Title: Dispenser Cathode Technology Review

DISPENSER CATHODE TECHNOLOGY REVIEW

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THREE BASIC TYPES OF THERMIONIC EMISSION

1. EMISSION FROM HOT PURE MATERIAL SURFACES

- TUNGSTEN
- LaB6

2. EMISSION FROM ACTIVATED METAL SURFACES

- TUNGSTEN DISPENSER CATHODES
- THORIATED TUNGSTEN CATHODES

3. EMISSION FROM SEMICONDUCTORS

- BaO CATHODES

OXIDE CATHODES

COATING OF ALKALINE EARTH CARBONATES ON NICKEL.
CONVERT CARBONATES TO OXIDES.
ARIUM ON BARIUM OXIDE RESULTS IN LOW WORK FUNCTION.
ADVANTAGES:
LOW TEMPERATURE
HIGH EMISSION DENSITY (PULSED)
LOW EVAPORATION RATE
<u>DISADVANTAGES:</u>
EASILY POISONED
ARCING
COATING CAN BE DESTROYED BY ION BOMBARDMENT

SURFACE CHEMISTRY AND PHYSICS

Ba forms dipole

Ba
0
W or Walloy

Barium on oxygen on tungsten
CHEMISTRY OF BARIUM GENERATION

CaCo3-------------------------------------CaO + CO2

BaCo3---> BaO + CO2

Ba0 + CaO + A1203 '-~ B   aCaA1~5 Impregnant
Ba Ca Al203 + W ~ BaO + CaA12O4
6Ba0+W Ba3W06+'3Ba

3 Ba3W06) 3BaWO4 + 3Ba

TRANSPORT OF BARIUM TO EMITTER SURFACE

NUDSEN FLOW
Dm AM 1/2
_______ __________ P
dt N(2pmkt)1/2

Where:

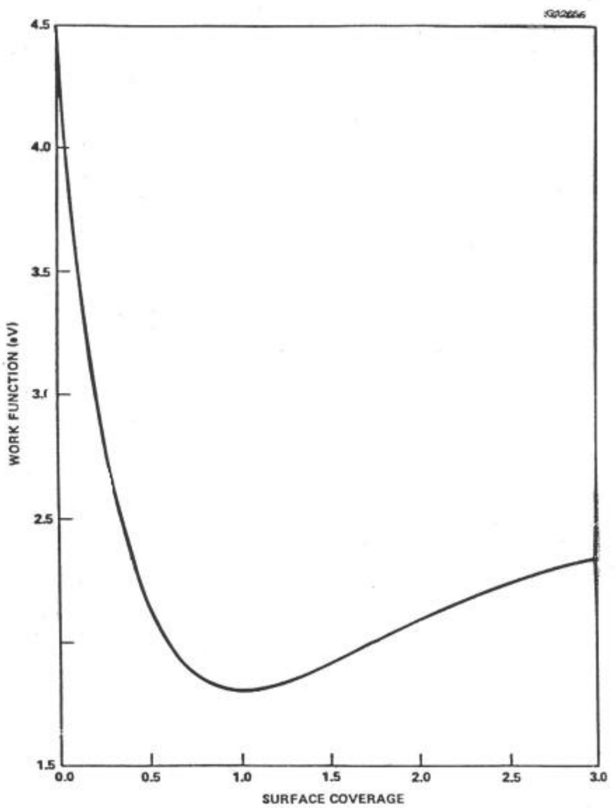
M= the mass flow through the plug
p= Barium Pressure
A-- Area of the sample
N=Avogadro’s weight of barium
M= Molecular weight of barium
porosity, deternined experimentably

EFFECT OF SUBSTRATE SURFACE

* METAL SUBSTRATE HAS VERY I)EFI~ITE EFFECTS ON EMISSION LEVEL.

* SOME THEORIZE HIGH WORK FUNCTION SUBSTRATE PRODUCES LOWER SYSTEM WORK FUNCTION.

* SOME SPECULATE IMPROVED COVERA~ DUE TO BETTER. DIFFUSION OR GEOMETRIC EFFECTS OF ATOMIC ORBITALS.



DISPENSER CATHODE CLASSIFICATIONS

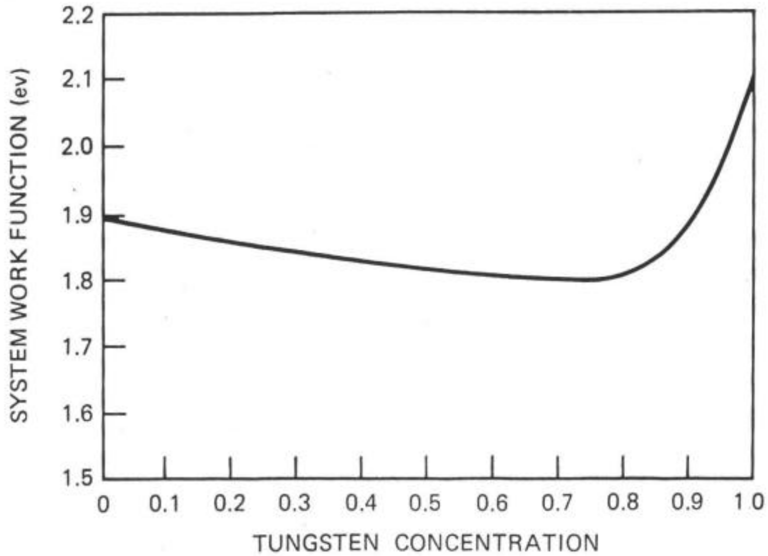
- Cavity Reservoir
  L, CPD, MK
- Impregnated
  B, S, M CD (Alloy)
  Scandate, mixed metal

