be disposed of in the appropriate waste receptacles in accordance with facility guidelines. For additional precautions and safety procedures, refer to the current TPCS SOP and the appropriate Material Safety Data Sheet.

7.4 Radiation

The TPCS does not generate ionizing radiation nor does it activate any of the surrounding materials when it operates. Therefore, no special precautions are required concerning radiation control and containment for the TPCS.

7.5 Laser

The TPCS uses a Helium Neon (HeNe) laser tube to align the system to the radiation source. The laser tube is normally classified as a class IIIb CW laser; however, the output light level is attenuated sufficiently to allow reclassification to class II. The class II classification allows the alignment laser to be used without any special precautions as long as the output attenuator remains in place.

7.6 Pressure Systems

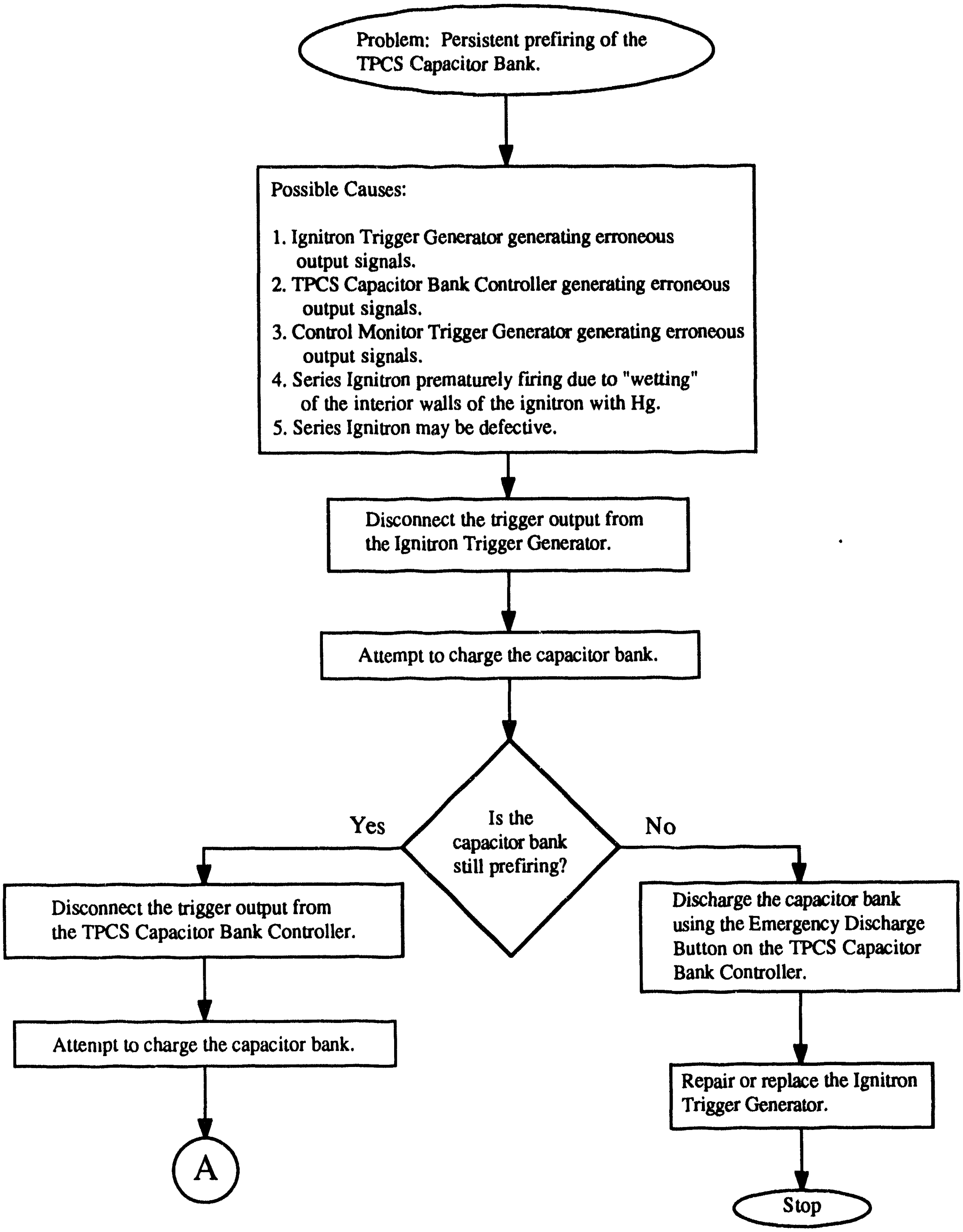
The One-piece Drift Tube section of the TPCS is a stainless steel tube ~ 4.3ft(1.3m) long with an ~ 11in(0.3m) i.d. and an internal volume <3ft^3(0.08m^3). The drift tube is normally operated at vacuum pressures approaching 1.0 x 10^{-6}torr. All spectrometer hardware meets Sandia National Laboratories pressure guidelines outlined in the SNL Pressure Safety Manual[8].

The Vacuum Gate Valve requires facility air @ ~ 60psi for operation. A 15' length of 3/8" Polyflow® tubing couples the air from the facility outlet to the Vacuum Gate Valve. The ends of the tubing must be tied down to either the building or the RSM1 Support Cart to prevent whipping of the ends in the event of a tubing failure.

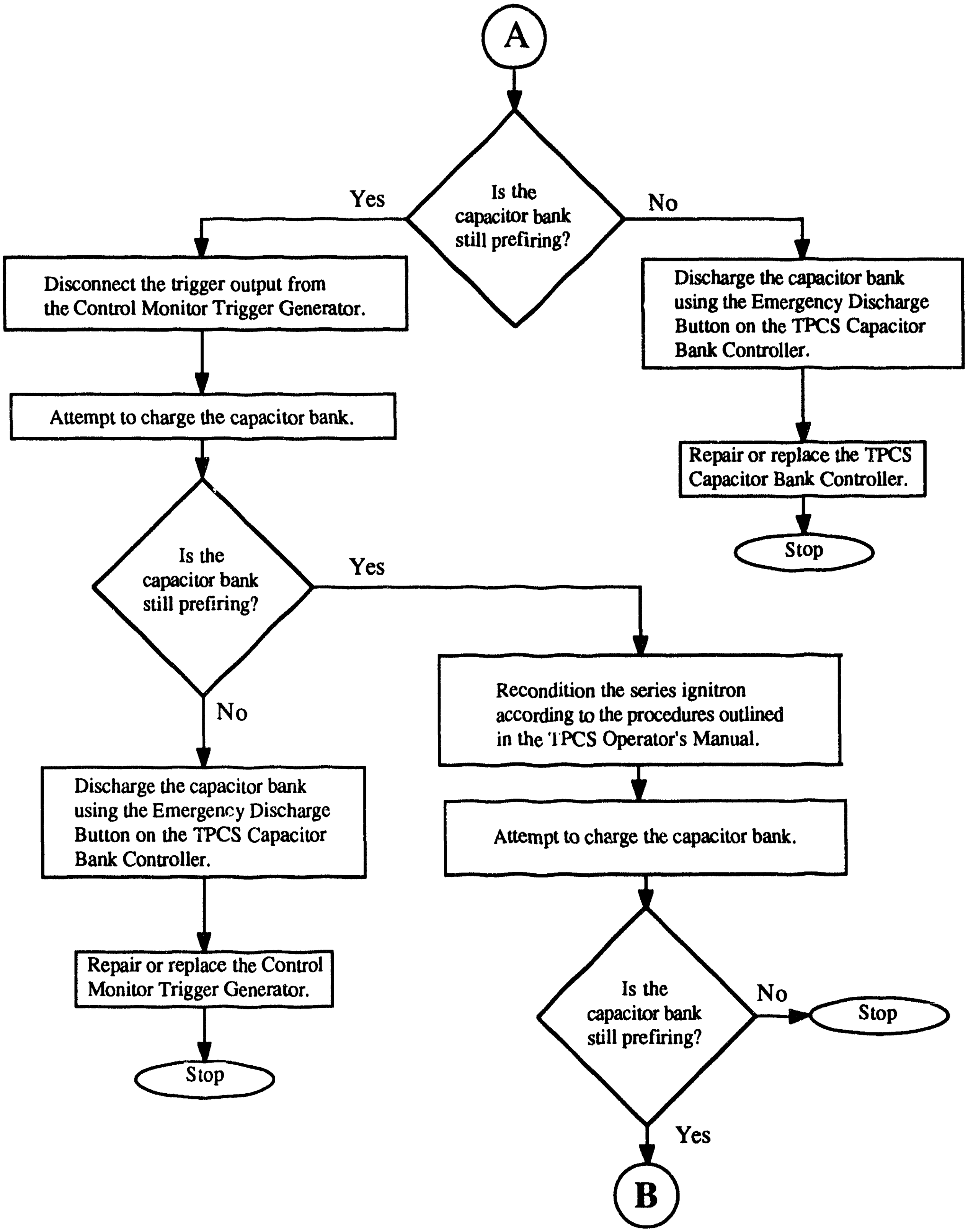
The electrohydraulic rotation system operates at pressures that can be dangerous if there is a system failure. It is, therefore, necessary to tie the ends of the hydraulic lines down to the RSM3 Support Cart to prevent whipping of the ends in the event of hose failure.

8.0 Troubleshooting

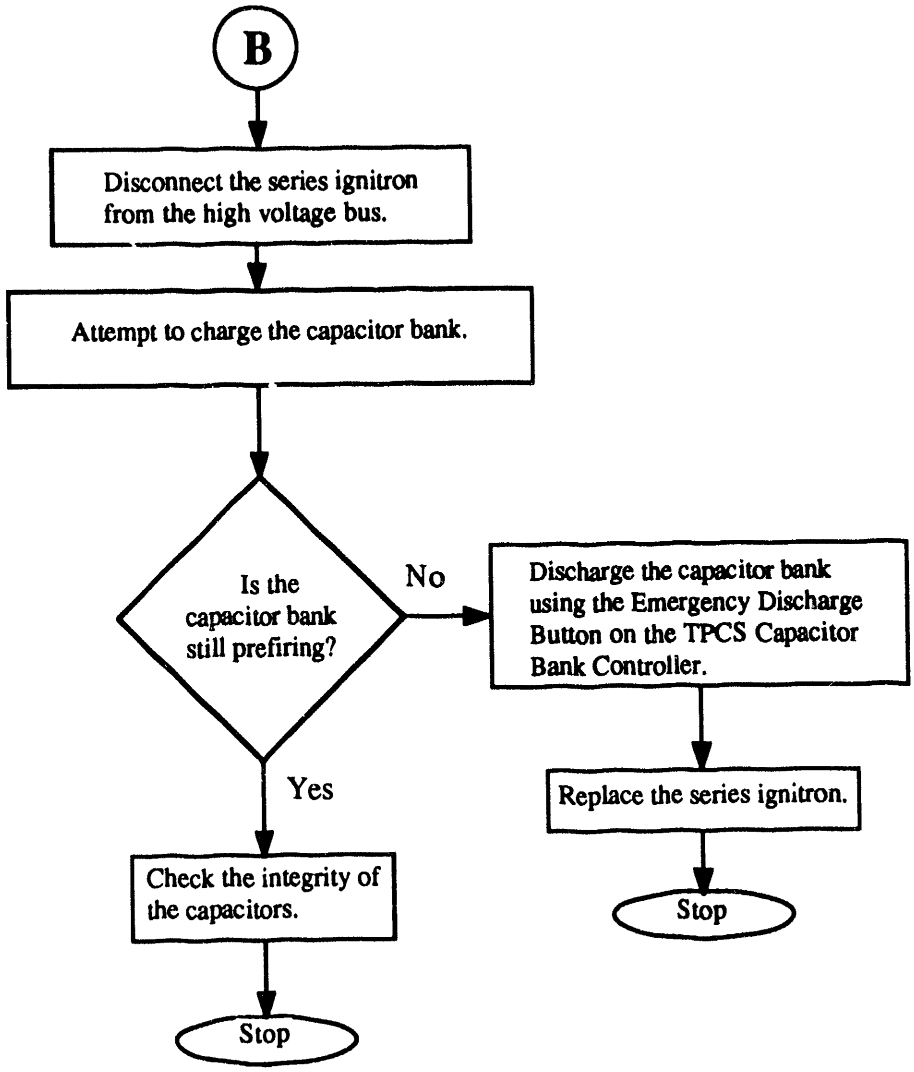
8.1 Persistent Prefiring Of the TPCS Capacitor Bank


Problem: Persistent prefiring of the TPCS Capacitor Bank.
Possible Causes:
1. Ignitron Trigger Generator generating erroneous output signals.
2. TPCS Capacitor Bank Controller generating erroneous output signals.
3. Control Monitor Trigger Generator generating erroneous output signals.
4. Series Ignitron prematurely firing due to "wetting" of the interior walls of the ignitron with Hg.
5. Series Ignitron may be defective.
Disconnect the trigger output from the Ignitron Trigger Generator.
Attempt to charge the capacitor bank.
Is the capacitor bank still prefiring?
Yes
No
Disconnect the trigger output from the TPCS Capacitor Bank Controller.
Attempt to charge the capacitor bank.
A
Discharge the capacitor bank using the Emergency Discharge Button on the TPCS Capacitor Bank Controller.
Repair or replace the Ignitron Trigger Generator.
Stop

Persistent Prefiring of the TPCS capacitor bank (continued)

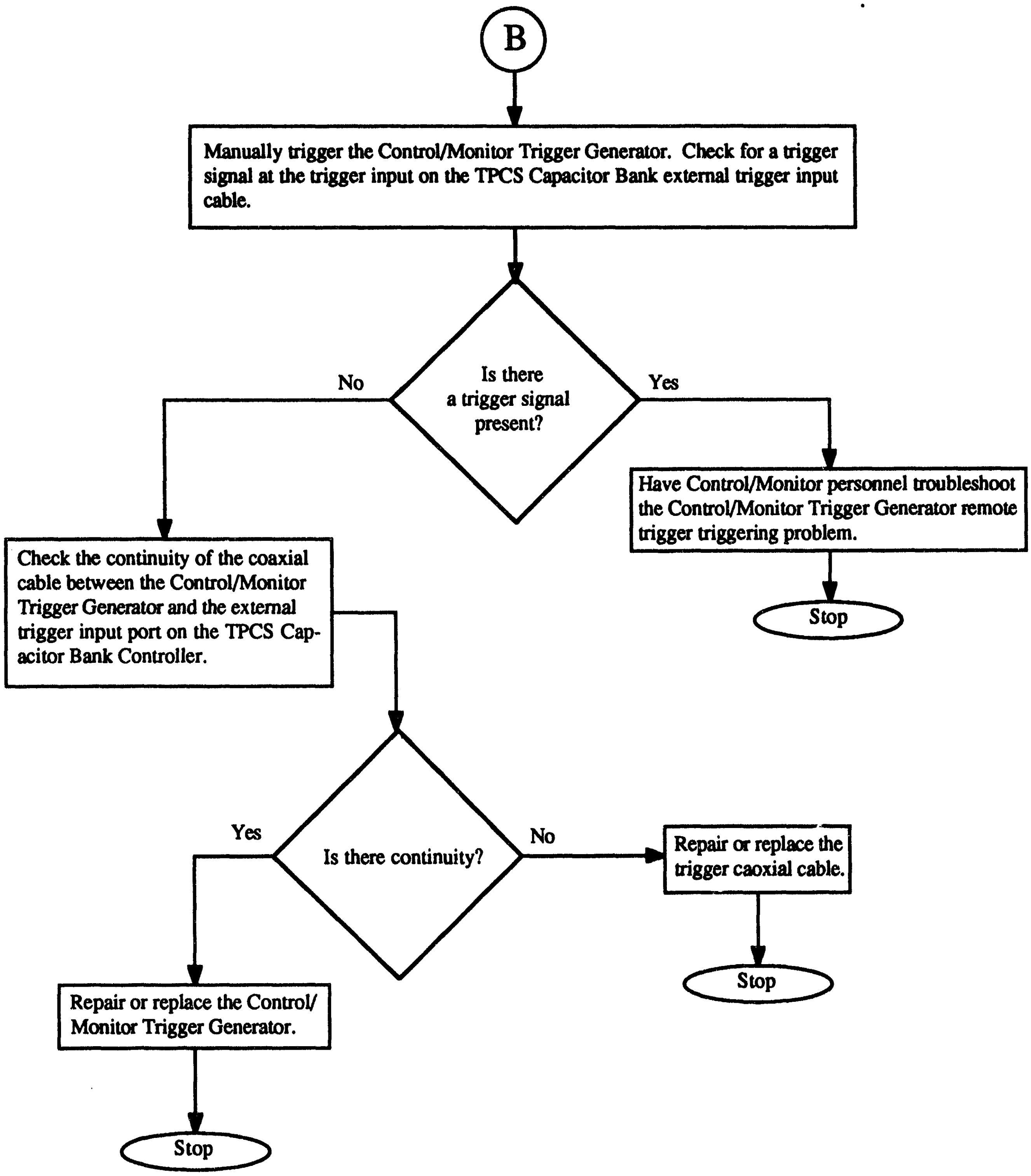


Persistent Prefiring of the TPCS capacitor bank (continued)

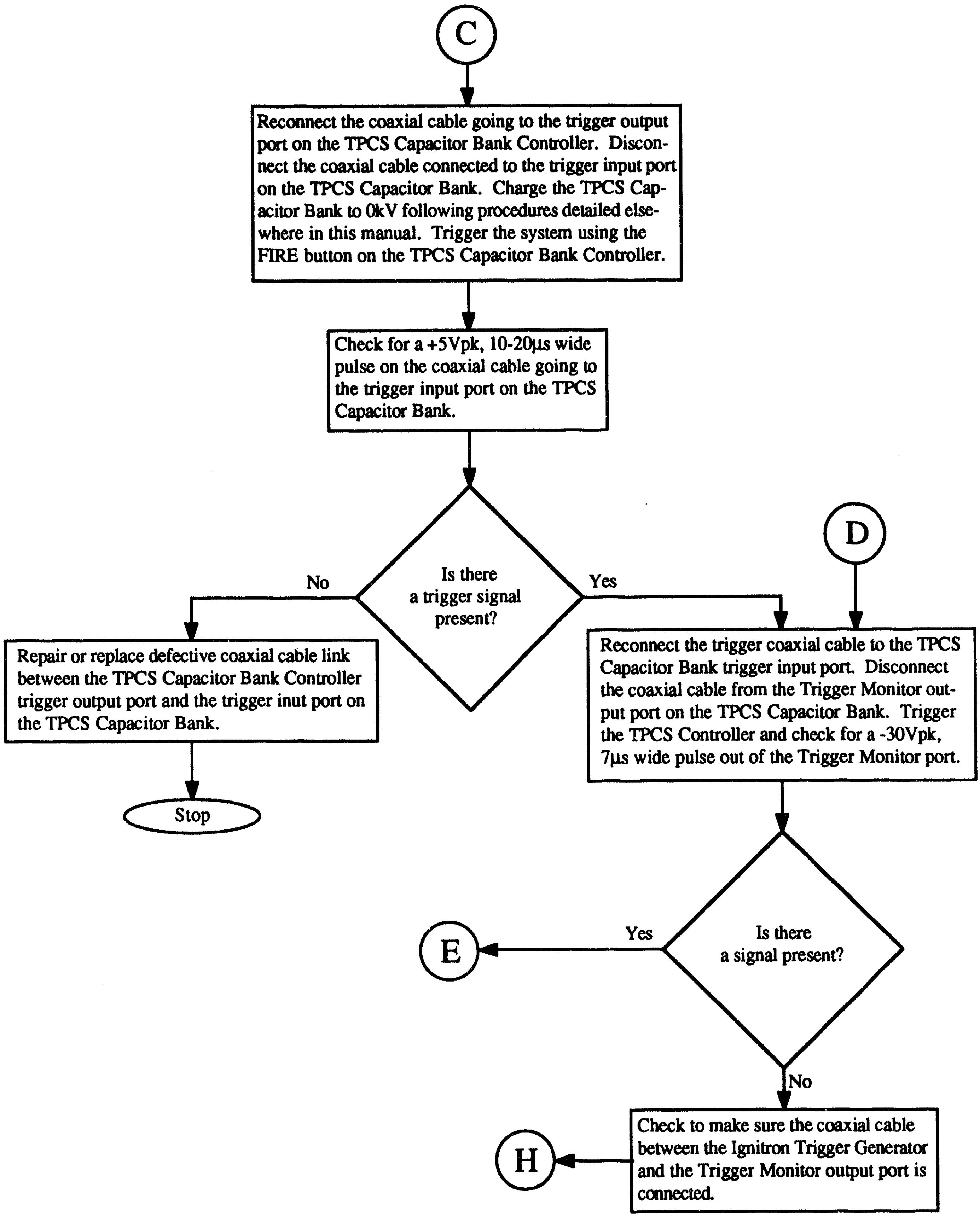


8.2 TPCS Capacitor Does Not Trigger

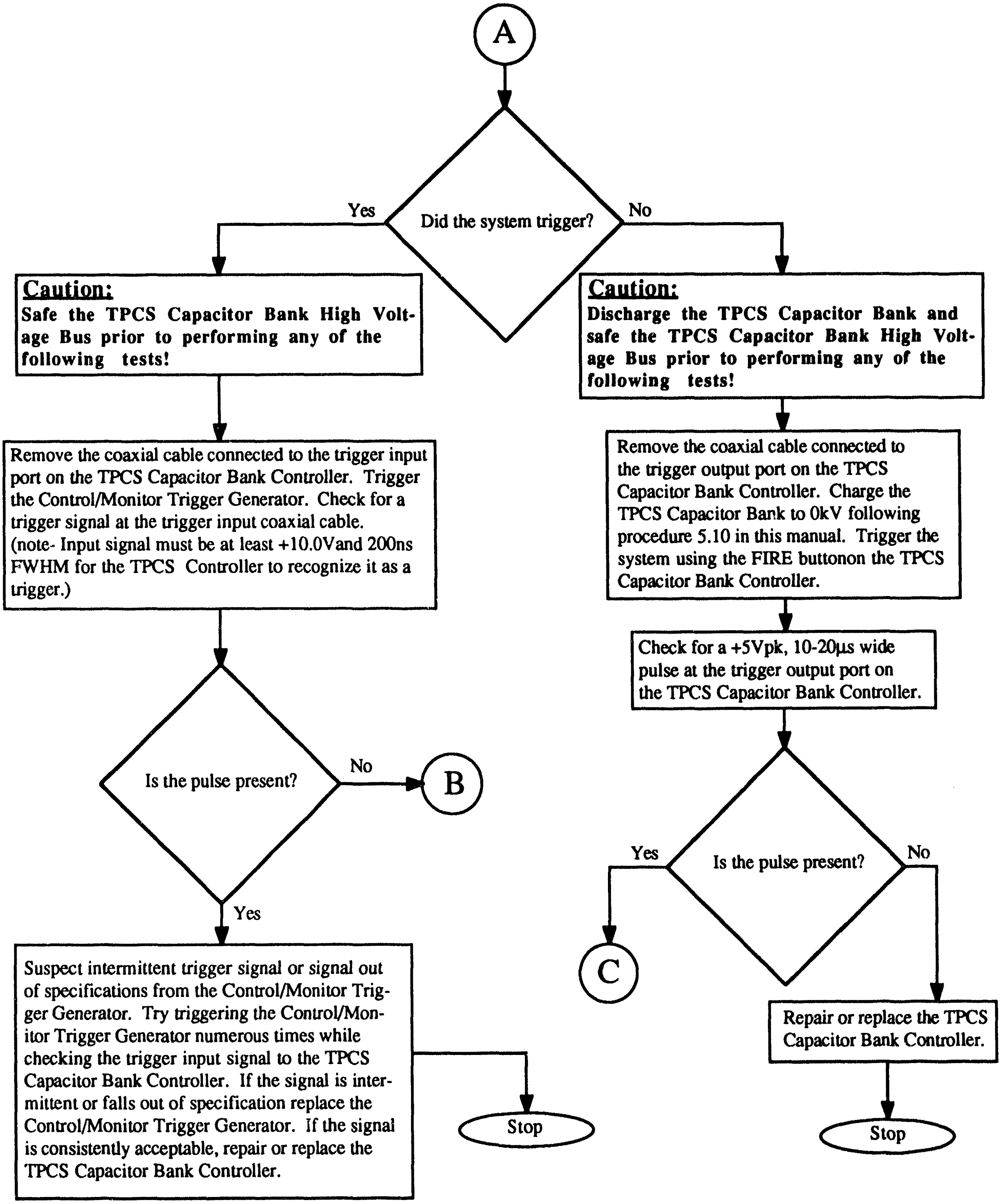
TPCS Capacitor Bank Does Not Trigger. (continued)



TPCS Capacitor Bank Does Not Trigger. (continued)



TPCS Capacitor Bank Does Not Trigger. (continued)



Problem: TPCS Capacitor Bank does not trigger or does not appear to trigger externally.(i.e.- Accelerator does not trigger after TPCS Capacitor Bank receives a trigger or accelerator triggers but the energy is not released from the TPCS Capacitor Bank.)

↓

Probable Causes:

1. Trigger Source Switch on the TPCS Capacitor Bank Controller is in INTERNAL instead of EXTERNAL mode.
2. Accelerator Control/Monitor Trigger Generator is not outputting a trigger to the TPCS Capacitor Bank Controller.
3. TPCS Capacitor Bank Controller is not outputting a trigger to the Capacitor Bank.
4. Ignitron Trigger Generator is not outputting a fire signal to the Ignitron Igniter Protection Circuit.
5. Ignitron Trigger Generator is not outputting a trigger monitor signal to trigger the accelerator.
6. Ignitron Igniter Protection Circuit is not outputting a trigger to the Series Ignitron igniter.
7. Series Ignitron igniter is not firing when it receives a trigger.
8. Triggering problem with the accelerator Control/Monitor.
9. Load circuit is open.

