BURLE INDUSTRIES
Recent Photomultiplier and Device Developments

NNN05

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BURLE INDUSTRIES

BURLE INDUSTRIES Overview

BURLE INDUSTRIES, INC.

- *Conversion Tubes*
- Power Tubes
- Real Estate

BURLE ELECTRO-OPTICS, INC.

BURLE INDUSTRIES GmbH

BURLE INDUSTRIES UK LIMITED

BURLE deMexico

Core Competencies

- Conversion Tubes, Lancaster PA
  - Conventional PMT design and fabrication
  - Photocathode processing
  - Image tube design and fabrication
  - PMT packaging
  - Electronics: VDN, Miniature HVPS, Front-end electronics
- Power Tubes, Lancaster PA
  - Design and fabrication of vacuum tubes for power generation and switching
  - Plating and environmental testing
  - Ceramic-to-Metal joining techniques
- BEO, Sturbridge MA
  - Microchannel plates
  - Channel multipliers
  - Fiber optics

PMT Markets

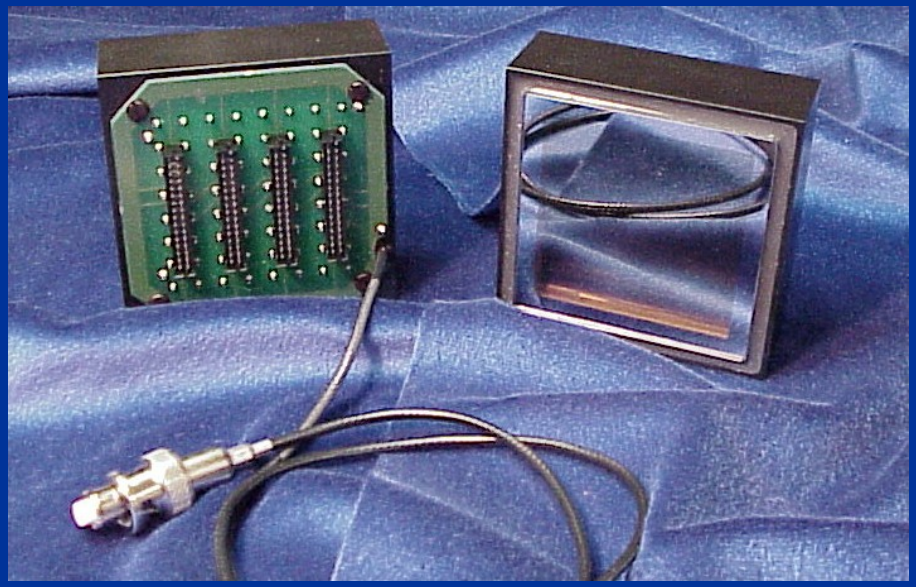
- Medical Imaging
  - Maintain ~ 30% market share and growing
  - Provide high-volume tubes for both SPECT and PET
- Have presence in general spectroscopy, scintillation counting, and HEP
- Have begun to target the HEP market more aggressively
  - Development of the PLANACON family
  - Cost competitive fast timing PMTs such as the 8575B.
  - SBIR grant to develop large area PMT