↓

Note: This troubleshooting procedure assumes that the TPCS Capacitor Bank was charged to the setpoint voltage, but the system would not trigger externally.

↓

Make sure power is applied to the the Ignitron Trigger Generator, the TPCS Capacitor Bank and the Control/Monitor Trigger Generator. If power was not applied to any of the above listed units, try to trigger the system again prior to proceeding with the troubleshooting procedure after power is turned on. Make sure the Trigger Source Switch on the TPCS Capacitor Bank Controller is in the EXTERNAL mode. If the Trigger Source Switch was not in the EXTERNAL mode, try to trigger the system again prior to proceeding with the troubleshooting procedure after the trigger source mode has been changed to EXTERNAL.

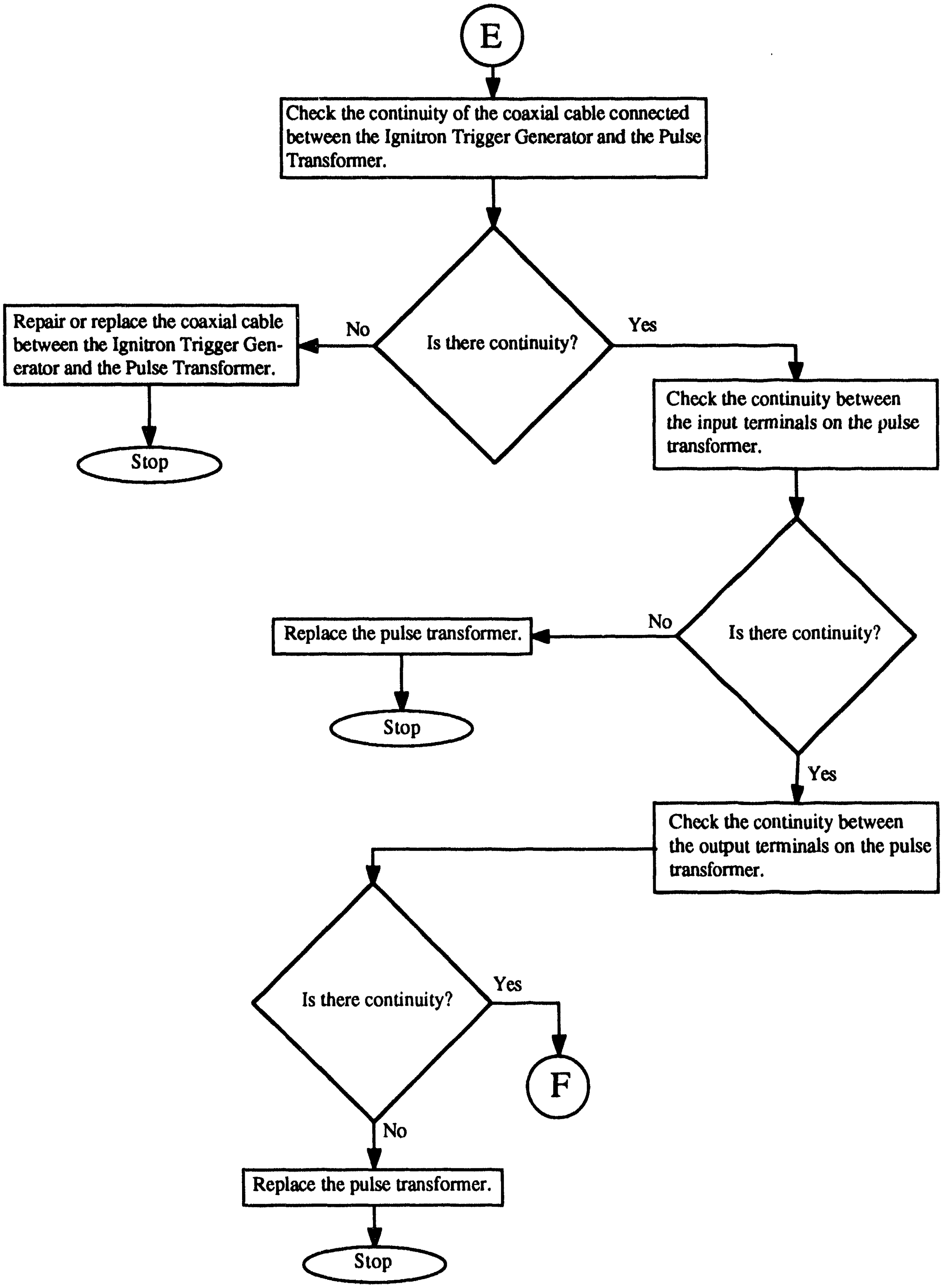
↓

Place the Trigger Source Switch on the TPCS Capacitor Bank Controller into INTERNAL mode. Charge the TPCS Capacitor Bank. Try to trigger the system internally by depressing the FIRE button on the TPCS Capacitor Bank Controller.

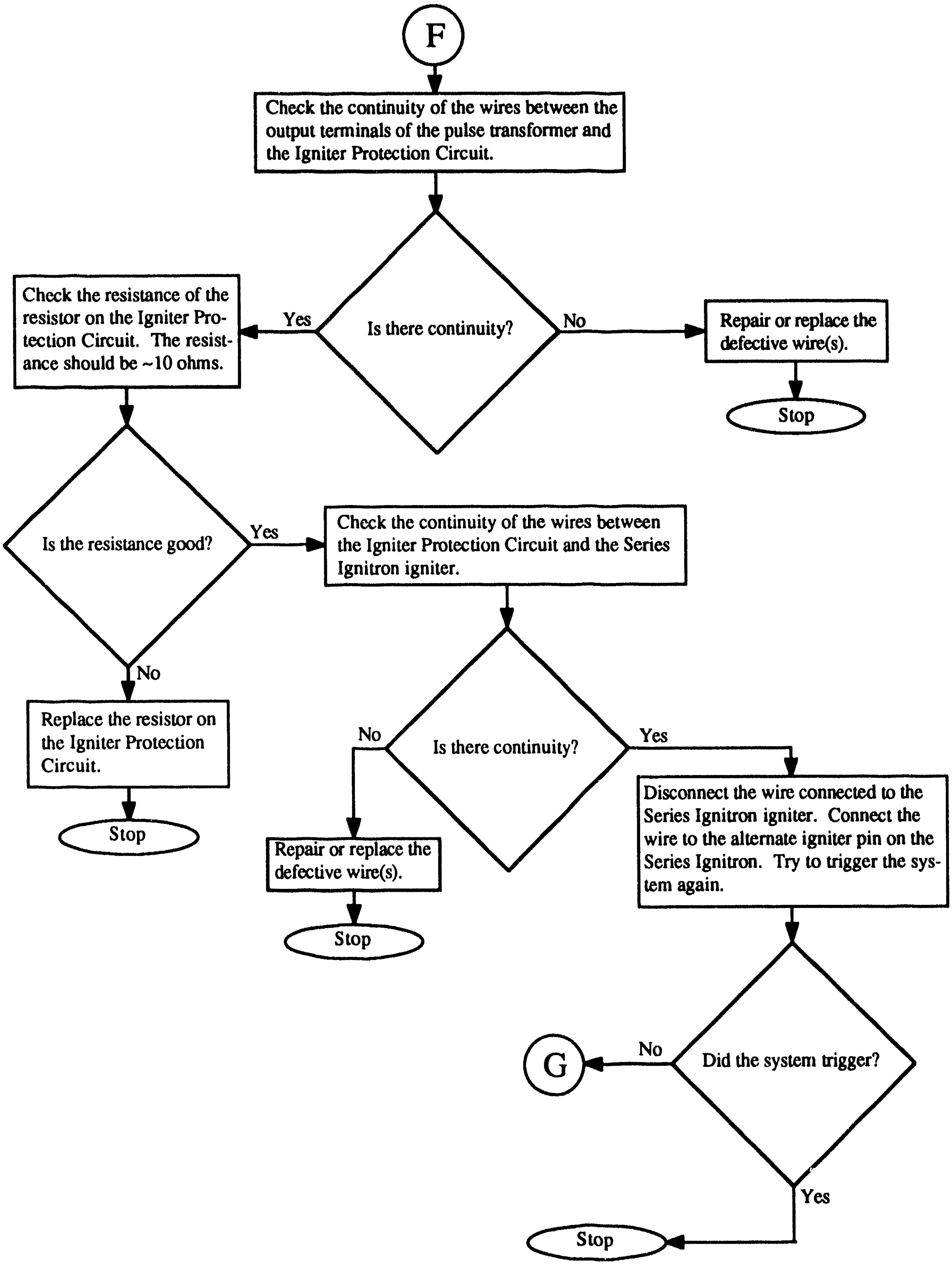
↓

(A)

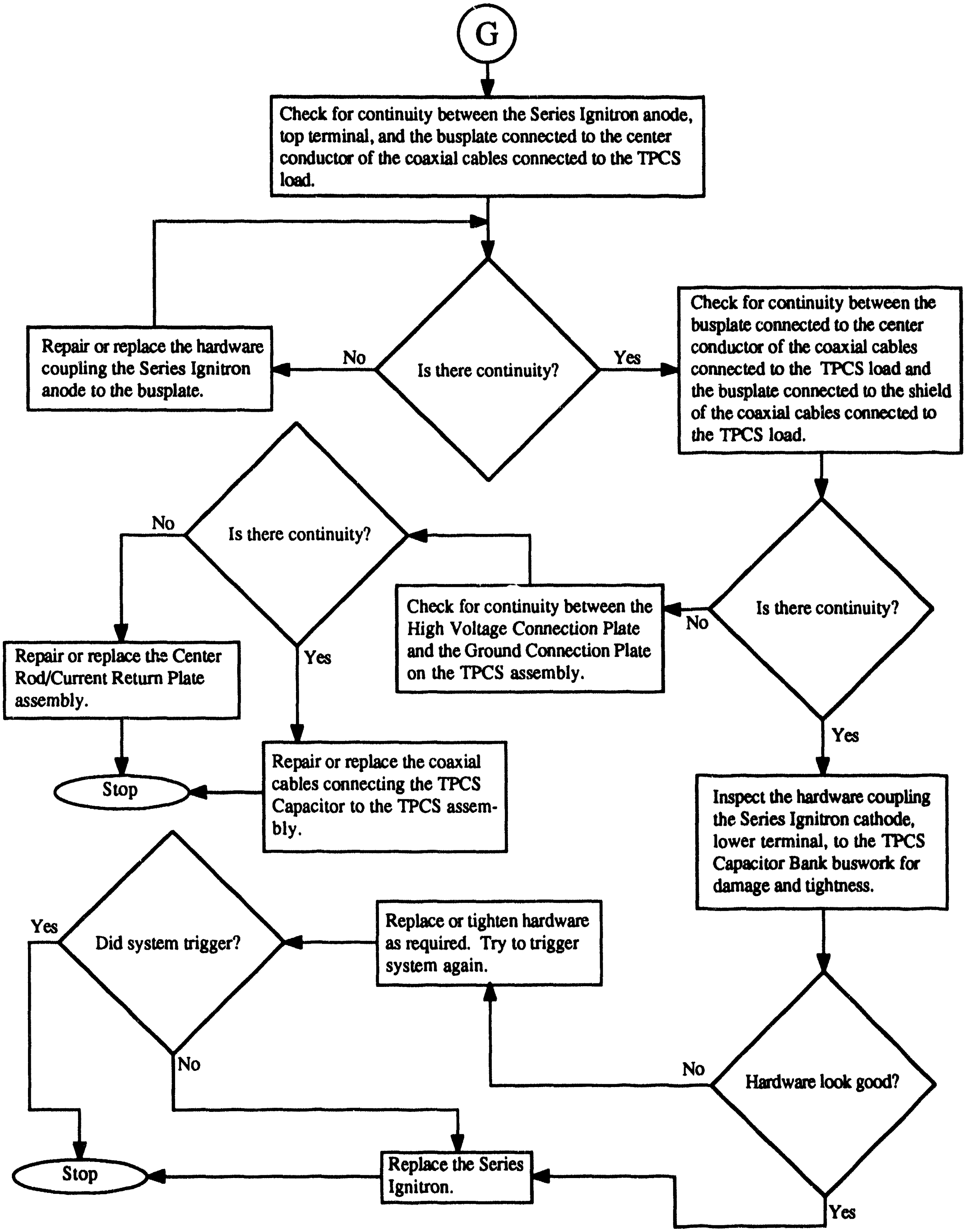
TPCS Capacitor Bank Does Not Trigger. (continued)



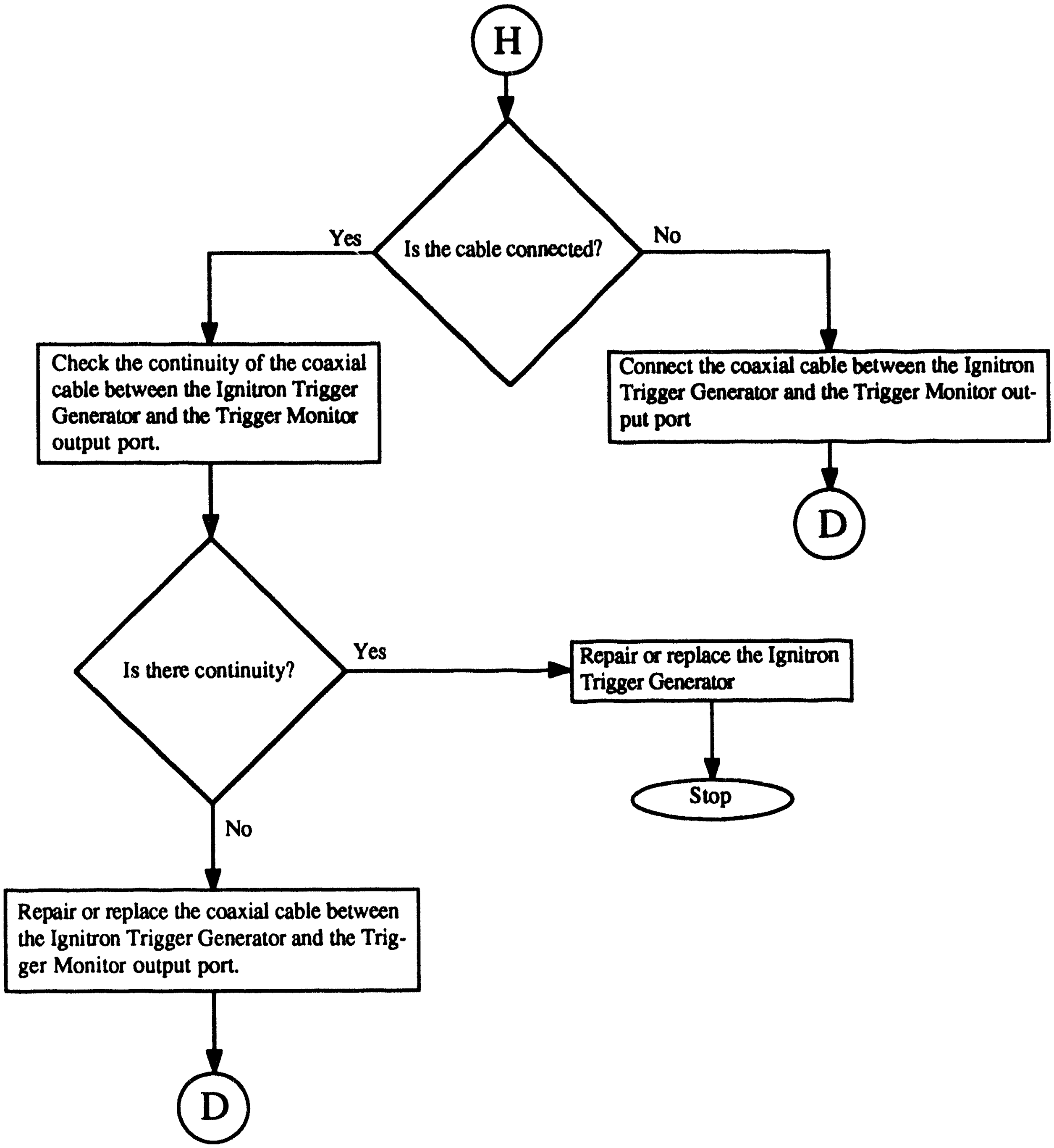
TPCS Capacitor Bank Does Not Trigger. (continued)



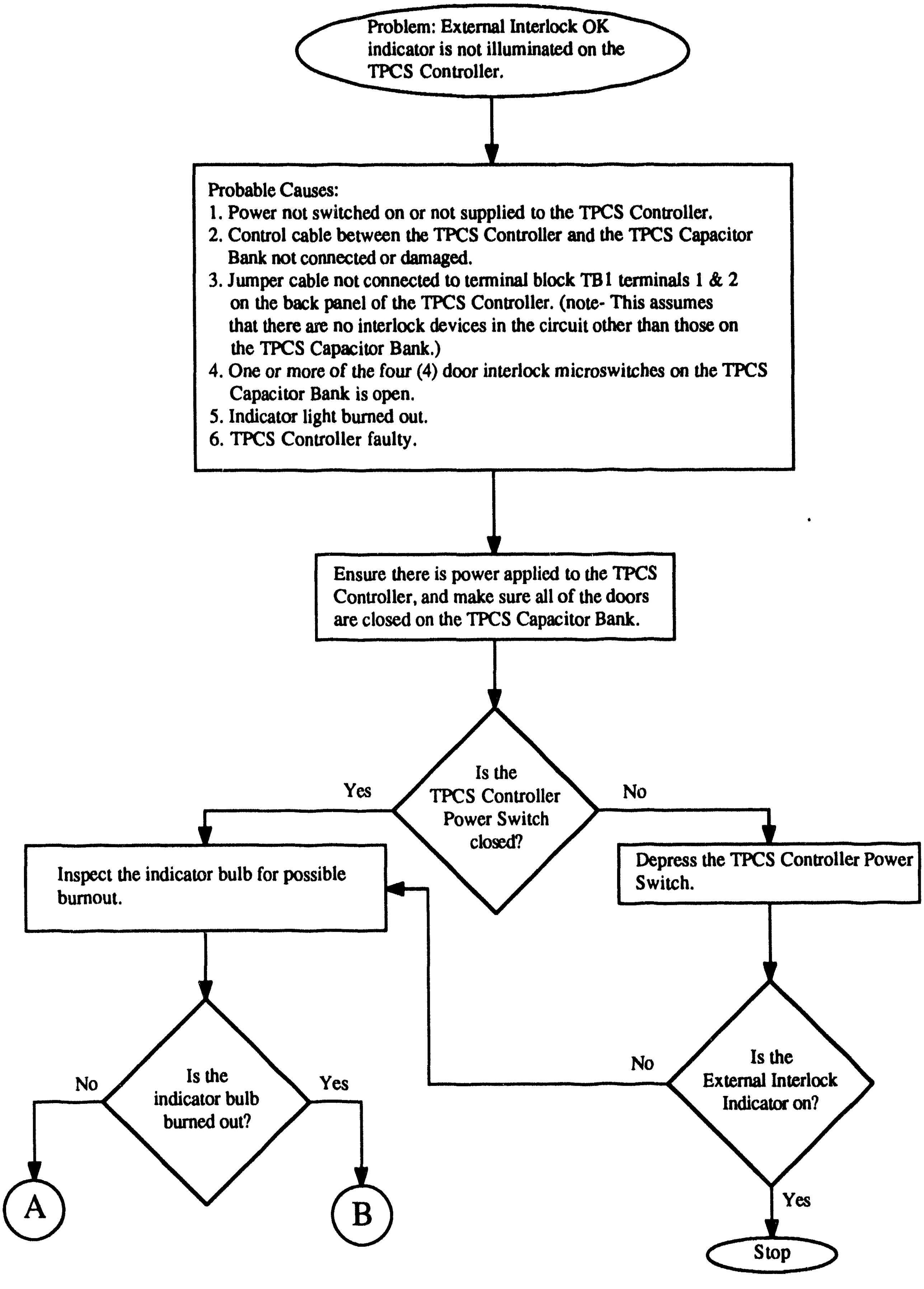
TPCS Capacitor Bank Does Not Trigger. (continued)



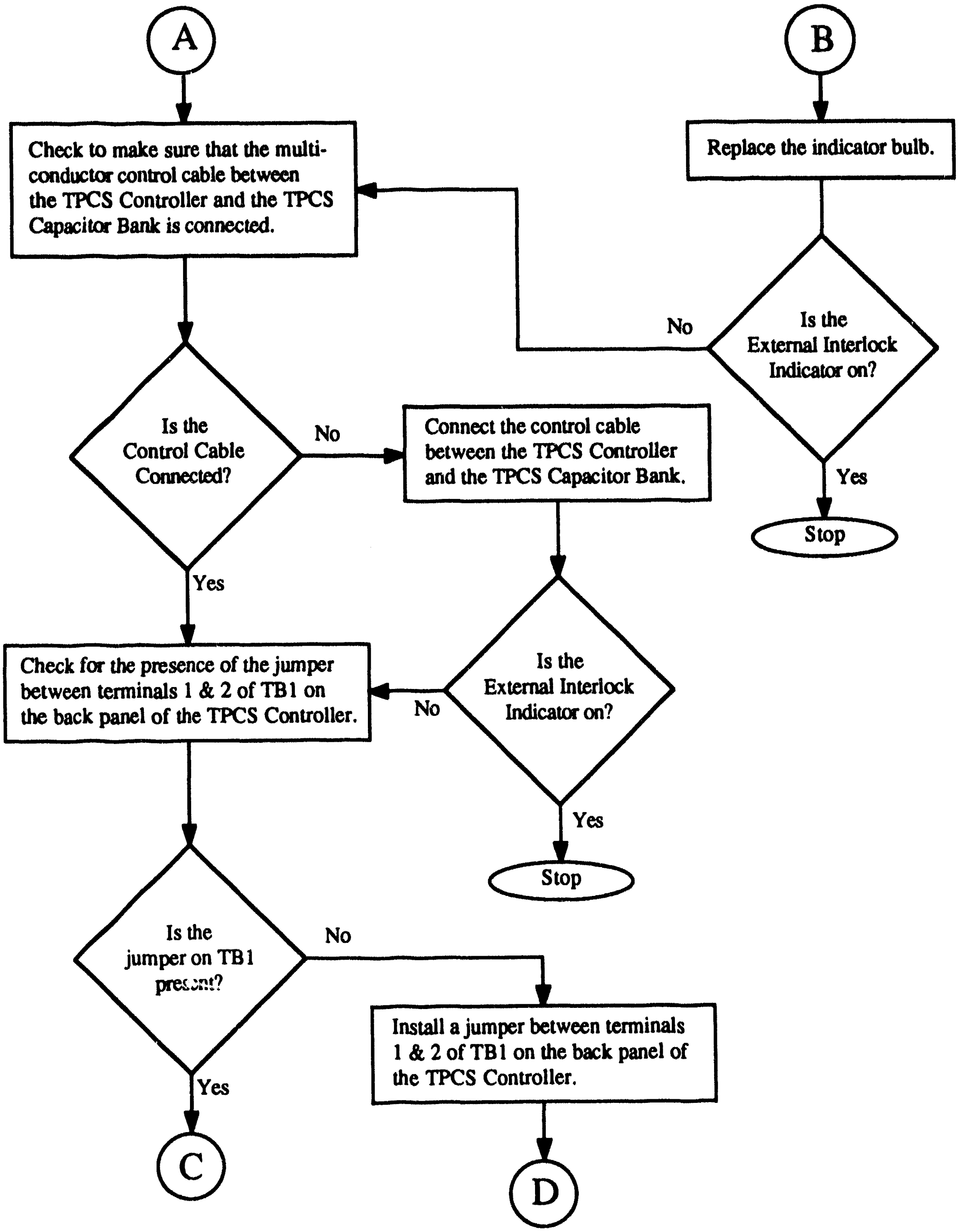
TPCS Capacitor Bank Does Not Trigger. (continued)



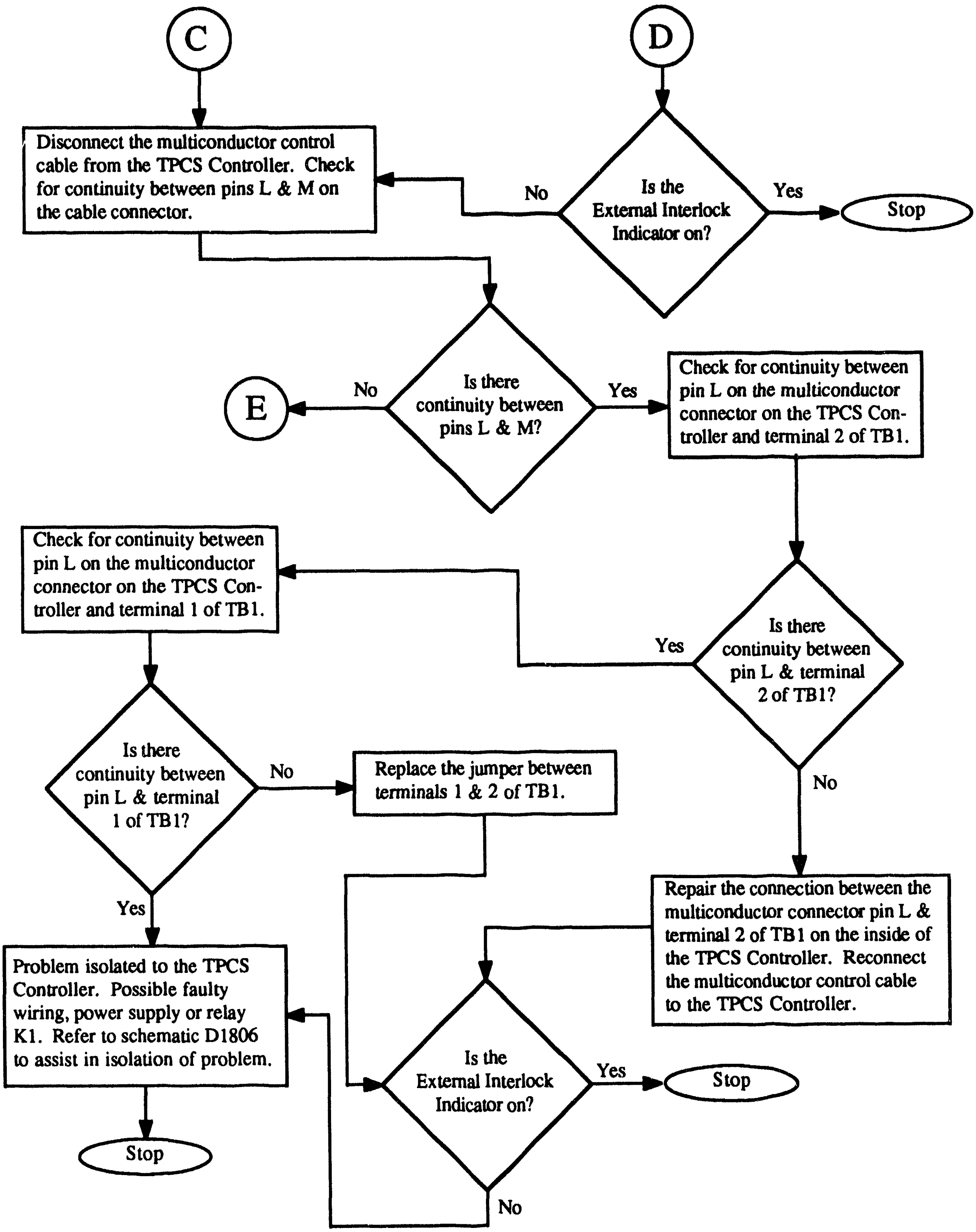
8.3 External Interlock OK Indicator Is Not Illuminated on the TPCS Controller


Problem: External Interlock OK indicator is not illuminated on the TPCS Controller.
Probable Causes:
1. Power not switched on or not supplied to the TPCS Controller.
2. Control cable between the TPCS Controller and the TPCS Capacitor Bank not connected or damaged.
3. Jumper cable not connected to terminal block TB1 terminals 1 & 2 on the back panel of the TPCS Controller. (note- This assumes that there are no interlock devices in the circuit other than those on the TPCS Capacitor Bank.)
4. One or more of the four (4) door interlock microswitches on the TPCS Capacitor Bank is open.
5. Indicator light burned out.
6. TPCS Controller faulty.
Ensure there is power applied to the TPCS Controller, and make sure all of the doors are closed on the TPCS Capacitor Bank.
Is the TPCS Controller Power Switch closed?
Yes
No
Inspect the indicator bulb for possible burnout.
Depress the TPCS Controller Power Switch.
Is the indicator bulb burned out?
No
Yes
A
B
Is the External Interlock Indicator on?
No
Yes
Stop

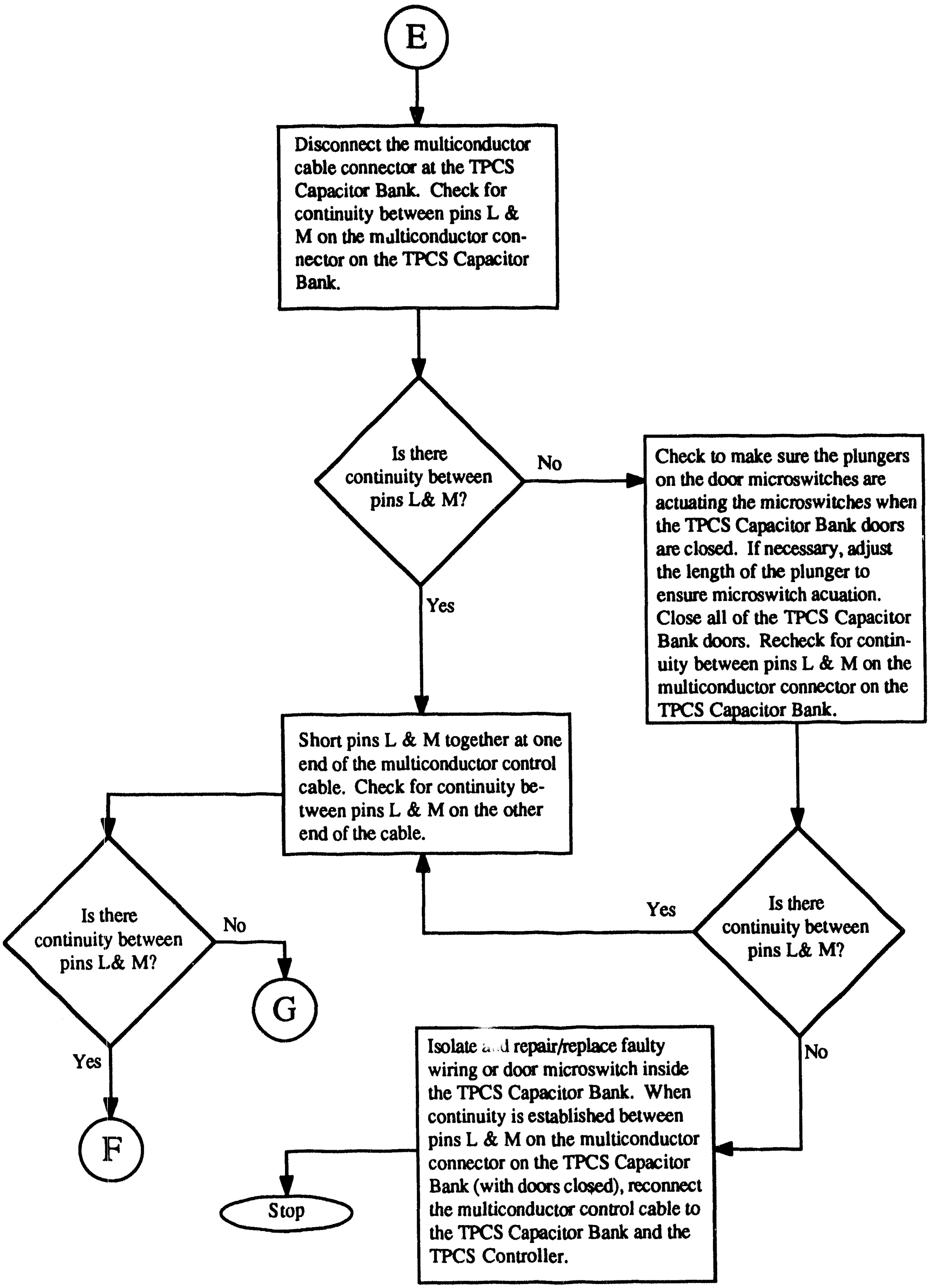
External Interlock OK Indicator Not Illuminated on the TPCS Controller (continued)



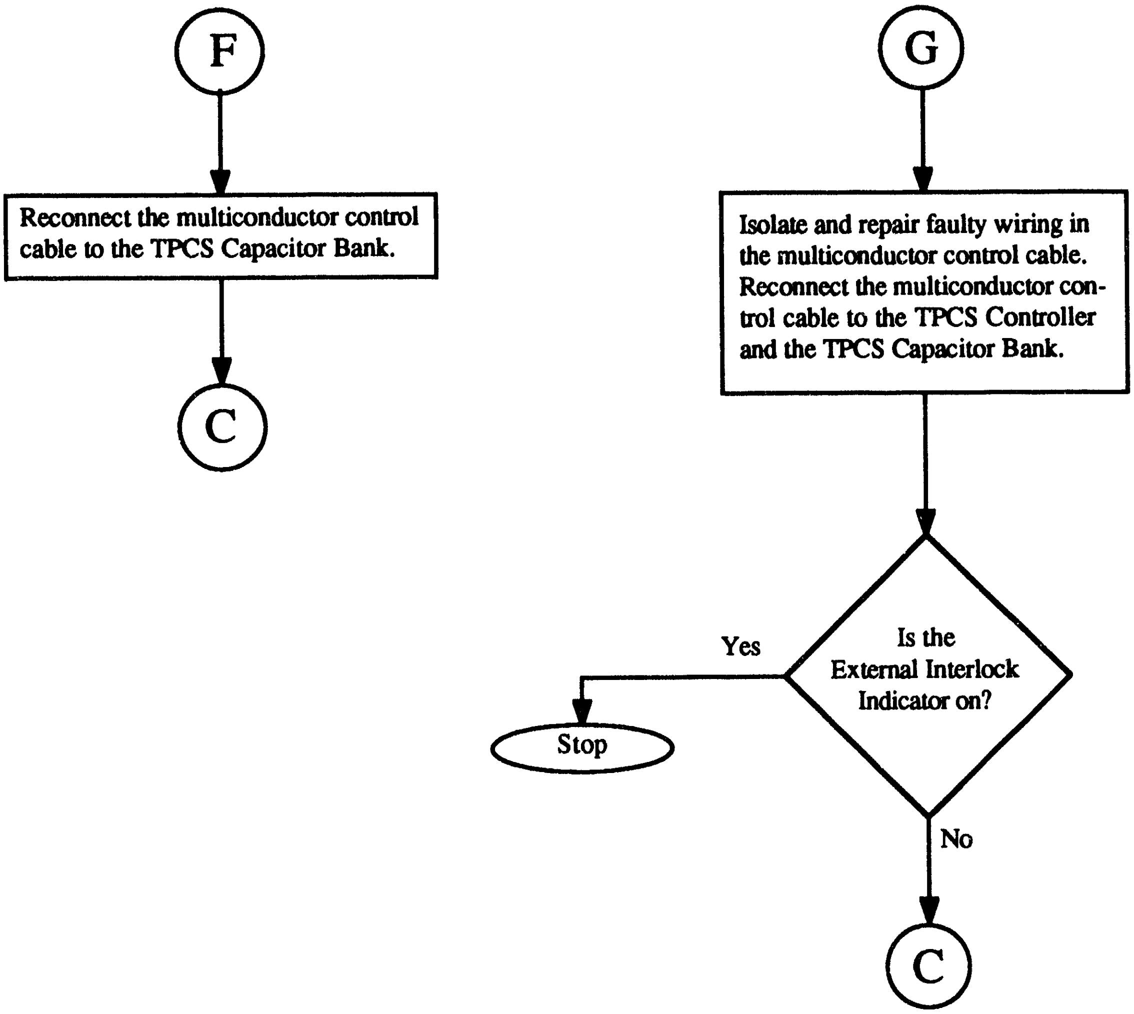
External Interlock OK Indicator Not Illuminated on the TPCS Controller (continued)



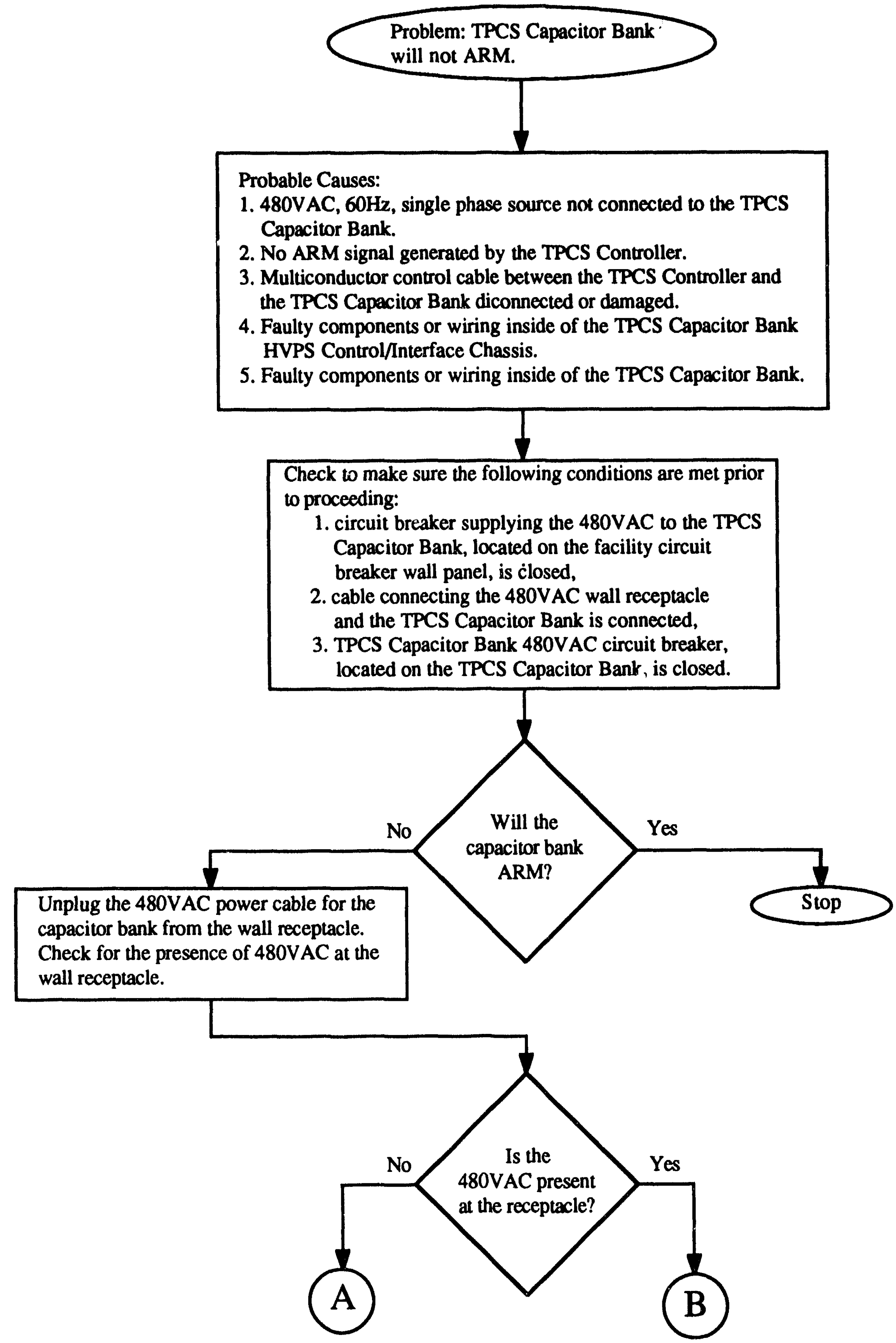
External Interlock OK Indicator Not Illuminated on the TPCS Controller (continued)



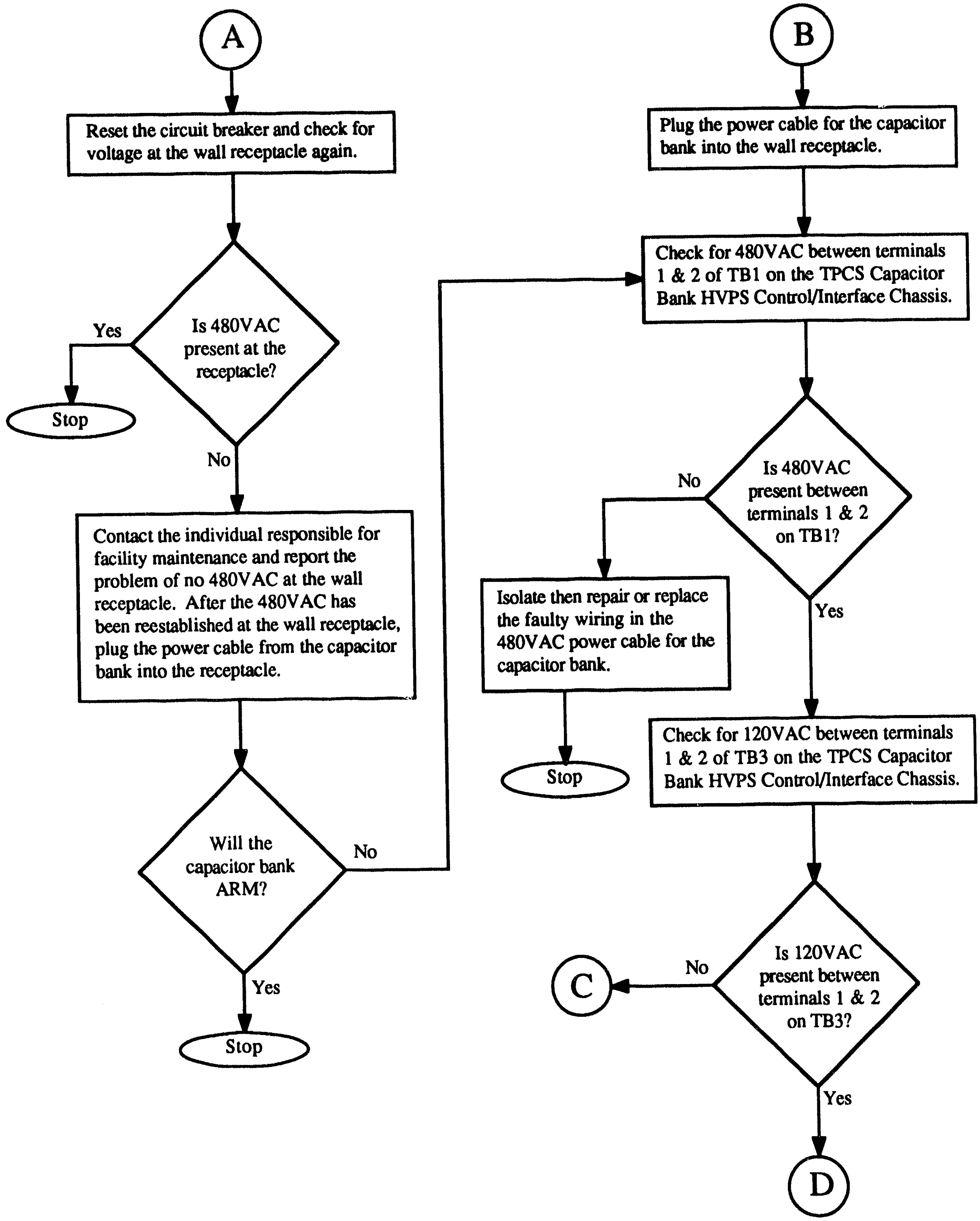
External Interlock OK Indicator Not Illuminated on the TPCS Controller (continued)



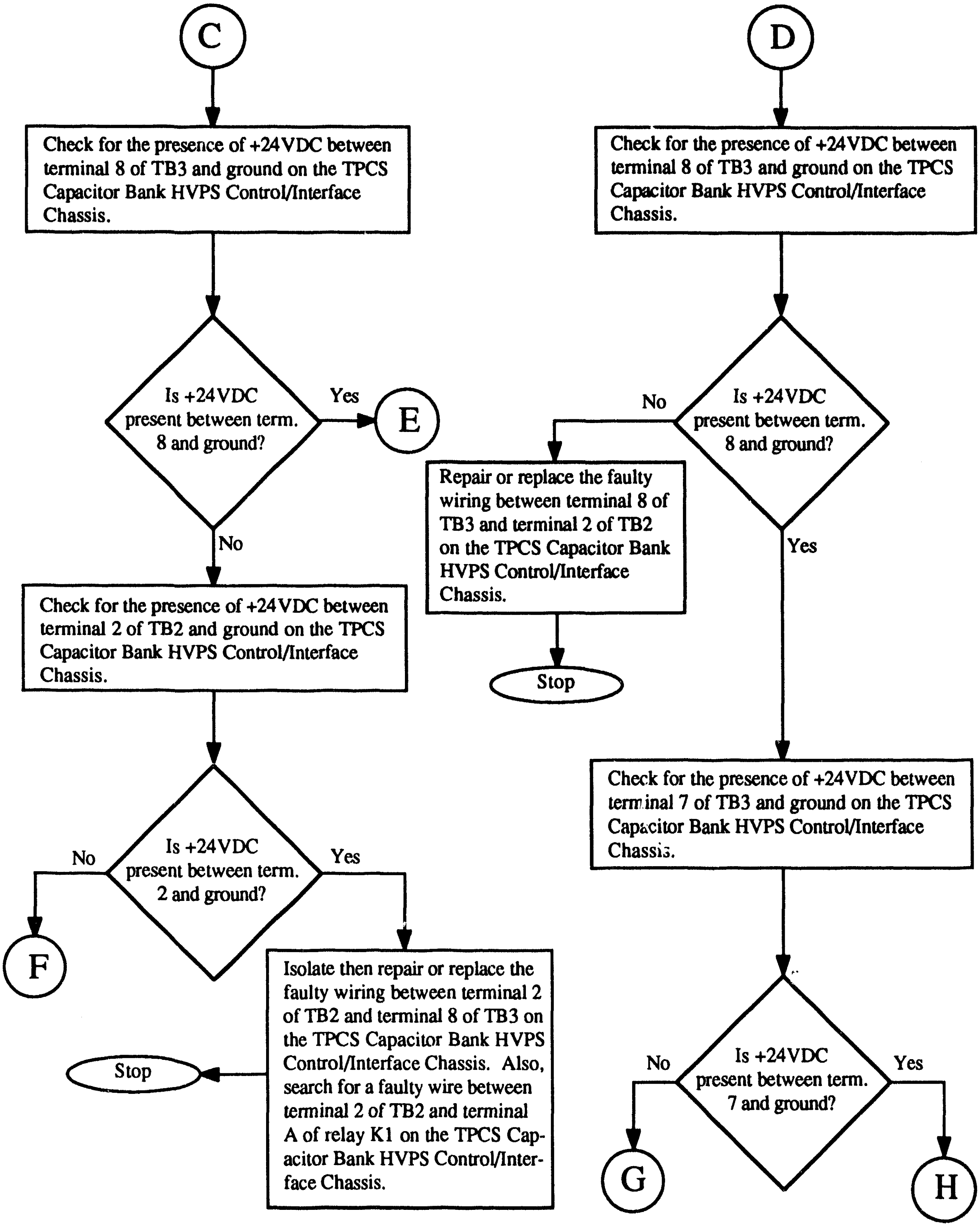
8.4 TPCS Capacitor Bank Will Not ARM


Problem: TPCS Capacitor Bank will not ARM.
Probable Causes:
1. 480VAC, 60Hz, single phase source not connected to the TPCS Capacitor Bank.
2. No ARM signal generated by the TPCS Controller.
3. Multiconductor control cable between the TPCS Controller and the TPCS Capacitor Bank diconnected or damaged.
4. Faulty components or wiring inside of the TPCS Capacitor Bank HVPS Control/Interface Chassis.
5. Faulty components or wiring inside of the TPCS Capacitor Bank.
Check to make sure the following conditions are met prior to proceeding:
1. circuit breaker supplying the 480VAC to the TPCS Capacitor Bank, located on the facility circuit breaker wall panel, is closed,
2. cable connecting the 480VAC wall receptacle and the TPCS Capacitor Bank is connected,
3. TPCS Capacitor Bank 480VAC circuit breaker, located on the TPCS Capacitor Bank, is closed.
Will the capacitor bank ARM?
No
Yes
Stop
Unplug the 480VAC power cable for the capacitor bank from the wall receptacle. Check for the presence of 480VAC at the wall receptacle.
Is the 480VAC present at the receptacle?
No
Yes
A
B