Recent Product Developments

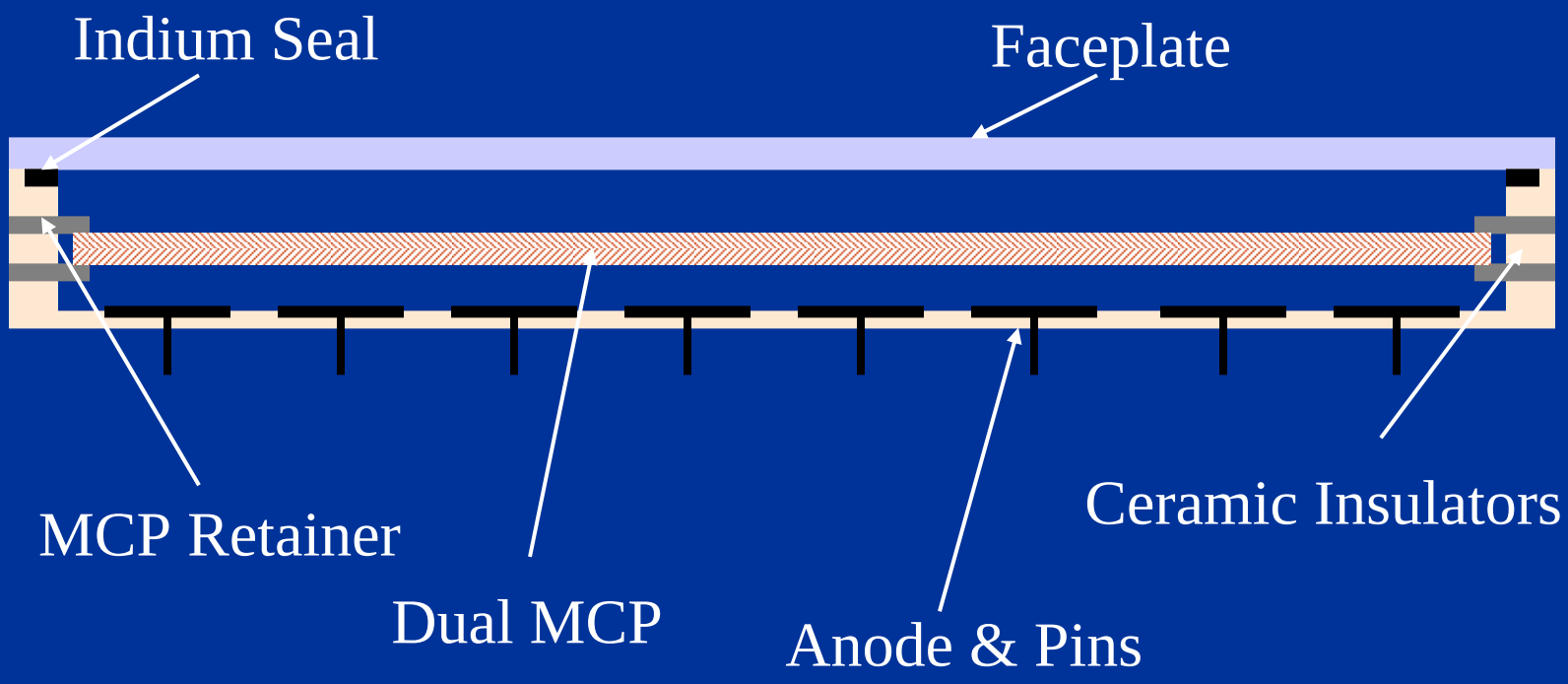
- Planacon
- Modules
- PMT’s

Planacon™ MCP-PMTs

- Two inch *square flat* PMT with dual MCP multiplier.
- Anodes, 2x2 and 8x8 configurations. Additional configurations available.
- Bi-alkali cathode on quartz faceplate or cryogenic bi-alkali.
- *Easily tiled, low profile, photon counting, good time resolution, multi-anode.*