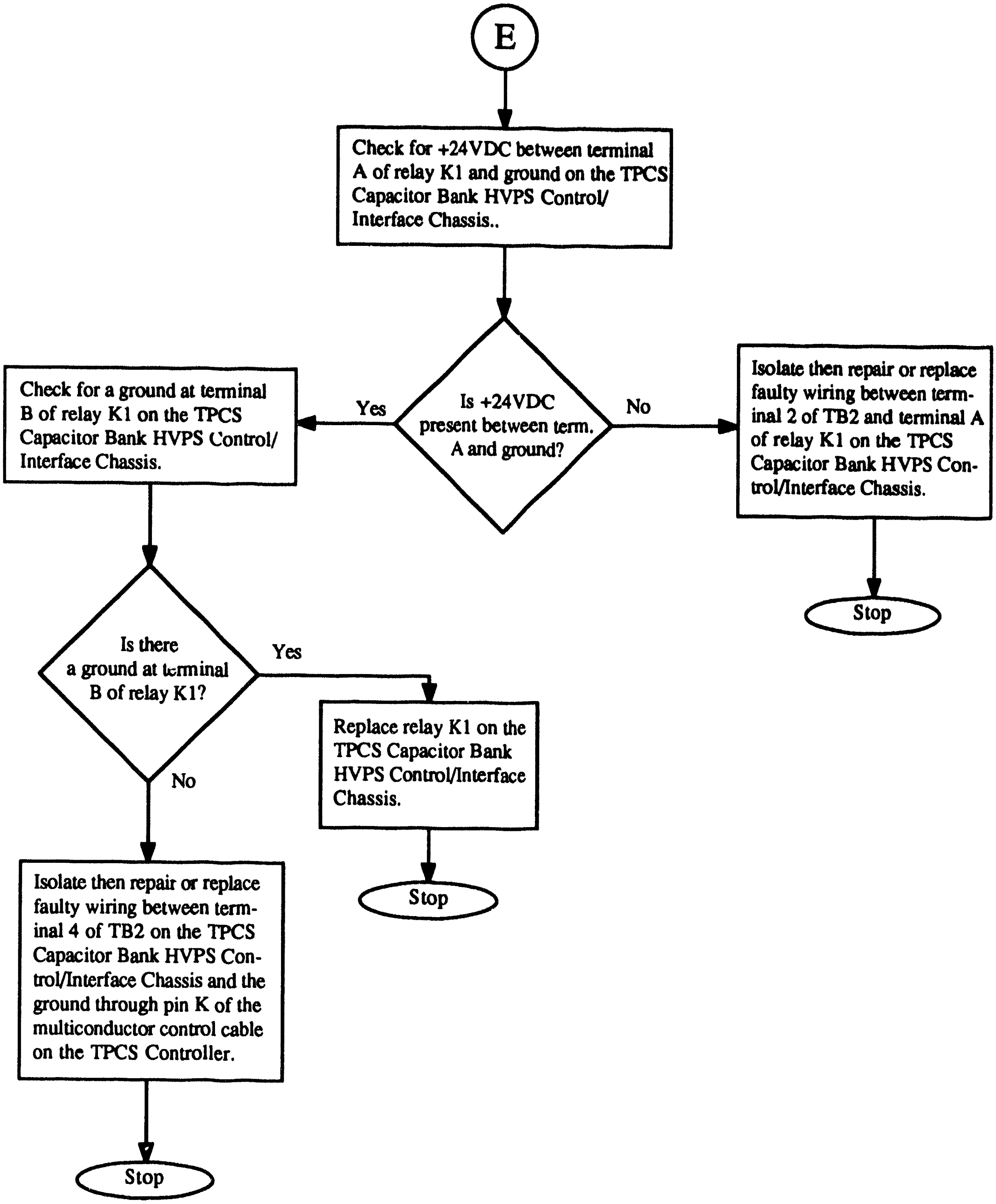
TPCS Capacitor Bank Will Not ARM (continued)



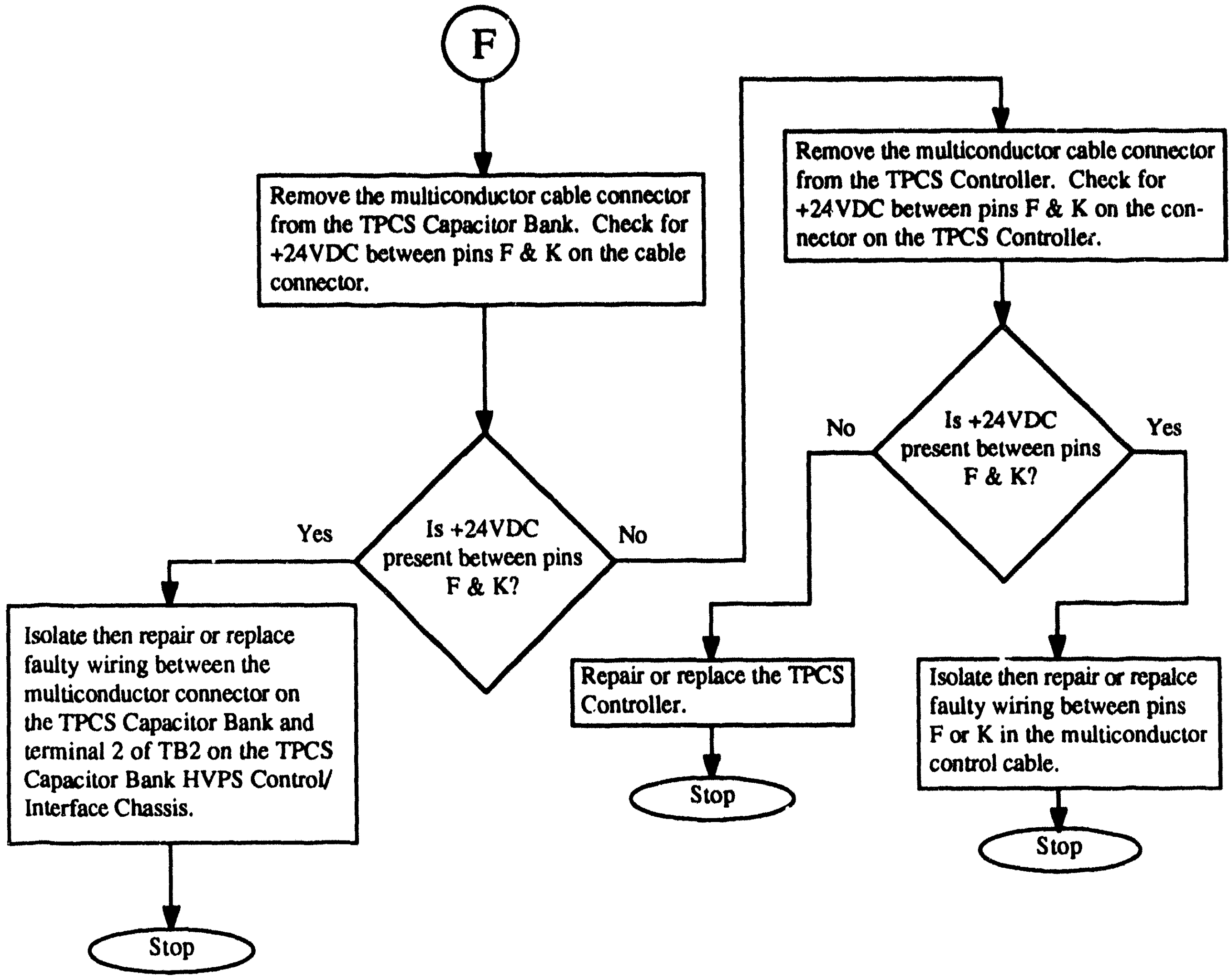
TPCS Capacitor Bank Will Not ARM (continued)



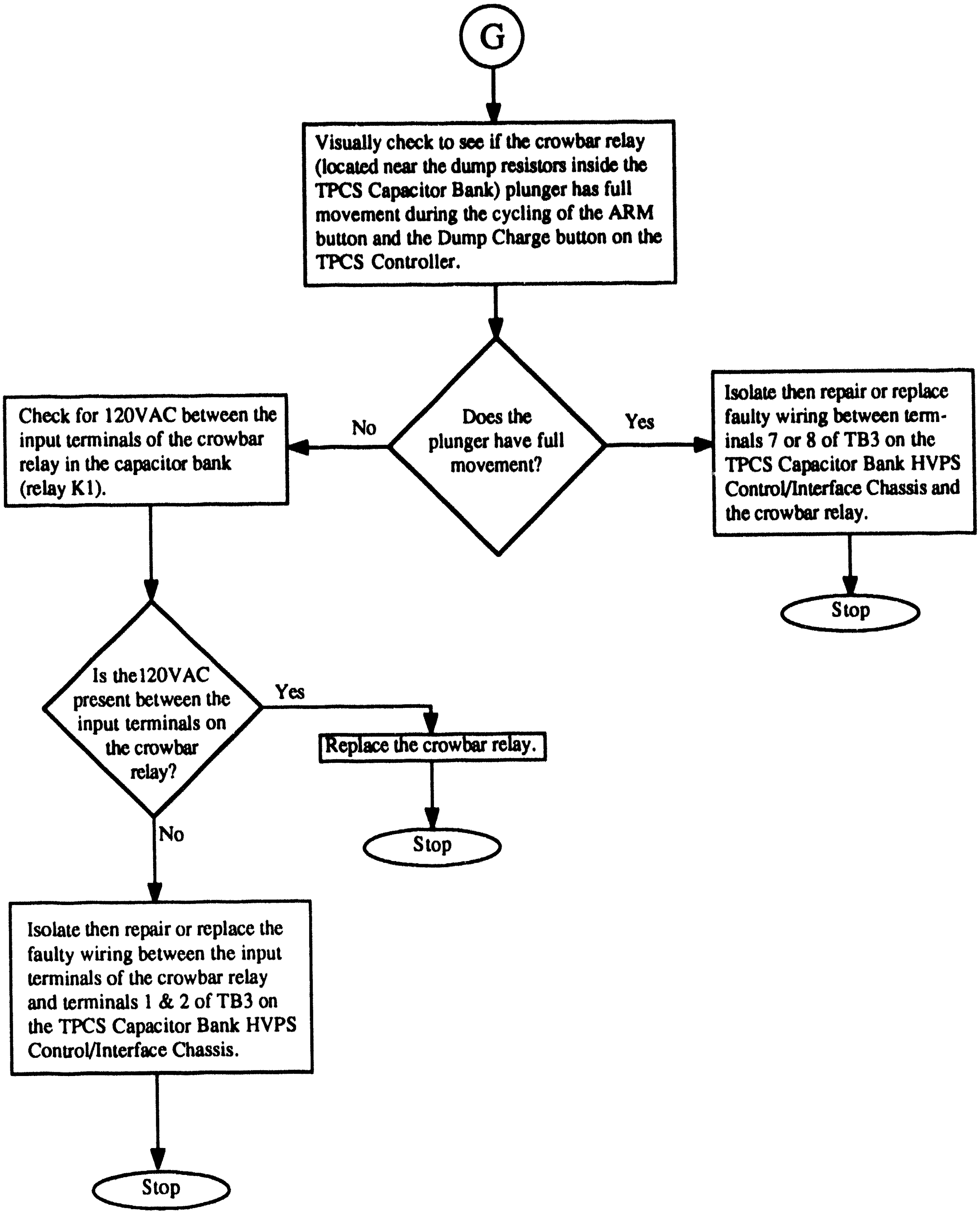
TPCS Capacitor Bank Will Not ARM (continued)



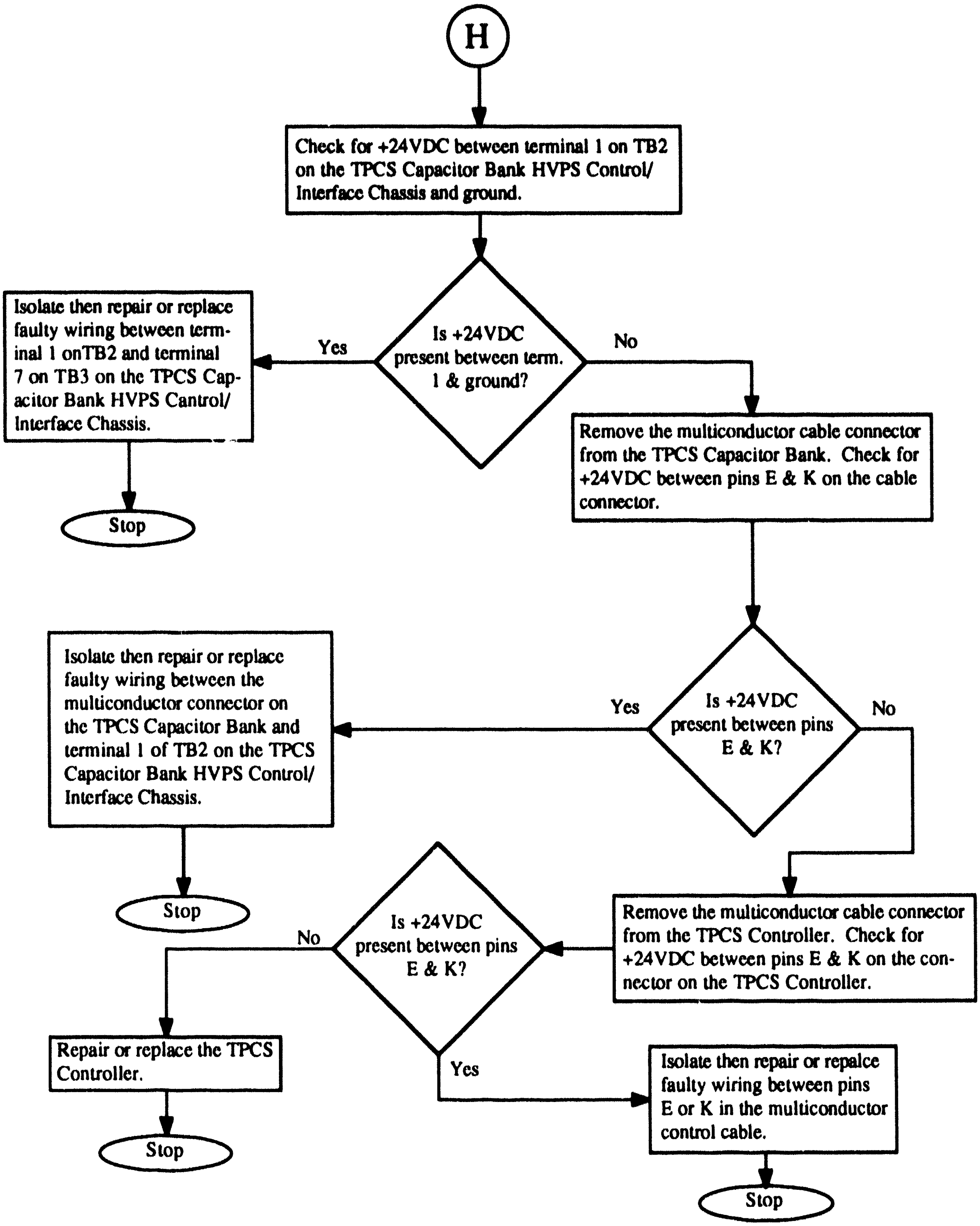
TPCS Capacitor Bank Will Not ARM (continued)



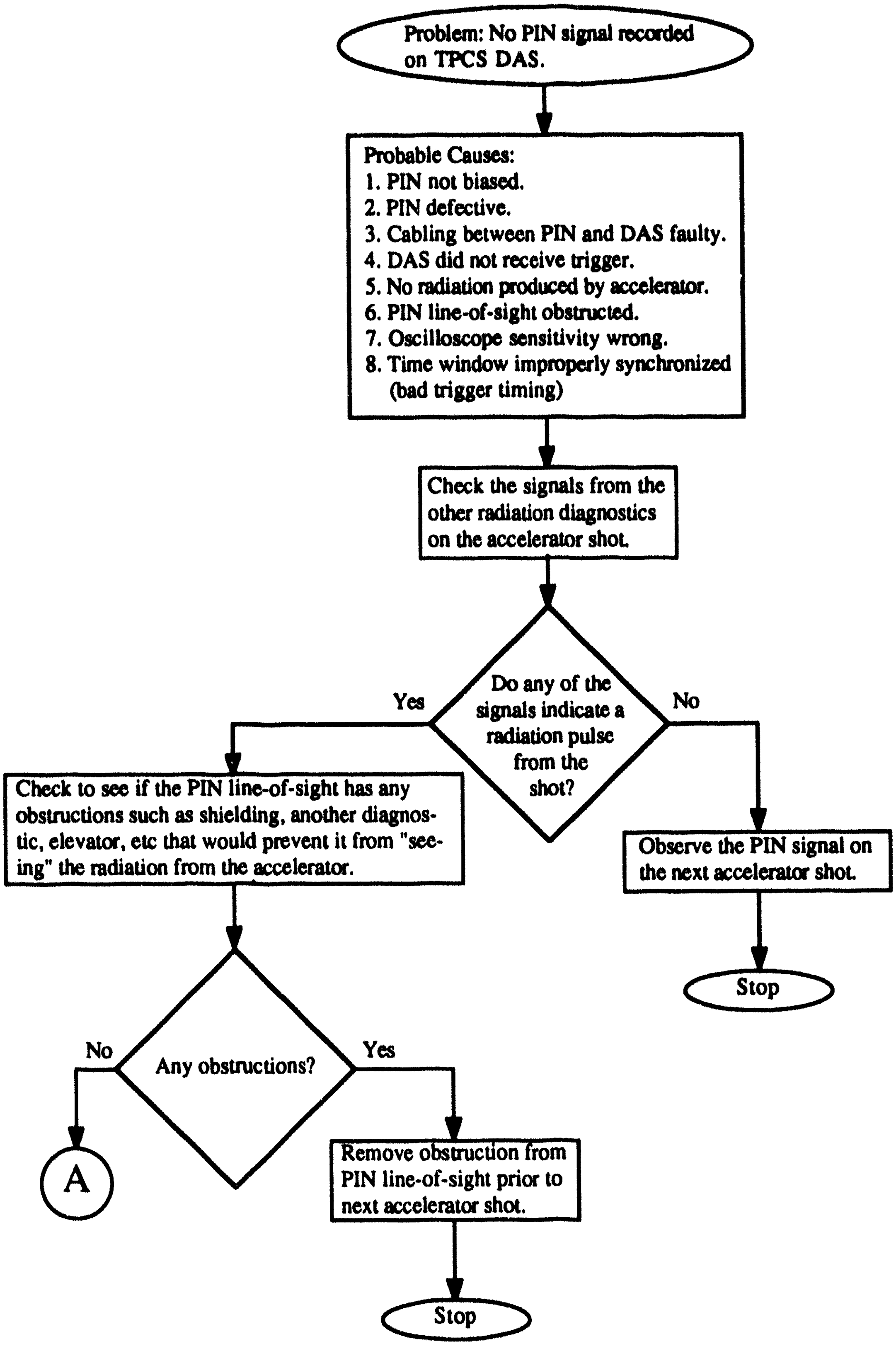
TPCS Capacitor Bank Will Not ARM (continued)



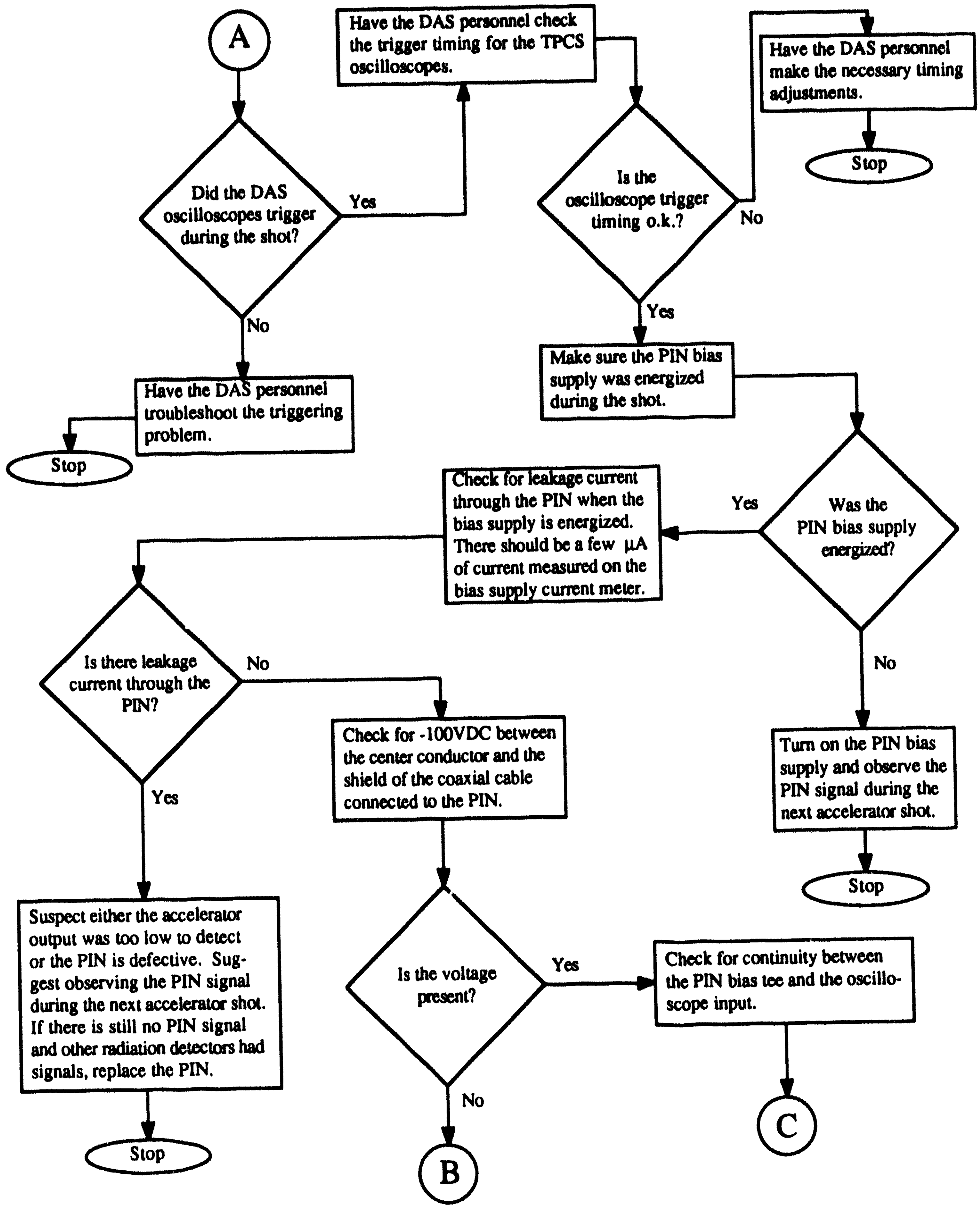
TPCS Capacitor Bank Will Not ARM (continued)



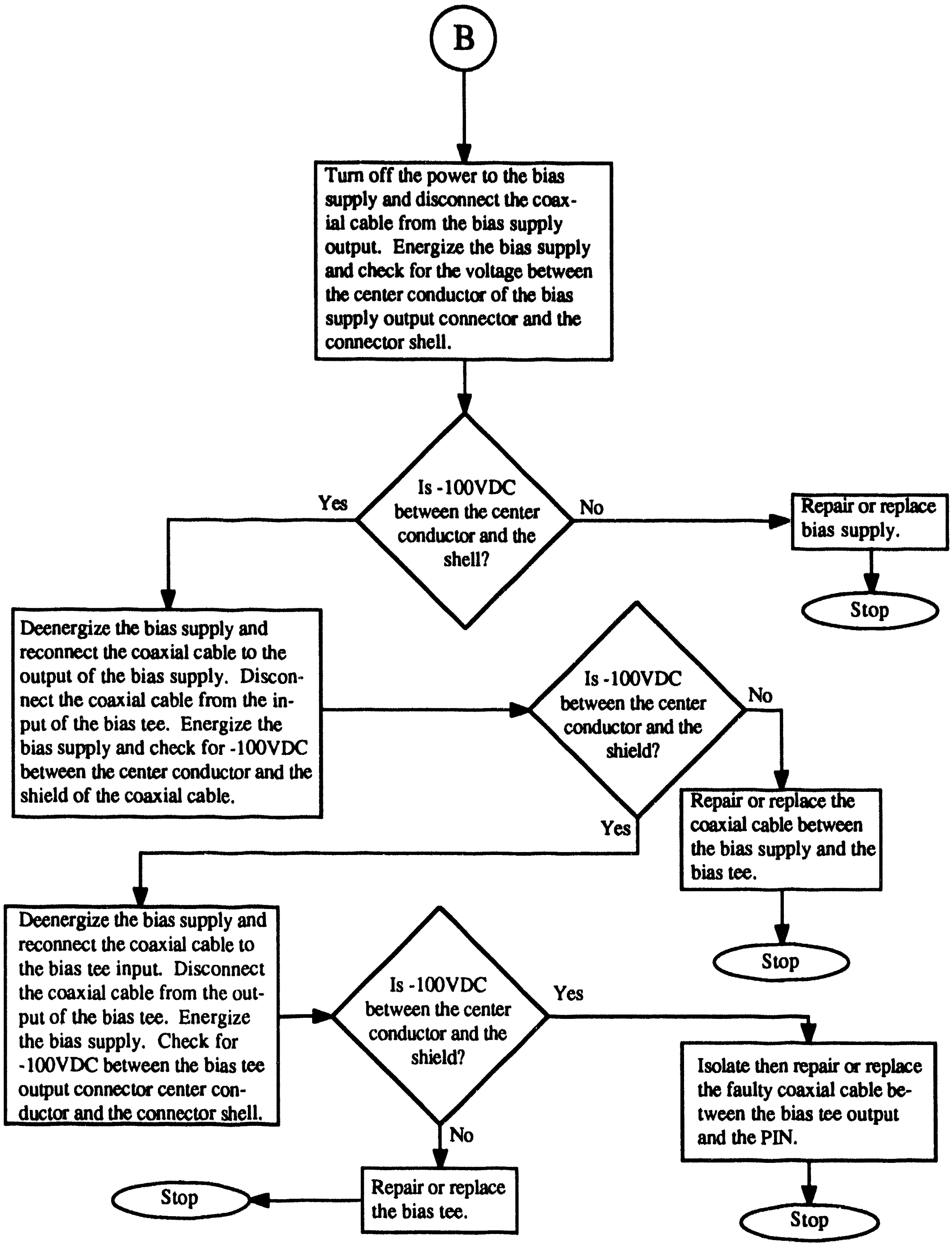
8.5 No PIN Signal Recorded on the TPCS DAS


Problem: No PIN signal recorded on TPCS DAS.
Probable Causes:
1. PIN not biased.
2. PIN defective.
3. Cabling between PIN and DAS faulty.
4. DAS did not receive trigger.
5. No radiation produced by accelerator.
6. PIN line-of-sight obstructed.
7. Oscilloscope sensitivity wrong.
8. Time window improperly synchronized (bad trigger timing)
Check the signals from the other radiation diagnostics on the accelerator shot.
Do any of the signals indicate a radiation pulse from the shot?
Yes
No
Check to see if the PIN line-of-sight has any obstructions such as shielding, another diagnostic, elevator, etc that would prevent it from "seeing" the radiation from the accelerator.
Observe the PIN signal on the next accelerator shot.
Stop
Any obstructions?
No
Yes
A
Remove obstruction from PIN line-of-sight prior to next accelerator shot.
Stop

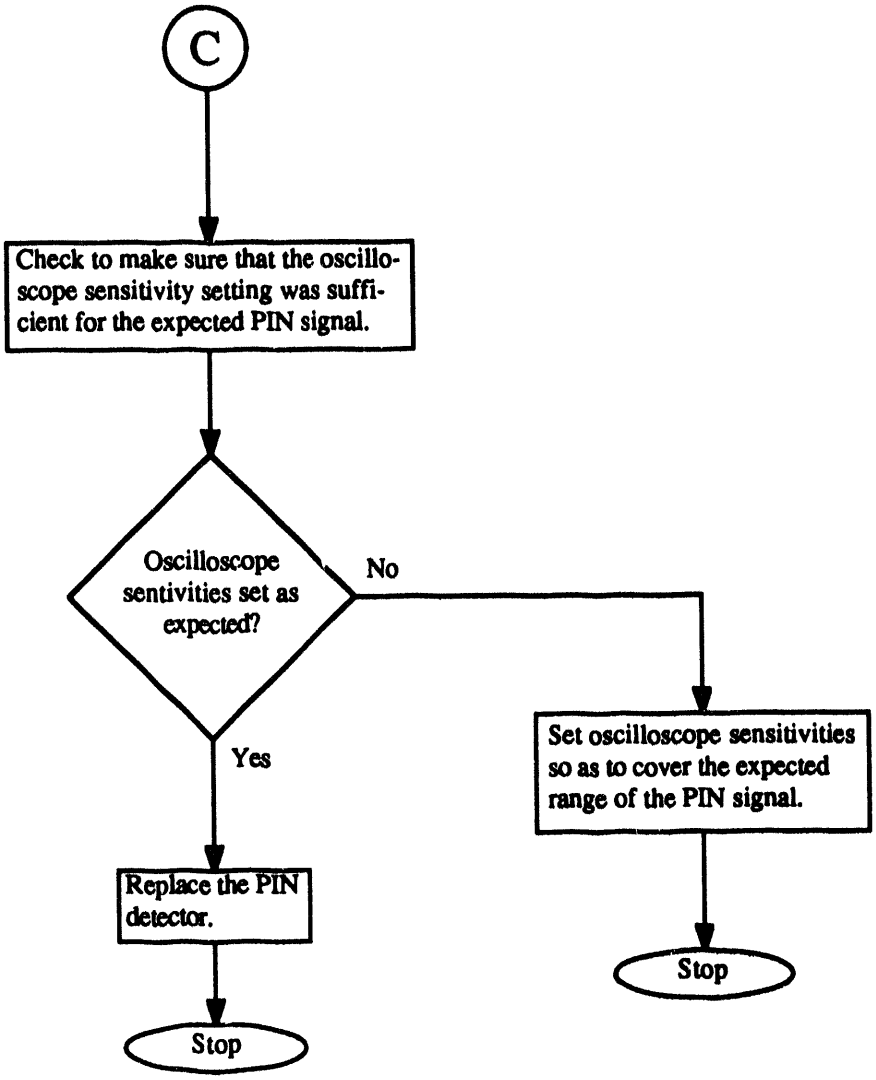
No PIN Signal Recorded on TPCS DAS (continued)



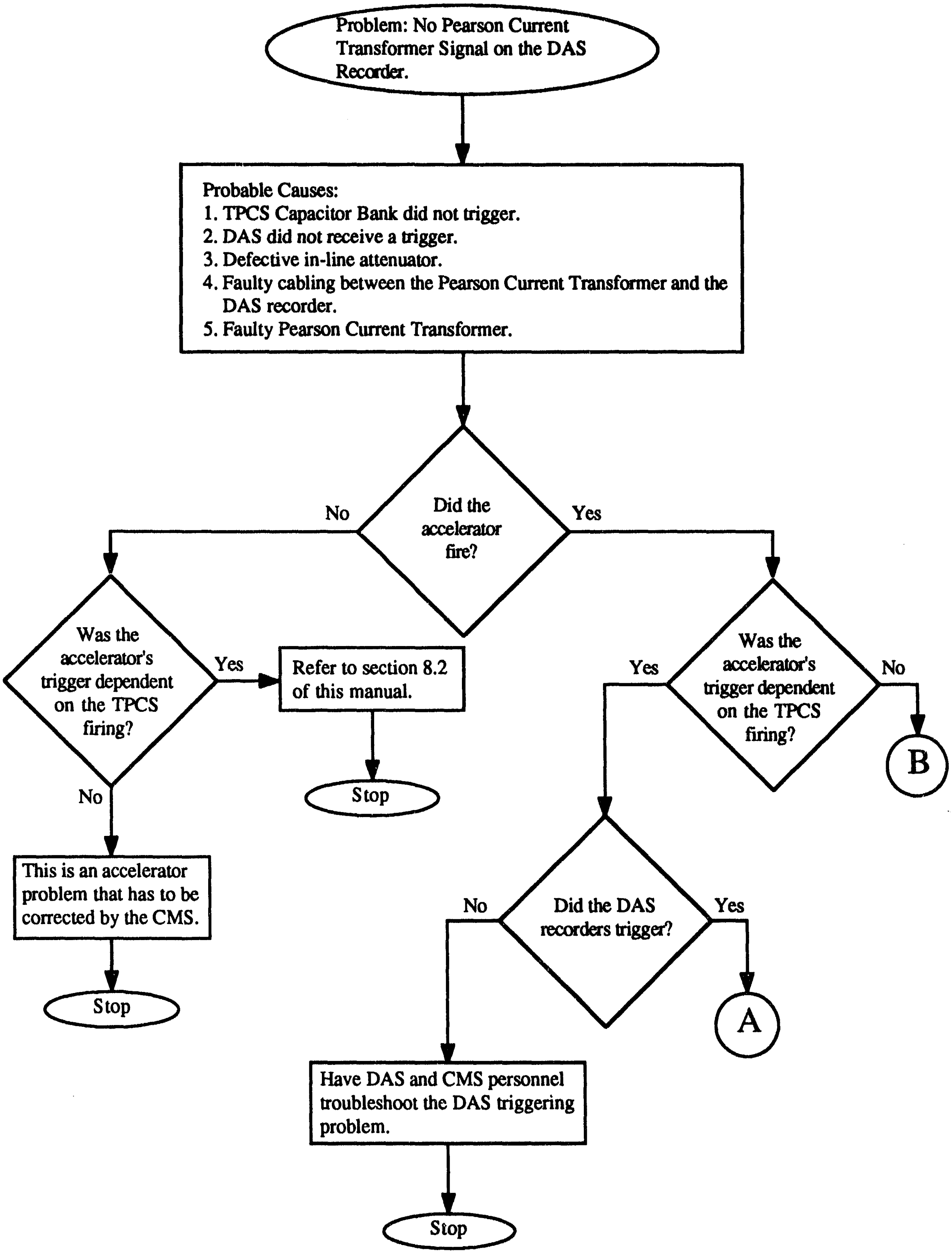
No PIN Signal Recorded on TPCS DAS (continued)



No PIN Signal Recorded on TPCS DAS (continued)

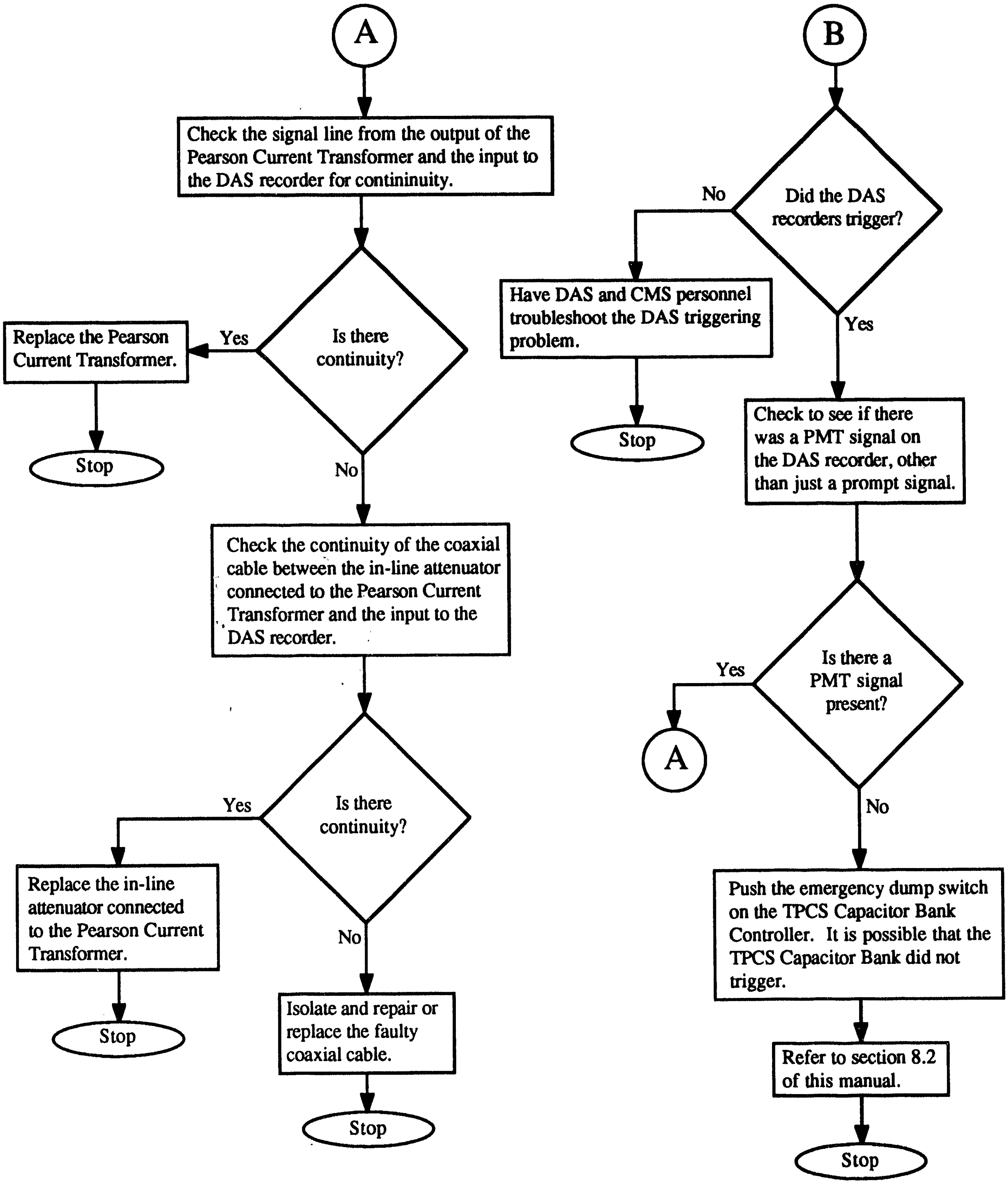


8.6 No Pearson Current Transformer Signal on the DAS Recorder

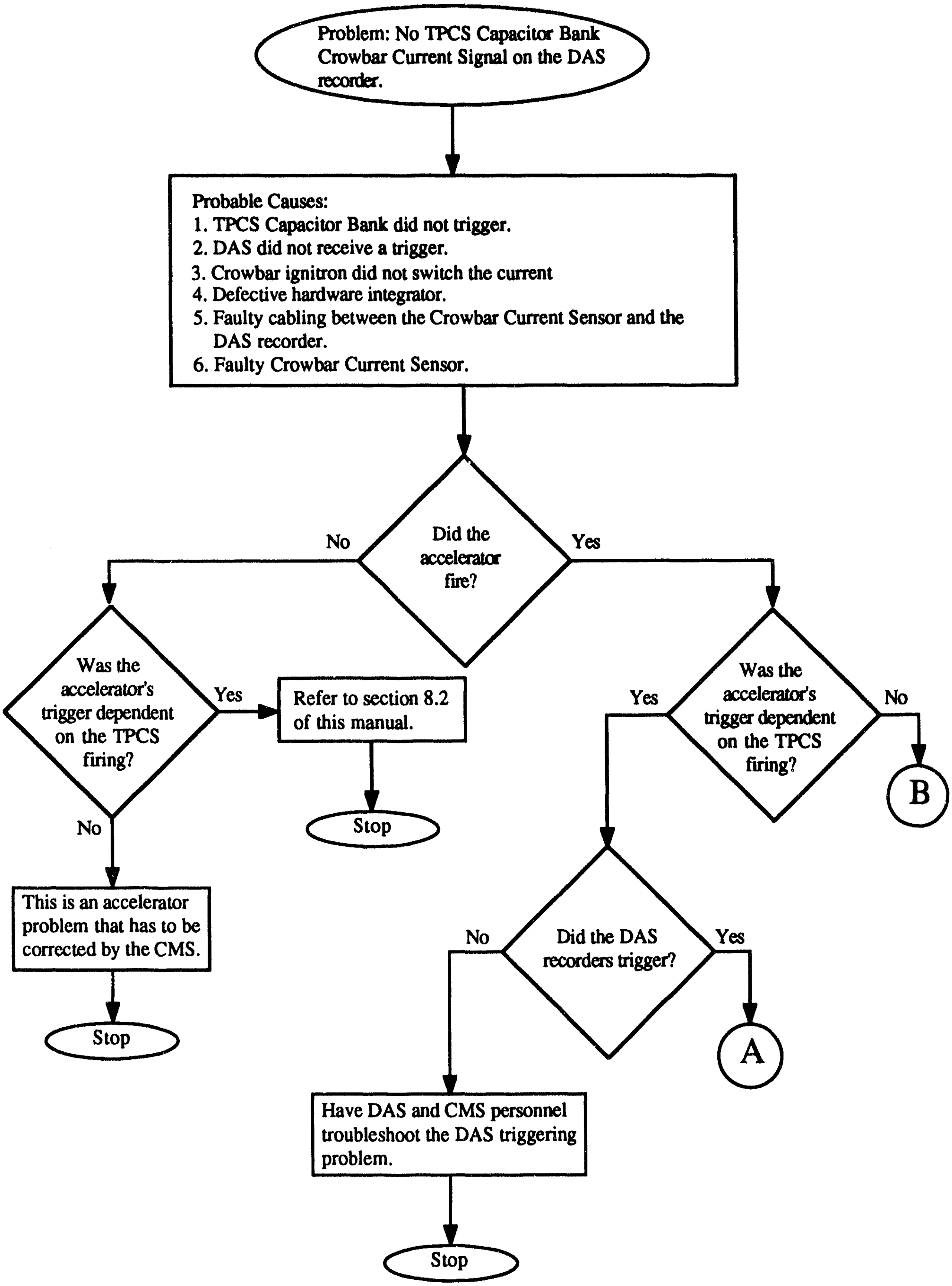


Problem: No Pearson Current Transformer Signal on the DAS Recorder.
Probable Causes:
1. TPCS Capacitor Bank did not trigger.
2. DAS did not receive a trigger.
3. Defective in-line attenuator.
4. Faulty cabling between the Pearson Current Transformer and the DAS recorder.
5. Faulty Pearson Current Transformer.
Did the accelerator fire?
No
Yes
Was the accelerator's trigger dependent on the TPCS firing?
Yes
Refer to section 8.2 of this manual.
Stop
No
This is an accelerator problem that has to be corrected by the CMS.
Stop
Was the accelerator's trigger dependent on the TPCS firing?
Yes
No
B
Did the DAS recorders trigger?
No
Yes
A
Have DAS and CMS personnel troubleshoot the DAS triggering problem.
Stop

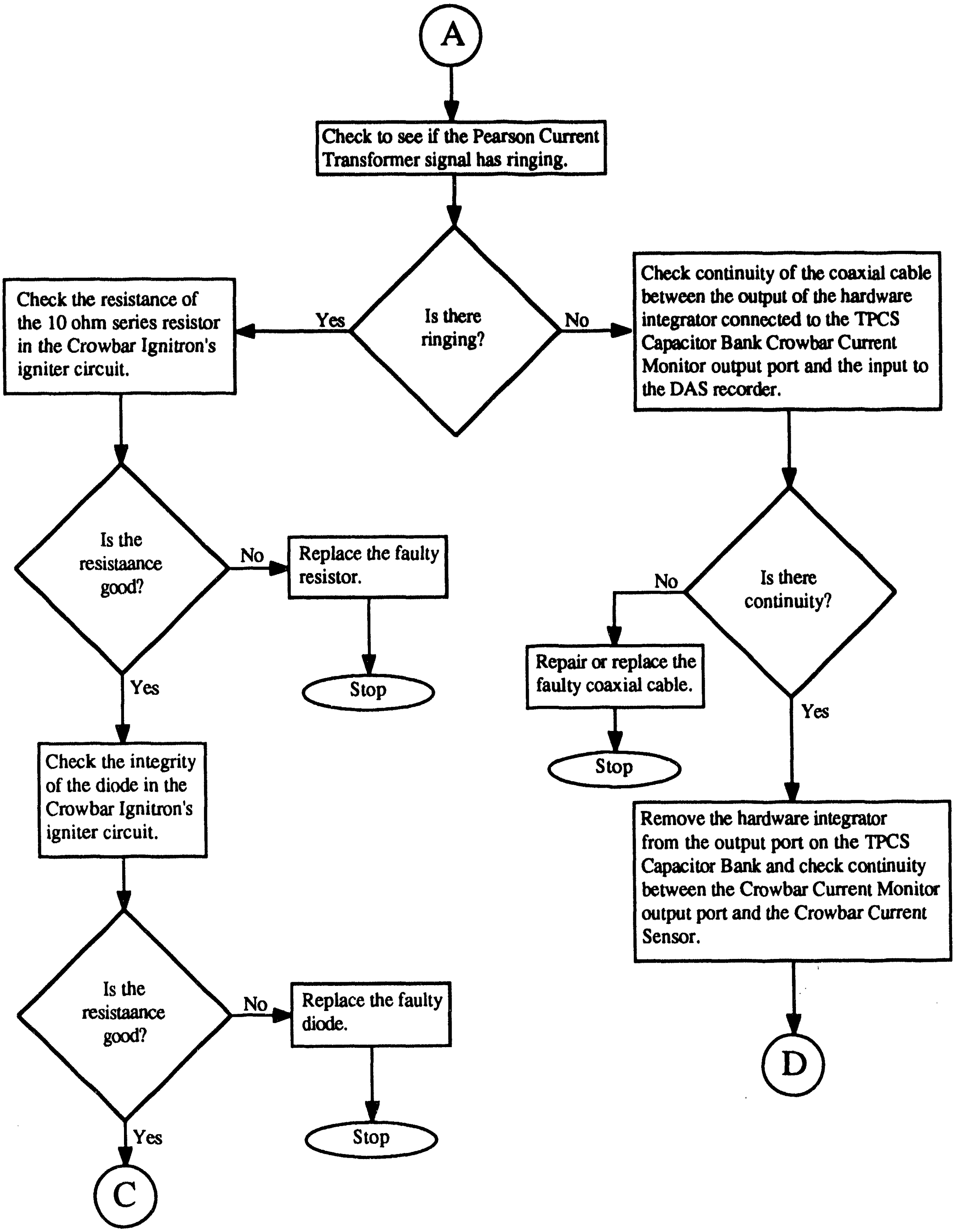
No Pearson Current Transformer Signal on the DAS Recorder (continued)



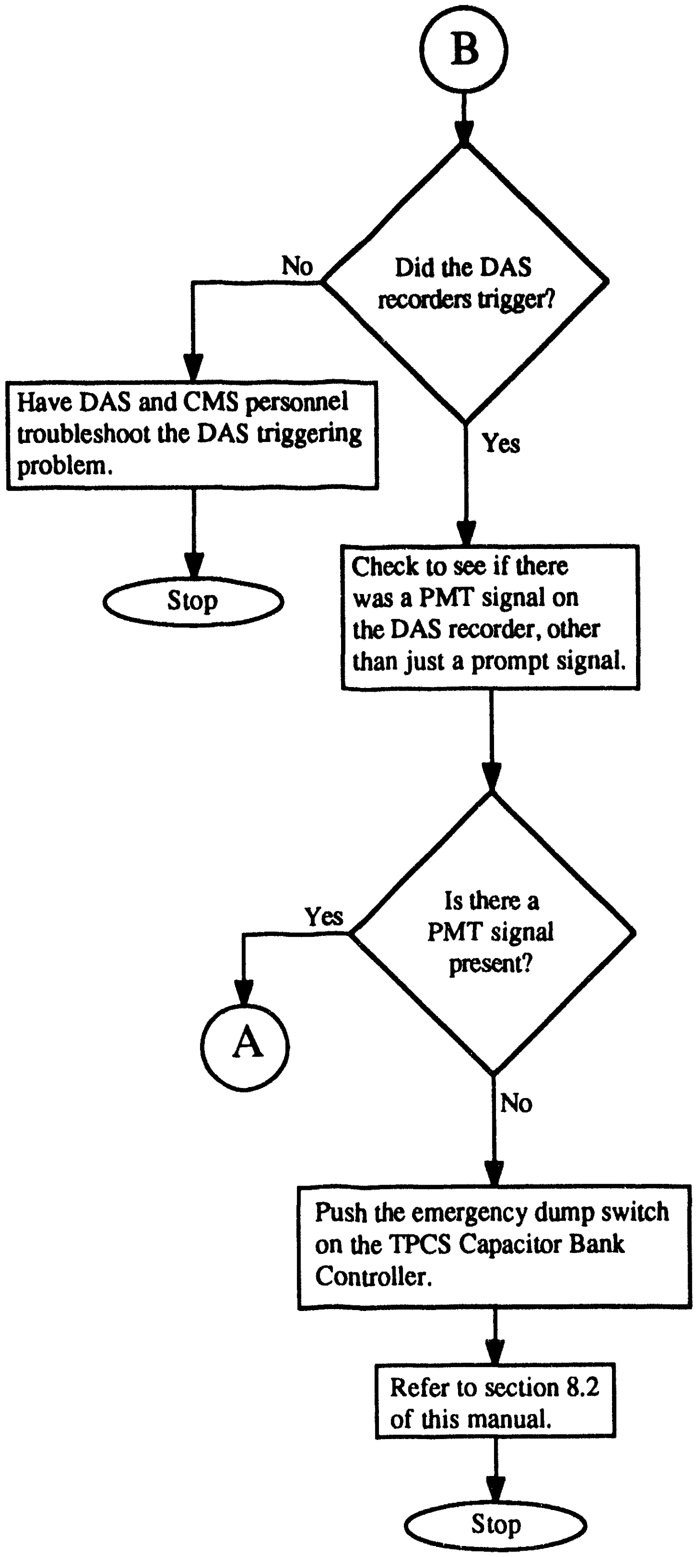
8.7 No TPCS Capacitor Bank Crowbar Current Signal on the DAS Recorder


Problem: No TPCS Capacitor Bank Crowbar Current Signal on the DAS recorder.
Probable Causes:
1. TPCS Capacitor Bank did not trigger.
2. DAS did not receive a trigger.
3. Crowbar ignitron did not switch the current
4. Defective hardware integrator.
5. Faulty cabling between the Crowbar Current Sensor and the DAS recorder.
6. Faulty Crowbar Current Sensor.
Did the accelerator fire?
No
Yes
Was the accelerator's trigger dependent on the TPCS firing?
Yes
Refer to section 8.2 of this manual.
Stop
No
This is an accelerator problem that has to be corrected by the CMS.
Stop
Was the accelerator's trigger dependent on the TPCS firing?
Yes
No
B
Did the DAS recorders trigger?
No
Yes
A
Have DAS and CMS personnel troubleshoot the DAS triggering problem.
Stop