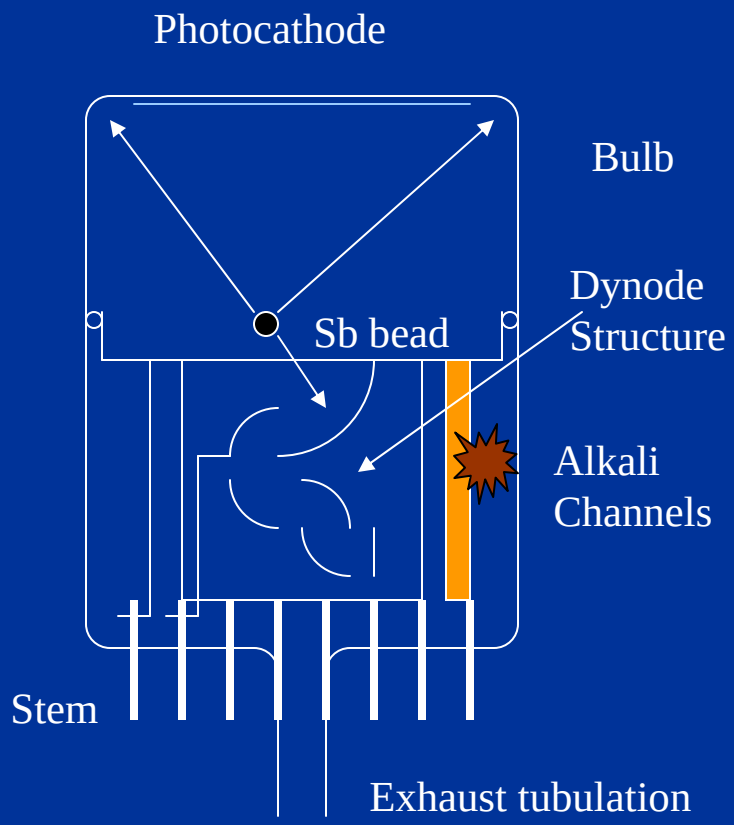
MCP-PMT Construction



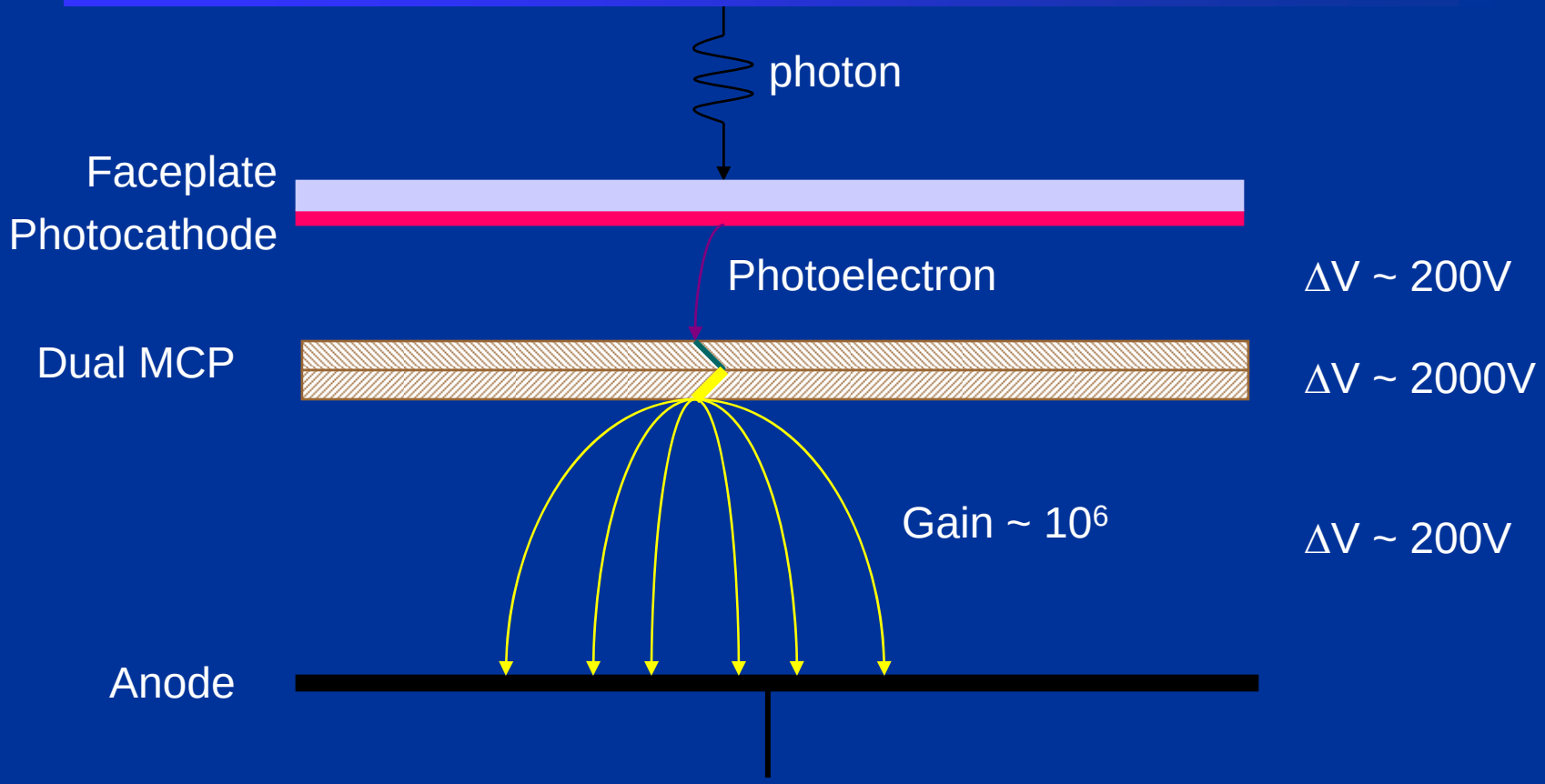
Spacing between faceplate and MCP and MCP and anode can be varied for different applications

PMT Construction/Processing

- Electron multiplier is supported by bulb spacers and leads to the stem
- Envelope is evacuated through an exhaust tubulation
- Cathode processed in-situ with Sb and alkali dispensers
- Tip-off of tubulation using flame or electric heater



MCP-PMT Operation



Planacon Characteristics

- Spatial resolution can be tailored by choice of faceplate, MCP, and pixilated anode
- Good photon counting properties at gains of 0.2 – 2 x 10^6.
- Peak to Valley typically > 2:1 with uniform illumination of faceplate.
- Output is relatively insensitive to external magnetic fields due to proximity of the cathode, MCP, and anode.
- Good pulse height resolution
  - 10% FWHM, 2” NaI crystal, 662keV.
- Cathode uniformity within 10% over full active area.
- Anode uniformity ~ 1.5:1 over the 2” active area in analog mode.
- Goal is to obtain 1.2:1 anode uniformity.
- Cross-talk < 1%.