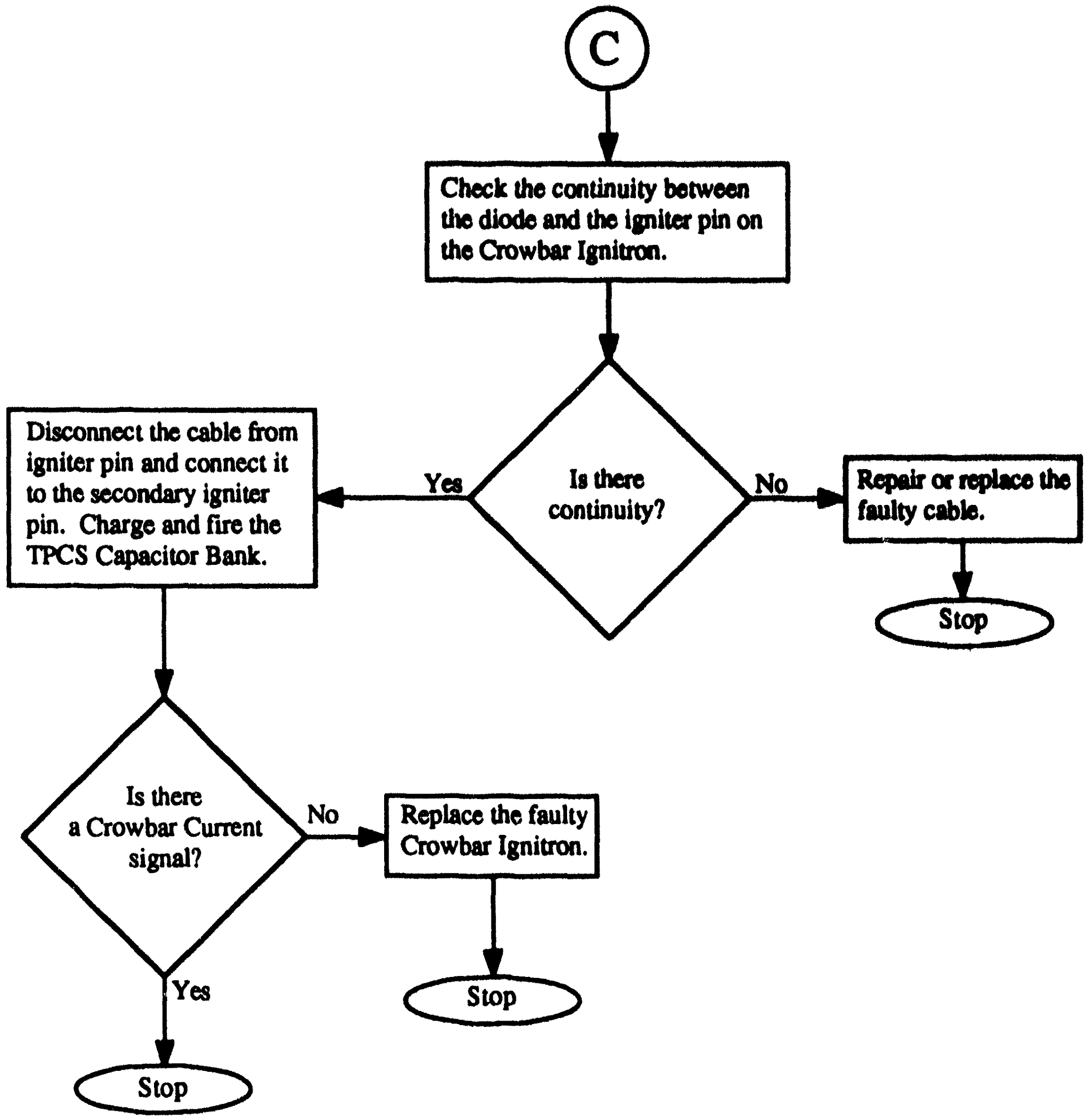
No TPCS Capacitor Bank Crowbar Current Signal on the DAS Recorder (continued)



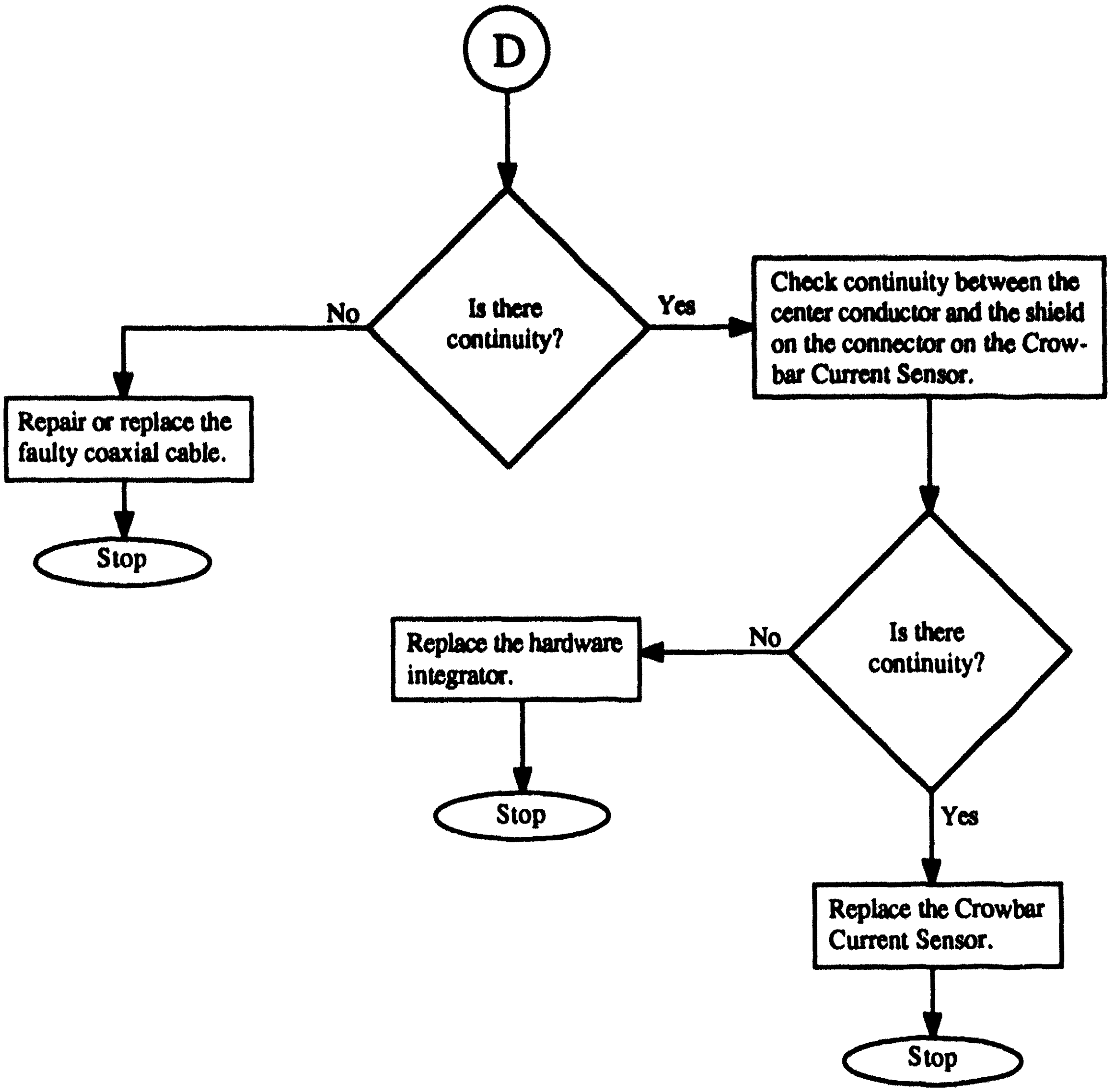
No TPCS Capacitor Bank Crowbar Current Signal on the DAS Recorder (continued)



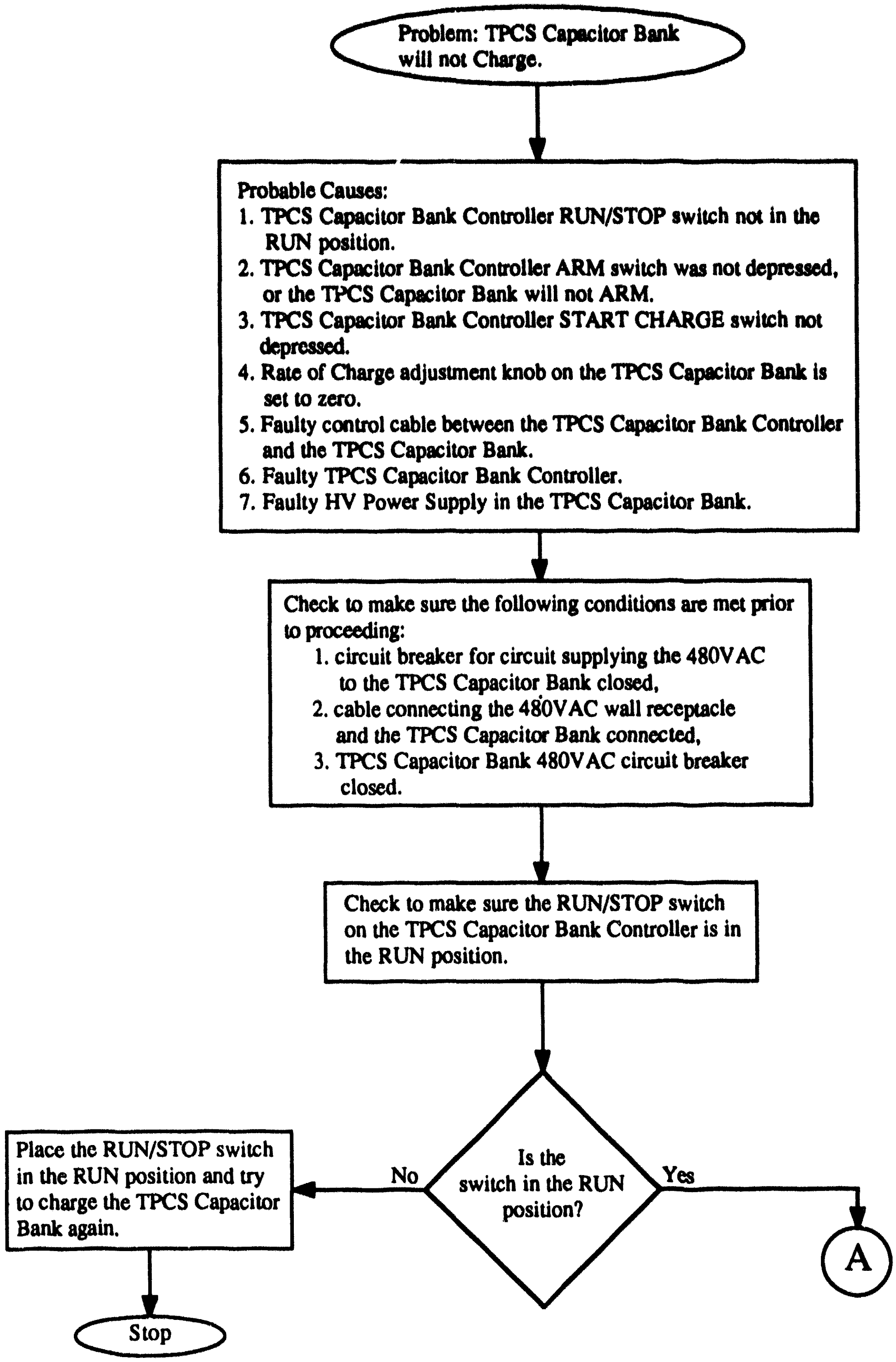
No TPCS Capacitor Bank Crowbar Current Signal on the DAS Recorder (continued)



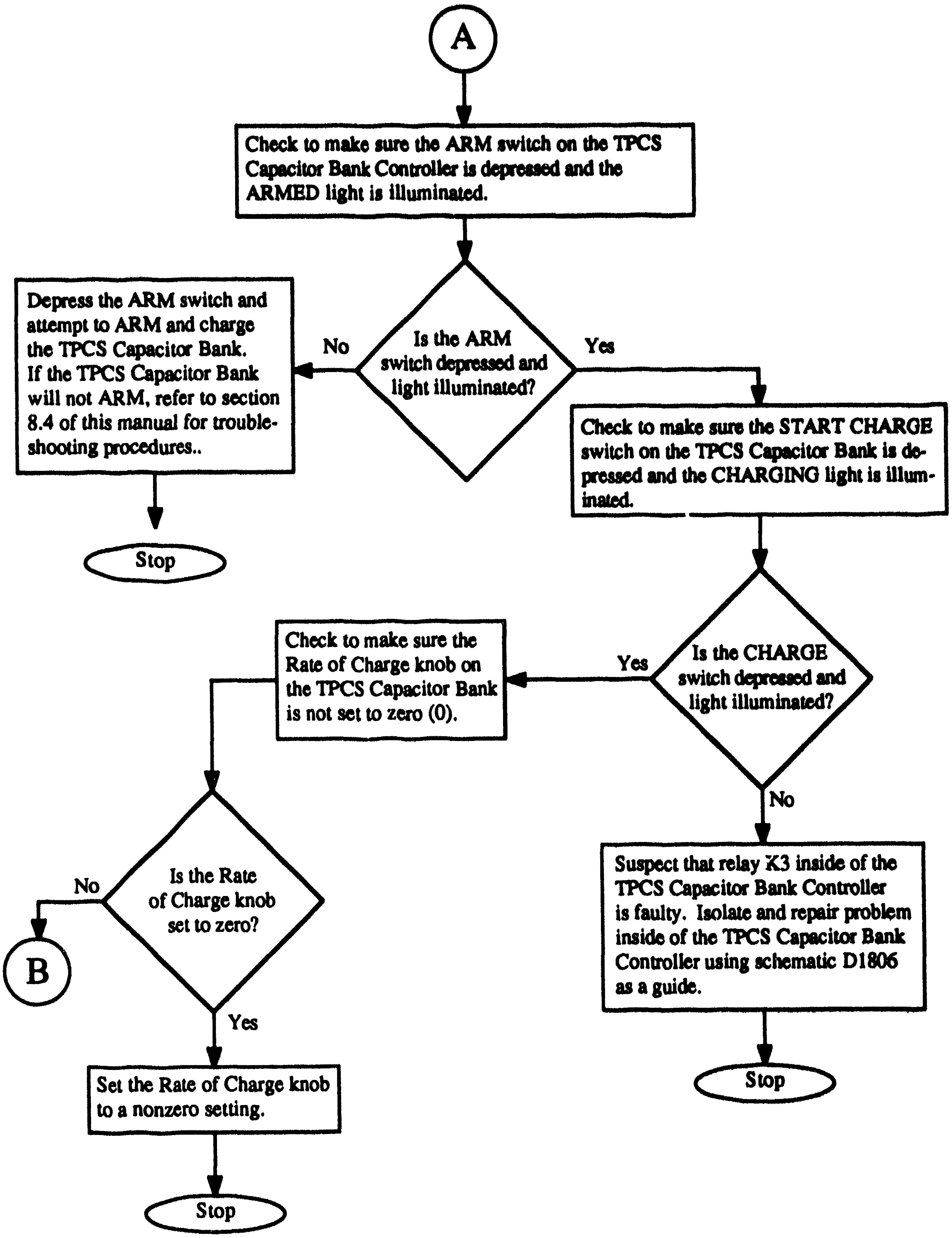
No TPCS Capacitor Bank Crowbar Current Signal on the DAS Recorder (continued)



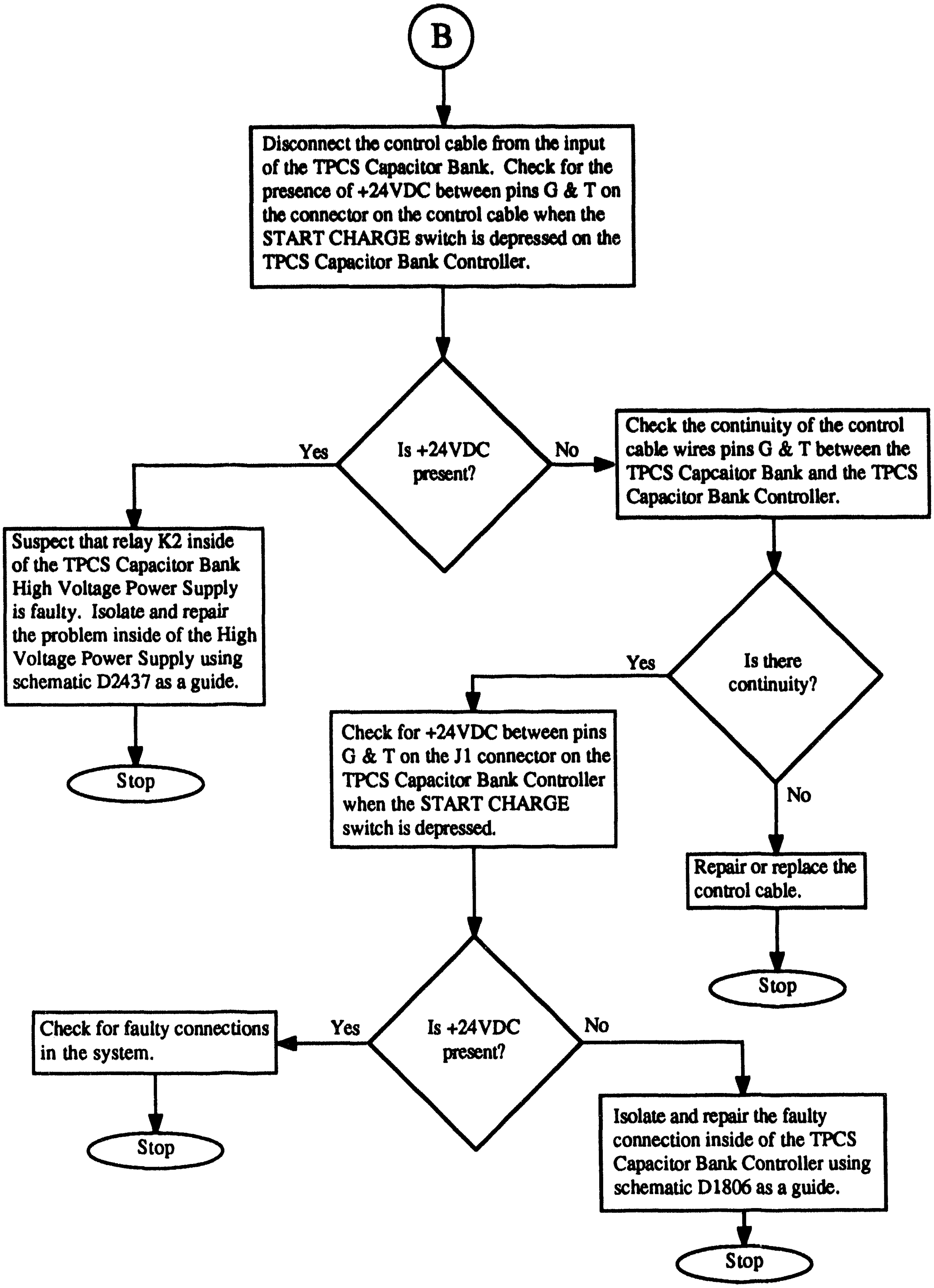
8.8 TPCS Capacitor Bank Does Not Charge


Problem: TPCS Capacitor Bank will not Charge.
Probable Causes:
1. TPCS Capacitor Bank Controller RUN/STOP switch not in the RUN position.
2. TPCS Capacitor Bank Controller ARM switch was not depressed, or the TPCS Capacitor Bank will not ARM.
3. TPCS Capacitor Bank Controller START CHARGE switch not depressed.
4. Rate of Charge adjustment knob on the TPCS Capacitor Bank is set to zero.
5. Faulty control cable between the TPCS Capacitor Bank Controller and the TPCS Capacitor Bank.
6. Faulty TPCS Capacitor Bank Controller.
7. Faulty HV Power Supply in the TPCS Capacitor Bank.
Check to make sure the following conditions are met prior to proceeding:
1. circuit breaker for circuit supplying the 480VAC to the TPCS Capacitor Bank closed,
2. cable connecting the 480VAC wall receptacle and the TPCS Capacitor Bank connected,
3. TPCS Capacitor Bank 480VAC circuit breaker closed.
Check to make sure the RUN/STOP switch on the TPCS Capacitor Bank Controller is in the RUN position.
Is the switch in the RUN position?
No
Yes
Place the RUN/STOP switch in the RUN position and try to charge the TPCS Capacitor Bank again.
Stop
A

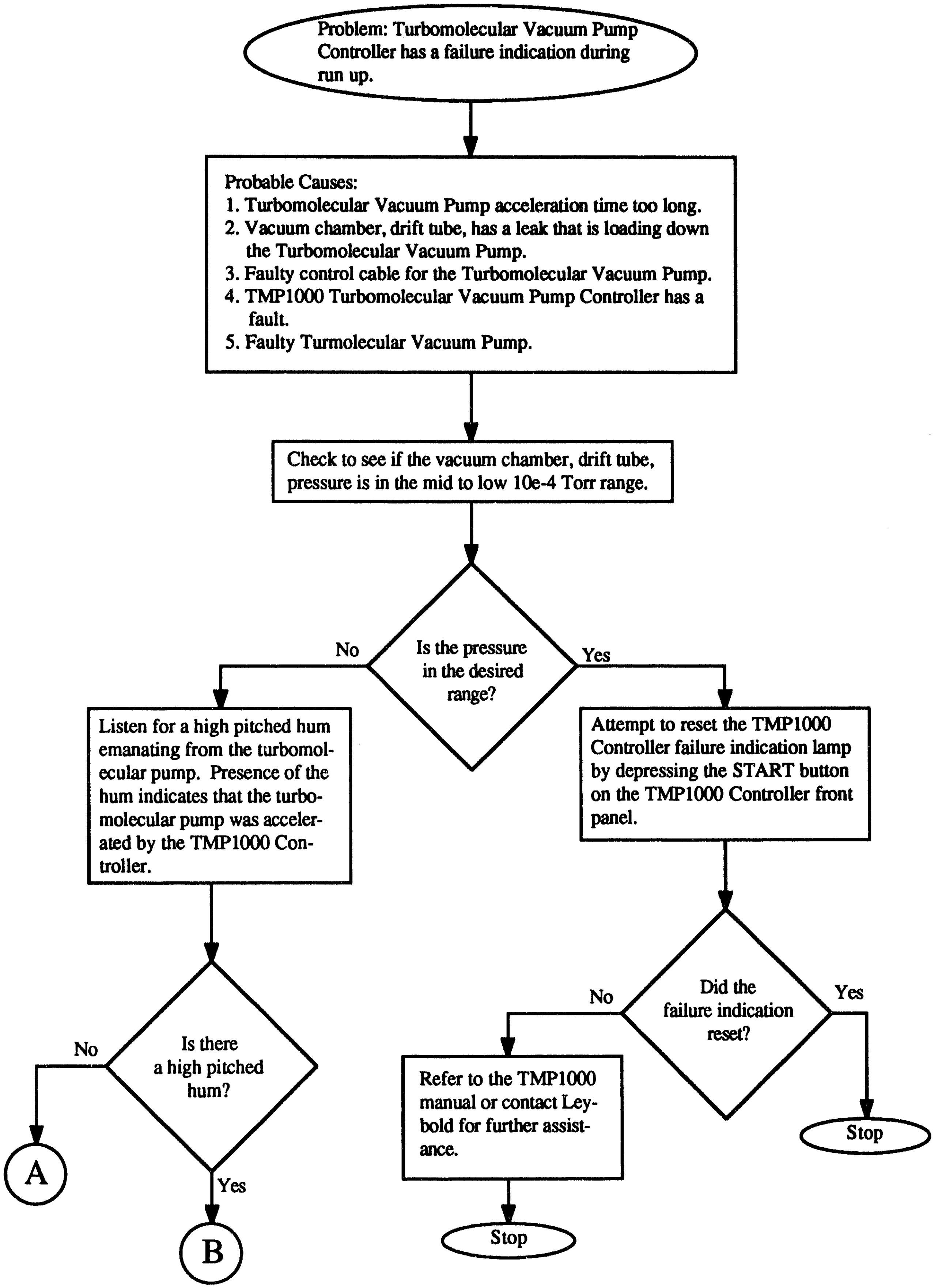
TPCS Capacitor Bank Does Not Charge (continued)



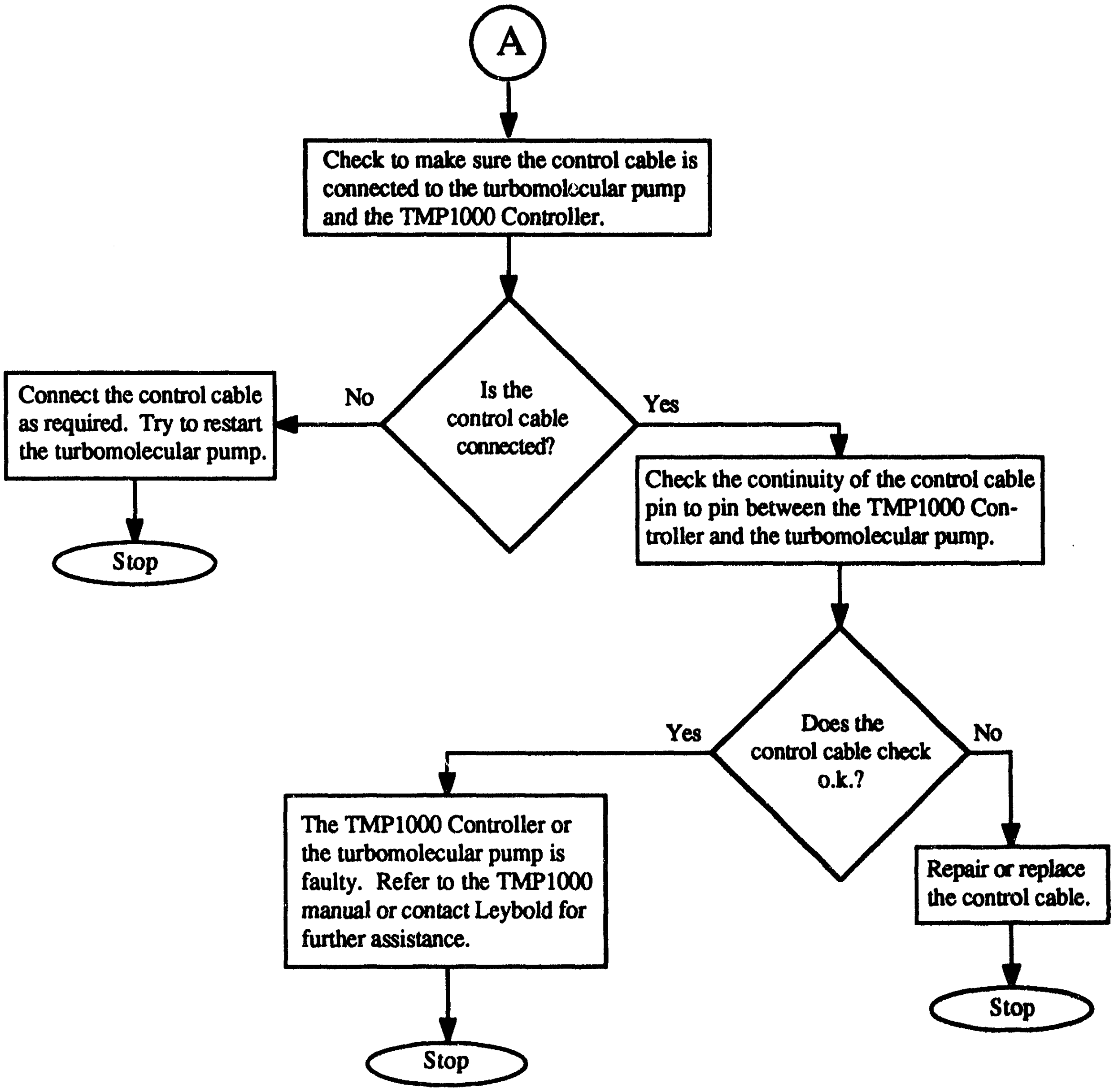
TPCS Capacitor Bank Does Not Charge (continued)



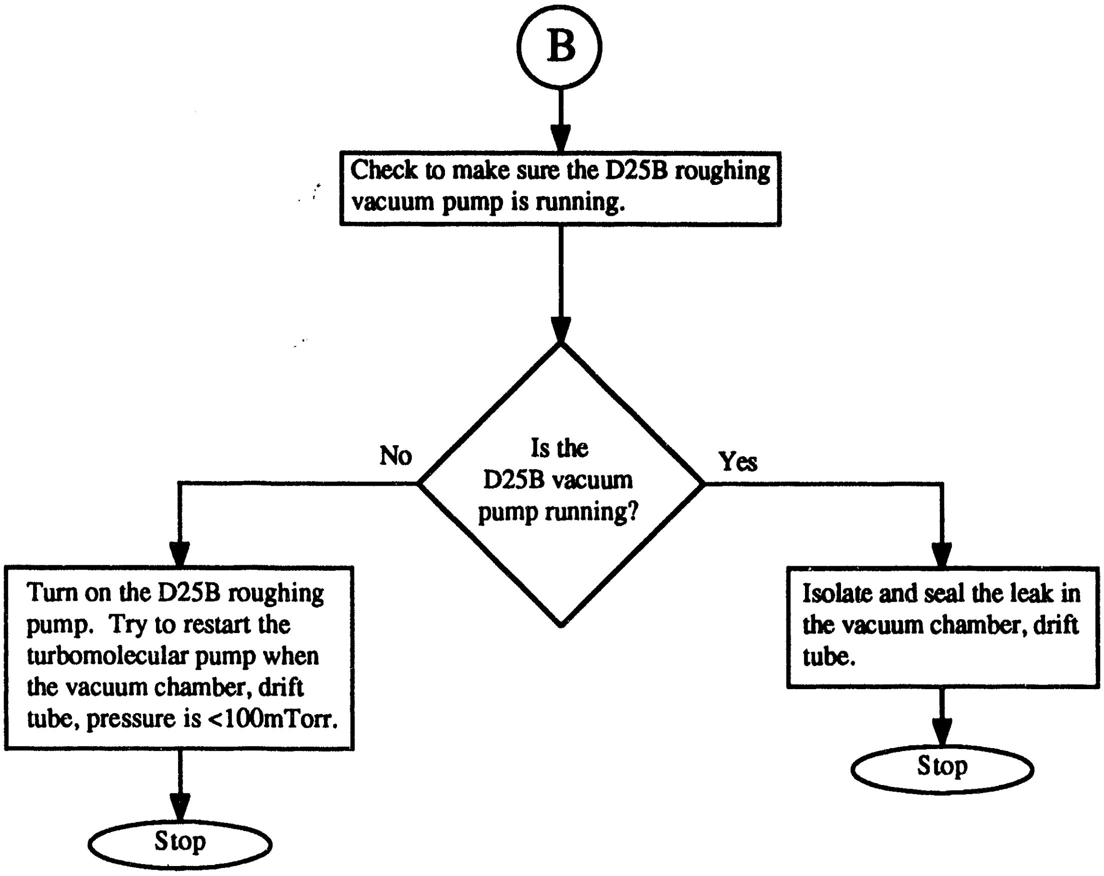
8.9 Turbomolecular Vacuum Pump Has a Failure Indication During Run Up


Problem: Turbomolecular Vacuum Pump Controller has a failure indication during run up.
Probable Causes:
1. Turbomolecular Vacuum Pump acceleration time too long.
2. Vacuum chamber, drift tube, has a leak that is loading down the Turbomolecular Vacuum Pump.
3. Faulty control cable for the Turbomolecular Vacuum Pump.
4. TMP1000 Turbomolecular Vacuum Pump Controller has a fault.
5. Faulty Turmolecular Vacuum Pump.
Check to see if the vacuum chamber, drift tube, pressure is in the mid to low 10e-4 Torr range.
Is the pressure in the desired range?
No
Yes
Listen for a high pitched hum emanating from the turbomolecular pump. Presence of the hum indicates that the turbomolecular pump was accelerated by the TMP1000 Controller.
Attempt to reset the TMP1000 Controller failure indication lamp by depressing the START button on the TMP1000 Controller front panel.
Is there a high pitched hum?
No
Yes
A
B
Did the failure indication reset?
No
Yes
Refer to the TMP1000 manual or contact Leybold for further assistance.
Stop
Stop

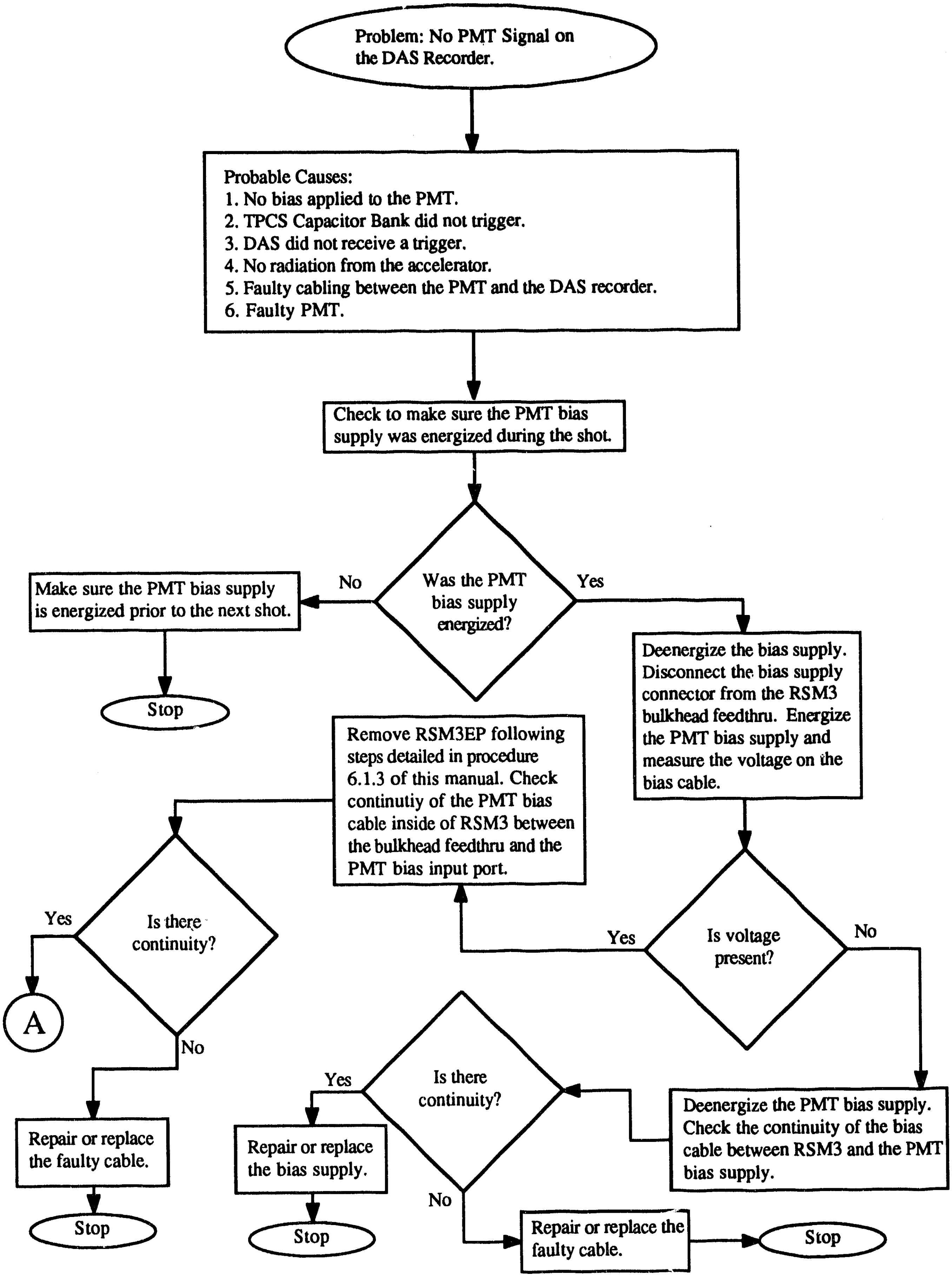
Turbomolecular Vacuum Pump Controller has a Failure Indication During Run Up (continued)



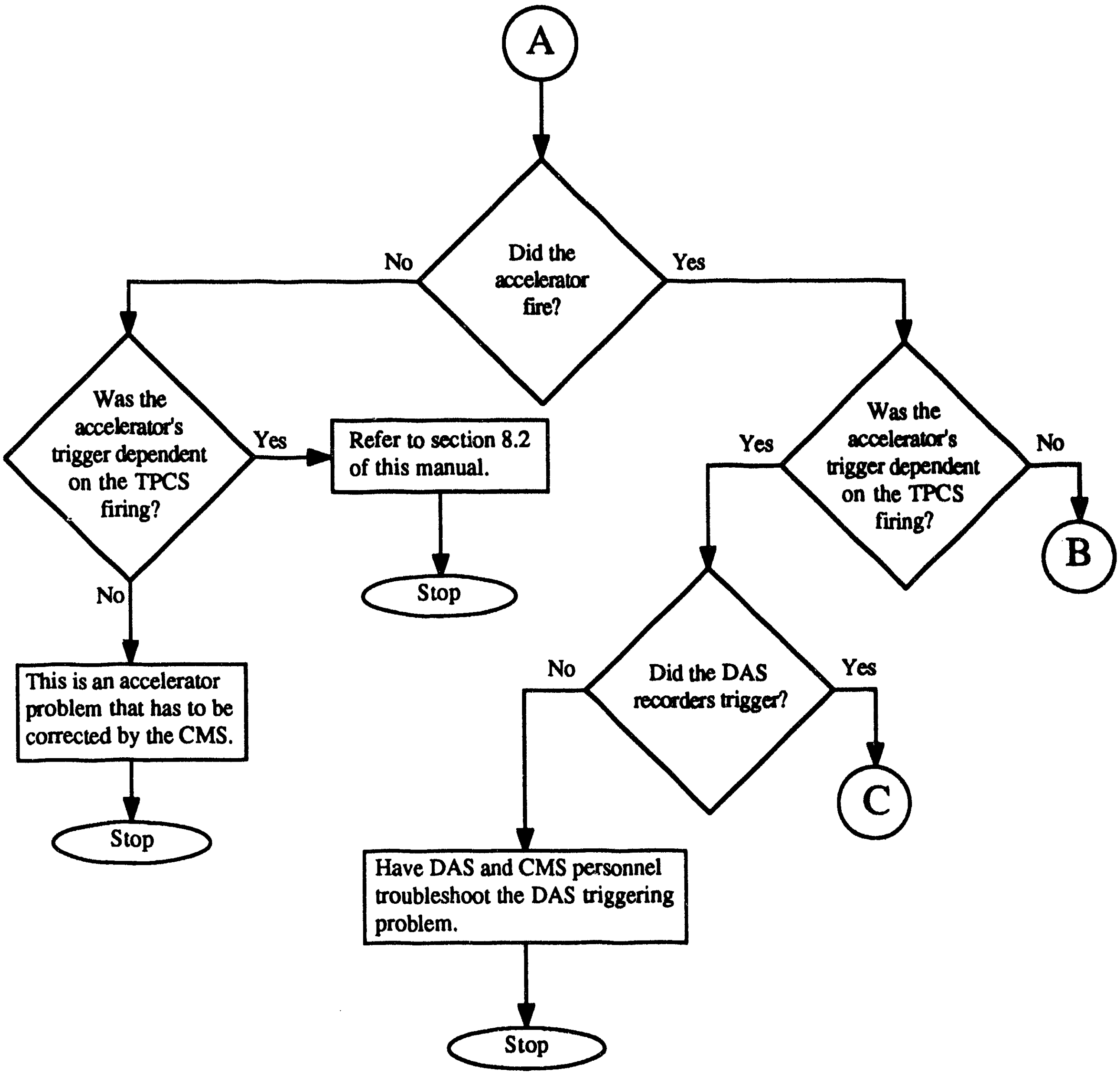
Turbomolecular Vacuum Pump Controller has a Failure Indication During Run Up (continued)



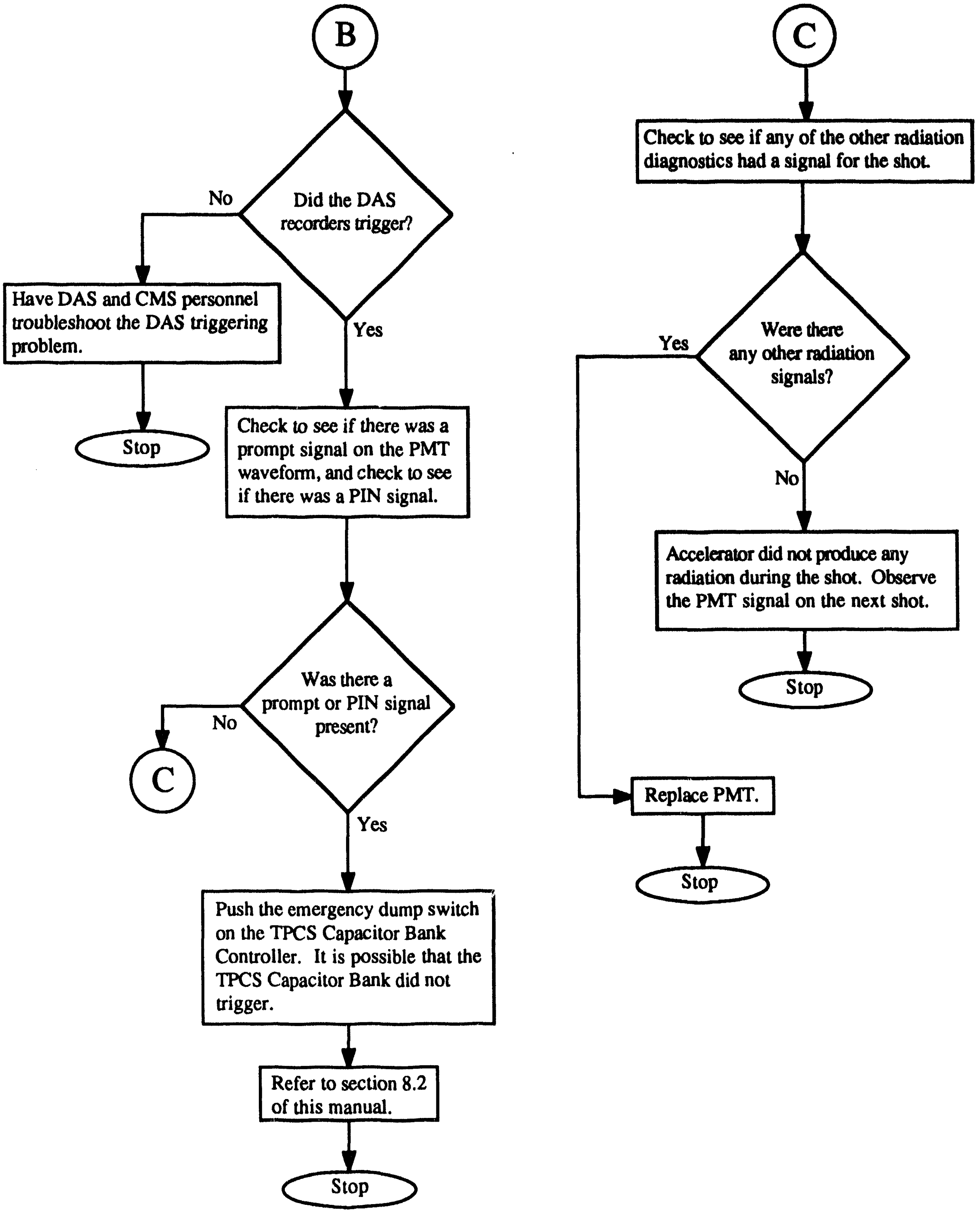
8.10 No PMT Signal on the DAS Recorder


Problem: No PMT Signal on the DAS Recorder.
Probable Causes:
1. No bias applied to the PMT.
2. TPCS Capacitor Bank did not trigger.
3. DAS did not receive a trigger.
4. No radiation from the accelerator.
5. Faulty cabling between the PMT and the DAS recorder.
6. Faulty PMT.
Check to make sure the PMT bias supply was energized during the shot.
Was the PMT bias supply energized?
No
Yes
Make sure the PMT bias supply is energized prior to the next shot.
Stop
Deenergize the bias supply. Disconnect the bias supply connector from the RSM3 bulkhead feedthru. Energize the PMT bias supply and measure the voltage on the bias cable.
Is voltage present?
Yes
No
Remove RSM3EP following steps detailed in procedure 6.1.3 of this manual. Check continutiy of the PMT bias cable inside of RSM3 between the bulkhead feedthru and the PMT bias input port.
Is there continuity?
Yes
A
No
Repair or replace the faulty cable.
Stop
Deenergize the PMT bias supply. Check the continuity of the bias cable between RSM3 and the PMT bias supply.
Is there continuity?
Yes
Repair or replace the bias supply.
Stop
No
Repair or replace the faulty cable.
Stop

No PMT Signal on the DAS Recorder (continued)



No PMT Signal on the DAS Recorder (continued)



9.0 General Maintenance

9.1 Vacuum System

The TPCS vacuum pumps were selected with low maintenance requirements in mind. The TMP1000 turbomolecular vacuum pump has a lifetime grease seal on the rotor bearings eliminating the need for periodic oil changes and inspections. The roughing pump, however, is oil filled and requires periodic inspection of the oil level, oil replenishment, and oil changing. Refer to the Leybold D25B pump manual for details regarding oil type and oil changing requirements.

9.2 Ignitron Reconditioning

The Ignitron Current Switches, located in the TPCS Capacitor Bank, need to be reconditioned whenever the system has indications of prefiring. Reconditioning is usually only required on the Series Ignitron Current Switch. A detailed procedure for reconditioning the Ignitron Current Switch can be found in the TPCS Capacitor Bank System Operation and Maintenance Manual, pp. 30-31.

9.3 Electrohydraulic Alignment System

The Electrohydraulic Alignment System consisting of the electrohydraulic pump, hydraulic hoses, and hydraulic actuating cylinder requires daily inspection, when the TPCS is in use, of the hydraulic fluid contained within the pump oil reservoir. Fluid levels should be maintained and replenished in accordance with guidelines detailed in the literature supplied with the electrohydraulic pump.

9.4 Reversible Boom Crane

The Air Technical Industries RBC2000 requires periodic greasing of fittings and charging of the batteries. Greasing requirements can be found in the RBC2000 manual. Battery charging requirements and battery charger operation instructions can be found in the RBC2000 and the Dayton Battery Charger manuals respectively.

10.0 Appendix

Required Screw Hardware		
Size	Material/Type	Quantity Required
2-56 x 5/8"	steel socket head	1ea
4-40 x 1/4"	steel flat head	4ea
4-40 x 5/16"	nylon pan head	2ea
4-40 x 3/8"	nylon pan head	4ea
4-40 x 7/16"	nylon pan head	4ea
4-40 x 7/8"	steel pan head	3ea
4-40 x 1"	steel socket head	2ea
6-32 x 5/16"	steel socket head	12ea
6-32 x 3/8"	steel socket head	2ea
6-32 x 7/16"	steel socket head	4ea
6-32 x 1/2"	nylon pan head	2ea
6-32 x 3/4"	steel socket head	8ea
6-32 x 1"	steel socket head	8ea
6-32 x 1-1/4"	steel socket head	3ea
6-32 x 1-1/4"	steel pan head	32ea
8-32 x 3/8"	steel socket head	8ea
8-32 x 1"	steel socket head	2ea
1/4-20 x 5/16"	steel socket head	8ea
1/4-20 x 3/8"	steel hex head	12ea
1/4-20 x 1/2"	steel socket head	8ea
1/4-20 x 5/8"	steel socket head	8ea
1/4-20 x 3/4"	steel socket head	8ea
1/4-20 x 3/4"	nylon flat head	6ea
1/4-20 x 1"	steel socket head	12ea
1/4-20 x 1-1/4"	steel socket head	4ea
1/4-20 x 1-1/2"	steel socket head	12ea
1/4-20 x 1-3/4"	steel socket head	14ea
1/4-20 x 2"	steel socket head	2ea
3/8-16 x 5/8"	steel hex head	2ea
3/8-16 x 3/4"	steel hex head	7ea
3/8-16 x 1"	steel socket head	4ea
3/8-16 x 1-3/8"	steel socket head	8ea
3/8-16 x 2"	G-10 stud	8ea
3/8-16 x 2-1/4"	steel hex head	4ea
1/2-13 x 2"	steel hex head	24ea
5/8-11 x 1-1/4"	steel hex head	8ea
5/8-11 x 2-1/2"	steel hex head	8ea
3/4-10 x 1"	steel hex head	8ea
3/4-10 x 1-1/4"	steel hex head	8ea

Required Washer Hardware		
Size	**Material/Type**	**Quantity Required**
7/16" o.d. (#6 screw)	steel flat	16ea
5/8" o.d. (1/4" screw)	steel flat	57ea
1.0" o.d. (3/8" screw)	steel flat	10ea
1.25" o.d. (1/2" screw)	steel flat	48ea
1.75" o.d. (5/8" screw)	steel flat	24ea
2.0" o.d. (3/4" screw)	steel flat	8ea

Required Nut Hardware		
Size	**Material/Type**	**Quantity Required**
6-32	steel hex	32ea
1/4-20	steel hex	6ea
1/4-20	steel wing	3ea
3/8-16	G-10 square	16ea
1/2-13	steel hex	24ea
5/8-11	steel hex	8ea

Required Nut Hardware	
Parker O-ring #	**Quantity Required**
2-124	2ea
2-125	1ea
2-138	2ea
2-166	1ea
2-204	2ea
2-236	1ea
2-238	1ea
2-252	2ea
2-259	2ea
2-266	1ea
2-275	3ea

Miscellaneous Required Hardware			
Item	Maufacturer	Part#	Quantity Required
Latch, tension, medium duty	Camloc	51L3-1-1BC	16ea
Strike	Camloc	51L7-BF	16ea
Feedthru, bulkhead, coaxial, Type-N	King's Electronics	#KN-99-34	3ea
Adapter, BNC female to UHF male	King's Electronics	#KC-99-02	1ea
Adapter, BNC male to N female	King's Electronics	#KN-97-06	1ea
Adapter, BNC female to N male	King's Electronics	#KN-94-05	1ea
Adapter, BNC female to BNC male (elbow)	King's Electronics	#KC-97-04	1ea
Adapter, HN bulkhead feedthru	King's Electronics	#UG-1019/u	1ea
Cable, coaxial	Alpha	#9223	10 to 12ft
Braid, tinned copper, Ø1"	Alpha	#2178	5 to 10ft
Braid, tinned copper, Ø1-1/2"	Alpha	#2182	5 to 10ft
Attenuator, 10X-50Ω, 2W, BNC	Tektronix	#011-0059-02	1ea

List of Miscellaneous Manufacturers	
Manufacturer/address	**Product**
Air Technical Industries 7501 Clover Ave. Mentor, OH 44060	hydraulic lifting machinery, boom cranes, lift tables
Alpha Wire Corporation 711 Lidgerwood Ave. Elizabeth, NJ 07207	wire, cable, flat braid, connectors
Bicron Corporation 12345 Kinsman Road Newbury, OH 44065	organic and inorganic scintillators, optical grade plastics (custom parts)
Camloc Products Fairchild Fastener Group 601 Rt. 46 West Hasbrouck Heights, NJ 07604	specialty fasteners, latches
CVC Vacuum Products, Inc. 525 Lee Road Rochester, NY 14603	vacuum gauges, vacuum sensors
Dayton Electric Company 5959 W. Howard St. Chicago, IL 60648	electrohydraulic pumps, motors
Eastman Kodak Co. 343 State St. Rochester, NY 14652	Wratten gel neutral density optical filters
EG&G Energy Measurements Las Vegas Operations 316 E. Atlas Circle North Las Vegas, NV 89030	custom photomultiplier tube assemblies, photonic detectors
English Electric Valve Co. 4 Westchester Plaza Elmsford, NY 10523	ignitron current switches
High Vacuum Apparatus Mfg., Inc. 1763 Sabre Street Hayward, CA 94545	vacuum gate valves, vacuum components
King's Electronics 40 Marbledale Rd. Tuckahoe, NY 10707	coaxial connectors
Leybold Vacuum Products 5700 Mellon Rd. Export, PA 15632	vacuum pumps and accessories
Malco Microdot Inc. 306 Pasadena Ave. Pasadena, CA 91030	miniature electrical connectors
MDC Vacuum Products Corporation 23842 Cabot Blvd. Hayward, CA 94545	vacuum components, valves, feedthrus
William F. Nye Inc. P. O. Box 8927 New Bedford, ME 02742	optical coupling gel