Planacon Characteristics (cont'd)

25μm pore size with 32 μm pitch, investigating the use of 10 μm pore size.

- 40:1 L/D ratio, probably moving to 60:1 for the 10 μm devices
- Gains of up to 10^6 with current MCPs
- Extended dynamic range glass
- Gain is very stable up to ~3% of strip current
- Chevron configuration

Improved Open Area Ratio Planacon

- Packaging is streamlined to maximize detector area relative to device dimensions
- 2.28” sq. vs. 2.50” sq.
- 0.45” vs. 0.65” ht.
- 86% vs. 66% OAR
- 68 gms vs. 128 gms

Future Directions

- Increase the anode configurations offered
- Improve Open Area Ratio for tiling applications
- Develop variants optimized for
  - Photon counting with high spatial resolution
  - Low cross-talk and magnetic field immunity
  - Cryogenic Applications
  - Ultra-low background
- Develop other geometries as required by specific markets and applications

Recent PMT and Module Offerings

- 8575B, a low cost variant of the 8575.
  - Window material is 8250
  - Assembly technique is simplified for improved manufacturability
- 8575Q, Quartz faceplate for UV applications
- 8575B-800, 8575B module with integrated HVPS and divider
- 83092 module, short 1” tube for oil well logging applications

8575B-800 Module

8575B-800 Characteristics

- Vacuum potted – ideal for high altitude balloon payloads
- Low noise (10mV)
- Low power (12V @ 1mA)
- Regulated
- Voltage or resistance controlled

Large Area PMT Program

- Actively working on Phase II objectives of a DOE SBIR to develop a 20” diameter PMT with cost < \$0.75/cm^2 of active area, including VDN and cabling
- Will also develop 2”, 5”, and 8” variants
- Want to establish close ties with researchers associated with proton-decay and neutrino experiments to aid in development
- Represents a BURLE commitment to becoming a major player in the HEP market

Requirements

Parameter	Value	Units	Comments
Spectral Response	300 - 650	nm	Response < 300nm not very useful due to attenuation length in water
Cathode QE at 390nm	20	%	Desire as high as possible
Collection Efficiency	70	%	Desire as high as possible
Gain	1×10^7		
Dark Counts	25	kcps	Desire 3 – 4 kHz at 30°C
Transit Time Spread (FWHM)	5.5	ns	Desire 3 ns
Photocathode area, head-on	2000	cm^2	Sized to give lowest cost per unit area
High Voltage	+2000	V	Could be higher
Pressure	8	atm	Total outside – inside pressure difference. Could use acrylic pressure vessel if needed.
Packaging			VDN + HV and signal cables, hermetically sealed
Chemical resistance			Pure H_2O

Photocathode Design

- Requirements for highest possible QE and lowest possible dark counts are in conflict.
- Trade-study will be performed and initial PMT builds will be designed to optimize these parameters. Dark counts of 3kcps are possible, but QE will probably be limited to 20% max.
- Electron multiplier design will influence the dark counts, and will be considered in that design

Current Activities

- Interfacing with glass and bulb manufacturers to optimize cost-effective bulb design and manufacturing approach.
- FEA and environmental testing to validate mechanical integrity of bulb.
- Employing 2-D and 3-D electron optics models.
  - Cathode to Dy1 fields
  - Dy1 to the electron multiplier fields
- Design and implement novel focusing elements. Required for a bulb with a small neck.
- Validated our design concepts on the 2” PMT. Will continue with the 5”, 8”, and 20” PMT’s.
- Reviewing different photocathode processes and or design to optimize balance of QE and Dark counts.

Summary

- Established a high volume Manufacturing facility in Mexico to maintain production of PET and SPECT PMT's
- Introducing new product lines to further service both the Medical Imaging Business, as well as other applications including HEP, oil well logging, X-ray digitizers.
- Offer Modules to make the application of PMT's more convenient to the user.
- Developing large PMT formats to service the HEP community.