List of Miscellaneous Manufacturers (continued)	
Manufacturer/address	**Product**
Parker Seal Group O-ring Division 2360 Palumbo Drive Lexington, KY 40512	elastomeric o-ring seals
Physics International Corp. Pulsar Products Division 2700 Merced St. San Leandro, CA 94577	high-energy storage systems
Quantrad Corporation 19900 S. Normandie Ave. Torrance, CA 90502	X-ray PIN detectors
Safety Line Inc. 973 86th Ave. Oakland, CA 94614	electrical safing devices (grounding sticks)
Schrader Scientific 2976 ARF AVE. Hayward, CA 94545	vacuum components, vacuum chambers
Daniel Woodhead Co. Northbrook, IL 60062	electrical switches, pendant switch boxes

Drawing #	Next Ass'y #	Revision	Drawing Title
3A3306	N/A	A	Time Projection Compton Spectrometer Assembly
3A3307		C	Clamp, Current Contact Gasket
3A3308		C	Target Foil
3A3309		C	Collimator #1
3A3310		B	Holder, PIN Detector
3A3311		B	Window, Vacuum, Collimator Port
3A3312		D	Scintillator
3A3313		C	Light Pipe Assembly
3A3314		A	Light Pipe
3A3315		E	Tube, Current Return
3A3316		B	Spacer, Insulating, Electron Detector
3A3317		C	Enclosure, Light Pipe
3A3318		C	Plate, Entrance, PMT Housing
3A3319		B	Rod, Mounting, PMT
3A3320		A	Clamp, Securing, Sum Coupler
3A3321		B	Ring, Sum Coupler Positioning, PMT
3A3322		C	Housing, PMT
3A3323		B	Collimator #2
3A3324		B	Collimator #3
3A3325		B	Clamp, Target Foil, Top
3A3326		A	Plate, Entrance, Blankoff, PMT Housing
3A3327		A	Tool, Alignment, Light Pipe
3A3328		A	Pin, Light Pipe Alignment Tool
3A3329		A	Ring, Light Pipe Alignment Tool
3A3330		C	Rod, Support, High Voltage Plate
3A3331		A	Shield, PMT Magnetic
3A3332		A	Case, PMT Divider String
3A3333		A	PMT Assembly
3A3334		B	Frame, Target Foil
3A3335		B	Clamp, Target Foil, Bottom
3A3336		A	Bracket, Target Foil Frame Mounting
3A3337		A	Target Foil Cutting Template Assembly
3A3338		A	Base Plate, Template, Target Foil Cutting
3A3339		A	Template, Target Foil Cutting
3A3340		A	Punch, Hole, Template, Target Foil
3A3342		A	Knob, Center Rod Tension Adjustment
3A3343		A	Washer, Center Rod Tension Adjustment Knob
3A3344		A	Rotatable Shield Assembly
3A3345		B	Radiation Shield Module One (Target End)

Drawing #	Next Ass'y #	Revision	Drawing Title
3A3346		B	Radiation Shield Module Two (Middle Section)
3A3347		B	Radiation Shield Module Three (PMT End)
3A3348		A	Plug, End, Radiation Shield Module One
3A3349		A	Plug, ND Filter Access Port
3A3350		A	Port, Shielded, Collimator
3A3351		A	Slug, Retaining, Collimator Stack
3A3352		A	Door, End Plug Access, Radiation Shield Module One
3A3353		A	Sum Coupler
3A3354		A	Handle, Neutral Density Filter Frame
3A3355		A	Plate, Retaining, Collimator Element
3A3356		A	Plug, Removable Insert, Radiation Shield Module One
3A3357		A	Ring, Adaptor, Insulating, Collimator Shielded Port
3A3358		A	Ring, Insulating, Vacuum Interface
3A3359		A	Lid, ND Filter Access Port, PMT Housing
3A3360		A	Ring, Target Foil Retaining
3A3361		A	Plate, Adaptor, Vacuum, 9" ASA to 11" ASA
3A3362		A	Tube, Middle Spacer, Collimator Stack
3A3363		A	10.750 I.D. Centering Ring Assembly
3A3364		A	11.500 I.D. Centering Ring Assembly
3A3365		A	Angle A, Centering Ring, TPCS
3A3366		A	Angle B, Centering Ring, TPCS
3A3367		A	Half Ring, Upper 10.750 I.D. TPCS
3A3368		A	Half Ring, Lower 10.750 I.D. TPCS
3A3369		A	Half Ring, Lower 11.500 I.D. TPCS
3A3370		A	Half Ring, Upper 11.500 I.D. TPCS
3A3371		A	Liner, Radiation Shield Module One
3A3372		A	Liner, Radiation Shield Module Two
3A3373		A	Liner, Radiation Shield Module Three
3A3374		A	Design Layout TPCS Radiation Shield with Detector Loading Cart
3A3375		A	Design Layout Centering Ring TPCS
3A3376		A	Alignment Pin, Radiation Shield Module Three End Plug
3A3377		A	Spacer, Male, Hydraulic Actuator
3A3378			Spacer, Female, Hydraulic Actuator
3A3379			Design Layout TPCS Radiation Shield Module Three End Plug

Drawing #	Next Ass'y #	Revision	Drawing Title
3A3380			Plug, End, Radiation Shield Module Three
3A3381			Insert, Line of Sight Shield, Radiation Shield Module Three
3A3382			Insert, Cable Shield, Radiation Shield Module Three
3A3383			Loading Fixture, Spectrometer, TPCS
3A3384			Plate, Connector Feedthru, Radiation Shield Module Three
3A3385			Shield, Instrumentation Cables, TPCS
3A3386			Shield, 8 Cable TPCS
3A3387			Plug, Target Foil Access Port
3A3388			Port, Feedthru, Vacuum
3A3389			Assembly, Gold Target Foil
3A3390			Spacer Ring
3A3392			Assembly, Downstream Vacuum Interface
3A3393			Clamp, Scintillator Center
3A3394			Feedthru, Scintillator Centering
3A3395			Ring, Scintillator Support
3A3396			End Plate, Outer, Downstream
3A3397			Window, Downstream End Plate
3A3398			Adaptor, Feedthru
3A3399			Feedthru, Light Pipe Centering
3A3400			Guide, Light Pipe
3A3401			Clamp, Compression, O-Ring, Upstream End Plate
3A3402			Clamp, Adaptor, Feedthru
3A3403			End Plate, Upstream
3A3404			Feedthru, O-Ring Retaining, Upstream End Plate
3A3405			Handle, Tee, TPCS Cart Caster Positioning, 45û right
3A3406			Handle, Tee, TPCS Cart Caster Positioning, 45û left
3A3407			Mount, Current Transformer
3A3408			Holder, PIN
3A3409			Holder, N. D. Filter, HeNe Alignment Laser
3A3410			Handle, Mount, HeNe Alignment Laser
3A3411			Rod, Mount, HeNe, Alignment Laser
3A3412			Mount, HeNe Alignment Laser Tube, Upper
3A3413			Mount, HeNe Alignment Laser Tube, Lower
3A3414			Plate, Insulating, High Voltage Bridge

Drawing #	Next Ass'y #	Revision	Drawing Title
3A3415			Plate, Current Return
3A3416			Plate, High Voltage Connection
3A3417			Plate, High Voltage Bridge
3A3418			Assembly, PMT Cable Feedthru
3A3419			Bracket, Support, PMT
3A3420			Cover, PMT, Divider String
3A3421			Window, Get-Lost Port
3A3422			End Plate, PMT Housing
3A3423			Clamp, High Voltage Cable
3A3424			Ring, Light Pipe Grouping
3A3425			Drift Tube, One-Piece
3A3426			Center Rod
3A3427			Plate, Electrical Ground Connection
3A3428			Design Layout TPCS Rotating Lead Shielding
3A3429			Window, Target Foil Viewing
3A3430			Plate, Target Foil Access
3A3431			Adaptor, Sum Coupler to Neutral Density Filter
3A3432			Frame, Neutral Density Filter Retaining
3A3433			Clamp, Neutral Density Filter Retaining
3A3434			Adaptor, Neutral Density Filter to PMT
3A3435			Pin, Neutral Density Filter Frame Retaining
3A3436			Handle, Neutral Density Filter Retaining Pin Actuating
3A3437			Vacuum Tee
3A3438			Insert, Insulating, Vacuum Feedthru Port Screw
3A3439			Bracket, Mounting, Type-N Bulkhead Feedthru
3A3440			Ring, Insulating, Screw
3A3441			Cap, End, Insulating, Center Rod
3A3442			Pan, Hydraulic Fluid Containment
3A3443			Pan, Vacuum Pump Oil Containment
R14211		B	Cart, Front Spectrometer
R14212		B	Cart, Rear Spectrometer

11.0 Procedure Checklists

Procedure Checklist for Operating the Time Projection Compton Spectrometer (TPCS) without the Accelerator

Shot Date: ___________

Time of shot: ___________ AM/PM

Procedure conforms with Safe Operating Procedure # _______________

Procedure approved by:

___________________	_________	____________________	_________
TPCS Owner	Date	Facility Manager	Date

Checklist completed by:

___________________	_________
Operator Name	Date

Sections completed:

_______ **I. Spectrometer**

_______ **II. Capacitor Bank**

_______ **III. Facility Control/Monitor**

_______ **IV. Facility Data Acquisition**

_______ **V. Pre-Shot Remarks**

_______ **VI. Post-Shot Checks**

_______ **VII. Post-Shot Remarks**

I. Spectrometer

A. Vacuum system

___ 1. Gate valve open, turbopump running.

___ 2. Pre-shot vacuum: ____________ torr @ ________ AM/PM

___ 3. Power off at GPT-450 Penthervac meter in C/M.

___ 4. Disconnect both vacuum gauge cables at the gauges.

B. HV system

___ 1. Check center rod tension adjustment.

___ 2. Insulating end cap on center rod.

___ 3. DAS cable connected to jumper cable from Pearson.

C. Detectors

___ 1. PMT used: serial # NPM-119-_______-LV

___ 2. ND filter used: ______________

___ 3. ND filter ring latched in place.

___ 4. Threaded plug in the ND Filter access port secured in place.

___ 5. PMT bias and signal cables connected.

___ 6. Light blocks on collimator, target access and get-lost ports.

II. Capacitor bank

A. Hardware

___ 1. HV cables: all clamps and nuts tight.

___ 2. Visually inspect interior of enclosure for component damage; repair and/or replace defective components as required.

___ 3. Remove shorting strap between bus plates.

___ 4. Remove the bus grounding cable.

___ 5. Close and lock the four enclosure access doors.

II. Capacitor bank (continued)

B. 480V circuit

___ 1. Facility 480V circuit breaker on. (The facility circuit breaker can only be reset by an authorized facility representative; therefore, inform appropriate personnel if the facility circuit breaker is tripped or in the off position.)

___ 2. 480V plug inserted in the facility wall receptacle.

___ 3. 480V switch/breaker on capacitor bank HVPS in the on position.

___ 4. %-charging current pot set: __________ %.

C. 120V circuit

___ 1. 120V plug inserted into the facility wall receptacle.

___ 2. Ignitron trigger generator power switch on.

D. Control cables

___ 1. Multiconductor cable connected.

___ 2. Trigger cable connected.

___ 3. Crowbar current monitor connected.

___ 4. 2 ms integrator in crowbar current monitor line.

E. Access Control

___ 1. HV warning signs posted and area cordoned off.

III. Facility Control/Monitor

A. Capacitor bank control

___ 1. Multiconductor cable connected.

___ 2. Trigger cable to cap bank connected.

___ 3. Key installed.

___ 4. Interlocks clear.

___ 5. Test Run/Arm/Charge sequence at 0 kV charge.

___ 6. Charge voltage set: ________ kV

___ 7. Internal trigger mode selected.

IV. Facility Data Acquisition

A. Bias

___ 1. PMT bias on: (-)______ V; current draw ______ μA.

B. HP54112D scope# ______ settings

___ 1. TPCSI (ch. 1): (10X ext. at Pearson), 2V/div, +4V offset, DC coupling, 50Ω.

___ 2. CRWBR (ch. 2): (2 ms integrator at cap bank), 1V/div, +1V offset, DC coupling, 1MΩ.

___ 3. PMTHP3 (ch. 3): 2X (power tee), 100 mV/div, -200mV offset, DC cplng, 50Ω, cable from other HP54112D ch. 2.

___ 4. Timebase: 5 ms/div, delay ref left, -200 ms delay, triggered.

___ 5. Trigger: edge, external, +1V level, +slope, external trigger off of TPCS1

___ 6. Display cleared; awaiting trigger.

V. Pre-shot Remarks:

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____

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____

VI. Post-shot Checks

___ 1. Latched cap bank fire voltage: ________ kV

___ 2. Turbo pump tripped? Yes/No

___ 3. Restart turbo (if necessary)

___ 4. PMT bias off.

___ 5. Bank secured.

___ 6. Post-shot vacuum: __________ torr @ _______ AM/PM

___ 7. Center rod tightness: _______ turn to tighten.

VII. Post-shot Remarks:

Procedure Checklist for Operating the Time Projection Compton Spectrometer (TPCS) with the Accelerator

Shot Date: ___________

Time of shot: ___________ AM/PM

Procedure conforms with Safe Operating Procedure # _______________

Procedure approved by:

___________________	_________	____________________	_________
TPCS Owner	Date	Facility Manager	Date

Checklist completed by:

____________________	_________
Operator Name	Date

Sections completed:

_______ **I. Spectrometer**

_______ **II. Capacitor Bank**

_______ **III. Facility Control/Monitor**

_______ **IV. Facility Data Acquisition**

_______ **V. Pre-Shot Remarks**

_______ **VI. Post-Shot Checks**

_______ **VII. Post-Shot Remarks**

I. Spectrometer

A. X-ray target/collimator

___ 1. Target material: ______________

___ 2. Target thickness: __________

___ 3. Target taper: $\Delta r/z$ = ______ (0.05, 0.10, 0.20, 0.30)

___ 4. Collimator aperture: ______________

B. Vacuum system

___ 1. Gate valve open, turbopump running.

___ 2. Pre-shot vacuum: ____________ torr @ _________ AM/PM

___ 3. Power off at Penthervac meter in C/M room.

___ 4. Disconnect both vacuum gauge cables at the gauges.

___ 5. Lead plug installed in target foil access port.

C. HV system

___ 1. Check center rod tension adjustment.

___ 2. Insulating end cap on center rod.

___ 3. DAS cable connected to jumper cable from Pearson.

___ 4. Small plug inserted and door closed, upstream end of shield.

D. Alignment

___ 1. Wheels chocked or casters rotated to prevent roll.

___ 2. Shield rotated to desired elevation.

___ 3. Confirm alignment with laser spot.

___ 4. Replace laser jig with collimator elements.

___ 5. Turnbuckles affixed and tight.

___ 6. Elevator cage pulled back and line-of-sight clear.

E. Detectors

___ 1. PMT used: serial # _____________

___ 2. ND filter used: ______________

I. Spectrometer (continued)

E. Detectors (continued)

___ 3. ND filter ring latched in place.

___ 4. Threaded access port to ND filter closed.

___ 5. Lead plug for ND filter access in place.

___ 6. PMT bias and signal cables connected.

___ 7. PIN detector affixed to get-lost port and cable connected.

___ 8. Light blocks installed on collimator, target access, and get-lost ports.

II. Capacitor bank

A. Hardware

___ 1. HV cables: all clamps and nuts tight.

___ 2. Visually inspect interior of enclosure for component damage; repair and/or replace defective components as required.

___ 3. Remove shorting strap between bus plates.

___ 4. Remove the bus grounding cable.

___ 5. Close and lock four access doors.

B. 480V circuit

___ 1. 480V circuit breaker on (SE wall, panel MSP-2, #C11).

___ 2. 480V plug inserted in wall receptacle.

___ 3. 480V switch/breaker on cap bank HVPS on.

___ 4. %-charging current pot set: __________ %.

C. 120V circuit

___ 1. 120V plug inserted into wall receptacle.

___ 2. Ignitron trigger generator power switch on.

D. Control cables

___ 1. Multiconductor cable connected.

___ 2. Trigger cable connected.

II. Capacitor bank (continued)

D. Control cables (continued)

___ 3. Trigger monitor connected.

___ 4. Crowbar current monitor connected.

___ 5. 2 ms integrator in crowbar current monitor line.

E. Access Control

___ 1. HV warning signs posted and area roped off.

III. Facility Control/Monitor

A. Pre-Cap Bank Delay

___ 1. Jumper on C/M patch panel: Cordin Delay Generator "delayed output" connected to "TPCS in."

___ 2. Cordin Delay Generator "Ready" light on.

___ 3. 10X attenuator in line to TPCS cap bank controller (on backside of "TPCS in" port on C/M patch panel).

B. Capacitor bank control

___ 1. Multiconductor cable connected.

___ 2. External trigger from C/M connected.

___ 3. Trigger cable to cap bank connected.

___ 4. Key installed.

___ 5. Interlocks clear.

___ 6. Test Run/Arm/Charge sequence at 0 kV charge.

___ 7. Charge voltage set: ________ kV

___ 8. External trigger mode selected.

C. Post-Cap Bank Delay

___ 1. Trigger monitor thru 10X atten. to back of "TPCS out" porton C/M patch panel.

___ 2. Jumper from "TPCS out" port to ext trigger of DG535 #3.

___ 3. DG535 #3 external trigger has 50Ω input impedance.

III. Saturn Control/Monitor (continued)

C. Post-Cap Bank Delay (continued)

___ 4. -0.5V trigger threshold (computer-controlled).

___ 5. Synchronization delay: ______ ms (DG535 ch. B output delay)

___ 6. Ch. B output to external trigger of DG535 #1.

D. Shot sequence

___ 1. Commence cap bank charge at _________ kV Saturn charge point.

IV. Facility Data Acquisition

A. Data recording channels

___ 1. All header changes made and confirmed.

___ 2. HP slow scope settings checked.

___ 3. HP fast scope settings checked.

___ 4. Both HP scopes: display cleared; awaiting trigger.

B. Bias

___ 1. PMT bias on: (-)______ V; current draw ______ mA.

___ 2. PIN bias on: (-)______ V; current draw ______ mA.

C. HP54112D scope #___ settings

___ 1. TPCSI (ch. 1): (10X ext. at Pearson), 2V/div, +4V offset (POS=2), DC coupling, 50Ω.

___ 2. CRWBR (ch. 2): (2 ms integrator at cap bank), 1V/div, +1V offset (POS=3), DC coupling, 1MΩ.

___ 3. PMTHP3 (ch. 3): 2X (power tee), 100 mV/div, -200mV offset (POS=6), DC cplng, 50Ω, cable from other HP54112D ch. 2.

___ 4. PINHP3 (ch. 4): 2X (power tee), 50 mV/div, +150mV offset (POS=1), DC coupling, 50Ω, cable from other HP54112D ch. 4.

___ 5. Timebase: 5 ms/div, delay ref left, -200 ms delay, triggered.

___ 6. Trigger: edge, external, +1V level, +slope, TG-125 trigger --> panel below scope.

___ 7. Display: filter on, 8K memory, quad frame.

IV. Facility Data Acquisition (continued)

C. HP54112D scope #___ settings (continued)

___ 8. Display cleared; awaiting trigger.

D. HP54112D scope #___ settings

___ 1. PMTHP1 (ch. 1): 2X (power tee), 0.5 V/div, -1.5V offset (POS=6), DC coupling, 1MΩ.

___ 2. PMTHP2 (ch. 2): 2X (power tee), 0.1 V/div, -0.3V offset (POS=6), DC coupling, 1MΩ.

___ 3. PINHP1 (ch. 3): 2X (power tee), 0.5 V/div, +1.5V offset (POS=1), DC coupling, 1MΩ.

___ 4. PINHP2 (ch. 4): 2X (power tee), 0.1 V/div, +0.3V offset (POS=1), DC coupling, 1MΩ.

___ 5. Timebase: 100 ns/div, delay ref ctr, 0s delay, triggered.

___ 6. Trigger: edge, external, 1V level, +slope, triggered by TTL signal from other HP54112D scope.

___ 7. Display: filter on, 8K memory, quad frame.

___ 8. Display cleared; awaiting trigger.

E. Tek7912 scope settings: PMT

___ 1. DAS ID: PMT1 & PMT2

___ 2. Vertical sensitivity: 0.5 & 0.1 V/div

___ 3. External attenuation: 2 & 2 X

___ 4. Vertical position: 6 & 6

___ 5. Timebase: 100 ns & 100 ns/div

___ 6. Trigger:

F. Tek7912 scope settings: PIN detector

___ 1. DAS ID: PINA & PINB

___ 2. Vertical sensitivity: 1 & 0.1V/div

___ 3. External attenuation: 2 & 2X

___ 4. Vertical position: 1 & 1

IV. Facility Data Acquisition (continued)

F. Tek7912 scope settings: PIN detector (continued)

___ 5. Timebase: 20 ns & 20 ns/div

___ 6. Trigger:

V. Pre-shot Remarks:

____
____
____
____
____
____
____

VI. Post-shot Checks

___ 1. Latched cap bank fire voltage: ________ kV

___ 2. Turbo pump tripped? Yes/No

___ 3. Restart turbo (if necessary)

___ 4. Note date and time of shot (on checklist page 1).

___ 5. PMT and PIN detector bias off.

___ 6. Bank secured.

___ 7. Post-shot vacuum: __________ torr @ _______ AM/PM

___ 8. Center rod tightness: _______ turn to tighten.

___ 9. Vacuum meter powered off.

VII. Post-shot Remarks:

____
____
____
____
____
____
____

12.0 Glossary of Terms/Acronyms

1. **CMS** - Control Monitor System
2. **DAS** - Data Acquisition System
3. **i.d.** - inner diameter
4. **LOS** - Line-of-Sight
5. **ND** - Neutral Density
6. **o.d.** - outside diameter
7. **PMT** - Photomultiplier Tube
8. **RSM1** - Radiation Shield Module One, dwg# 3A3345
9. **RSM2** - Radiation Shield Module Two, dwg# 3A3346
10. **RSM3** - Radiation Shield Module Three, dwg# 3A3347
11. **TPCS** - Time Projection Compton Spectrometer
12. **UVT** - Ultraviolet Transmitting (used in reference to optical grade acrylic)

13.0 Footnotes/References

Footnotes/References:

[1] Glenn F. Knoll, Radiation Detection and Measurement, 2nd ed. (John Wiley & Sons, Inc., New York, 1989), pp. 305-306.

[2] J. R. Lee, et al, "Gradient B drift transport of high current electron beams", J. Appl. Phys., 56, 3175 (December 1984).

[3] G. T. Baldwin and J. R. Lee, "Modeling Studies of a Time Projection Compton Spectrometer (TPCS)", SAND86-1621, Sandia National Laboratories.

[4] G. T. Baldwin and J. R. Lee, "Time Projection Compton Spectrometer (TPCS)", IEEE Trans. Nucl. Sci. NS-33(6), 1298, (December 1986).

[5] G. T. Baldwin, et al., "Flash X-ray Measurements with a Time Projection Compton Spectrometer", Nuclear Instruments and Methods in Physics Research, A299(1), 66, (December 1990).

[6] G. T. Baldwin et al., " Extending the Range of the Time Projection Spectrometer to Lower Energy" , IEEE Trans. Nucl. Sci. (1992).

[7] Obtained from Bicron Corporation, 12345 Kinsman Road, Newbury, OH 44065, type BC-420.

[8] Obtained from EG&G Energy Measurements, Las Vegas Operations, 316 E. Atlas Circle, North Las Vegas, NV 89030, model# NPM-119.

[9] Obtained from Dayton Electric Mfg. Co., 5959 W. Howard Street, Chicago, IL 60648.

[10] Obtained from Quantrad Corporation, 19900 S. Normandie Ave., Torrance, CA 90502, model# 010-PIN-T05.

[11] Obtained from Bicron Corporation, 12345 Kinsman Road, Newbury, OH 44065, type BC-420.

[12] Obtained from Eastman Kodak Co., 343 State Street, Rochester, NY 14652.

[13] Obtained from High Vacuum Apparatus Mfg., Inc., 1763 Sabre Street, Hayward, CA 94545, model# 122-0601.

[14] Obtained from Leybold Vacuum Products, Inc., 5700 Mellon Road, Export, PA 15632, model# D25B.

[15] Obtained from Leybold Vacuum Products, Inc., 5700 Mellon Road, Export, PA 15632, model# TMP1000.

[16] Obtained from CVC Products, Inc., 525 Lee Road, Rochester, NY 14603, model# GT-034.

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17 Obtained from CVC Products, Inc., 525 Lee Road, Rochester, NY 14603, model# GPH-001A.

18 Obtained from CVC Products, Inc., 525 Lee Road, Rochester, NY 14603, model# GPT-450.

19 Obtained from Physics International Co., Pulsar Products Division, 2700 Merced St., San Leandro, CA 94577, purchased under Sandia National Laboratories Contract# 33-4873.

20 Obtained from Safety Line, Inc., 973 86th Ave., Oakland, CA 94621, model# 19119526DB3E.

21 Obtained from Safety Line, Inc., 973 86th Ave., Oakland, CA 94621, model# 19119526DB3E.

22 Obtained from Pearson Electronics, Inc., 1860 Embarcadero Road, Palo Alto, CA 94303, model# 3442.

23 Obtained from Air Technical Industries, 7501 Clover Ave., Mentor, OH 44060, model# RBC2000.

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