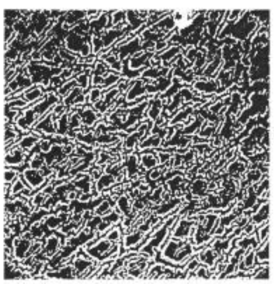
IMPREGNATED DISPENSER

- Porous Tungsten Impregnated with 5:3:2 BaO- CaO-A2O3
- Used extensively for 30 years
- Work Function 2.1 EV
- Developed at Philips

IMPREGNATED DISPENSER

- Impregnated porous tungsten overcoated with Osmium/ Ruthenium
- Longer Life expectancy
- Either B or S can be used as substrate
- Work Function 1.80 EV
- Developed at Philips





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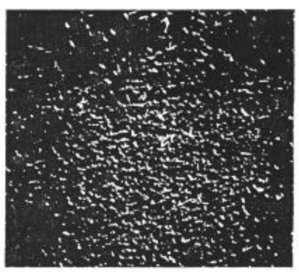
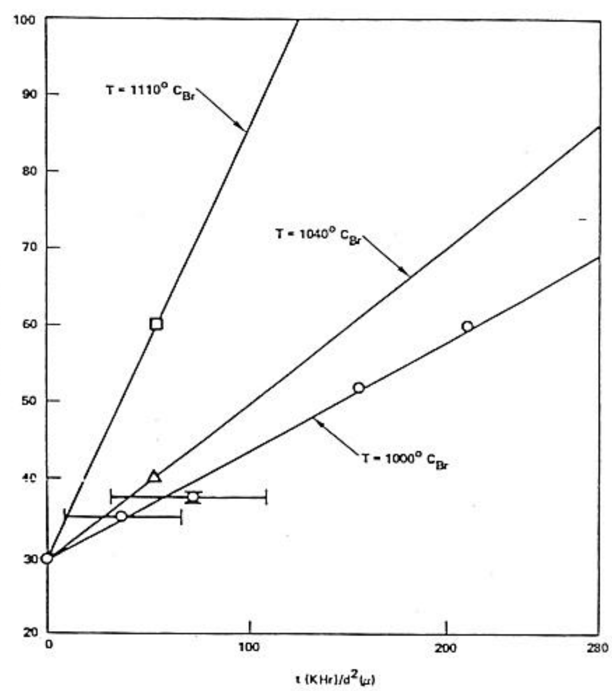


PHM09 PHILIPS M CATHODE PRIOR TO AGING

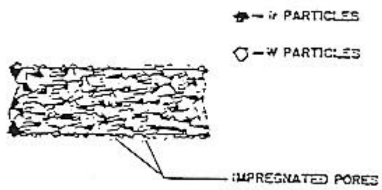
PHM09 PHILIPS M CATHODE AGED 22,984 HOURS



M-coating diffusion data - percent surface concentration of tungsten versus the parameter age/thickness.

ADVANTAGES

-STABLE SURFACE COMPOSITION



LIMITATIONS

-CRITICAL PARTICLE SIZE & DISTRIBUTION

-DIFFICULT TO REPRODUCE

-SURFACE ROUGHNESS

Fig. 9. Cross section of mixed metal dispenser cathode.

- IMPREGNATED POROUS MATRIX OF TUNGSTEN AND EITHER IRIDIUM, OSMIUM, RUTHENIUM OR RHENIUM
- INTENDED FOR HIGH CURRENT DENSITY
- WORK FUNCTION I .80 EV
- DEVELOPED AT VARIAN

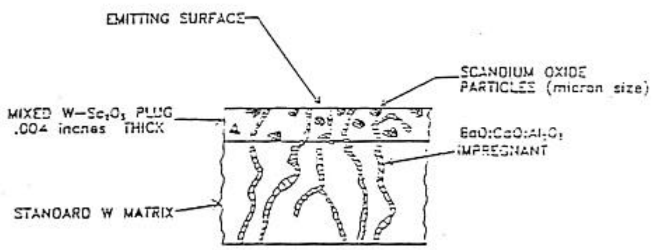
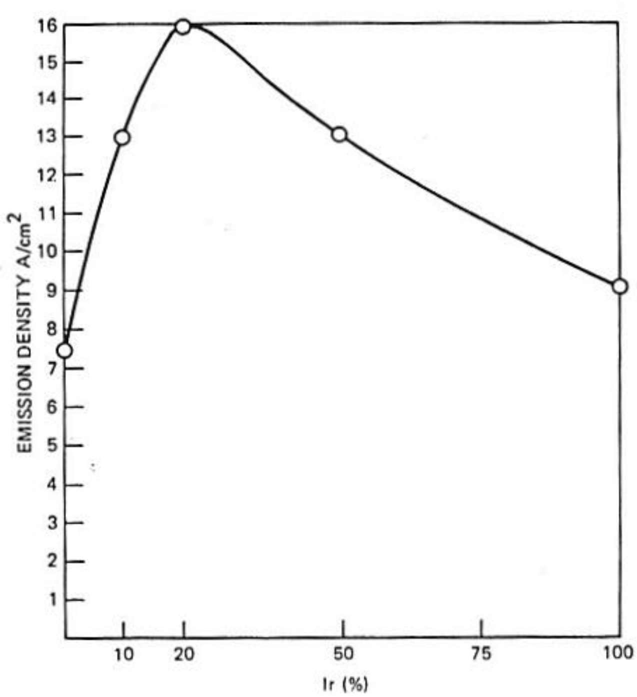
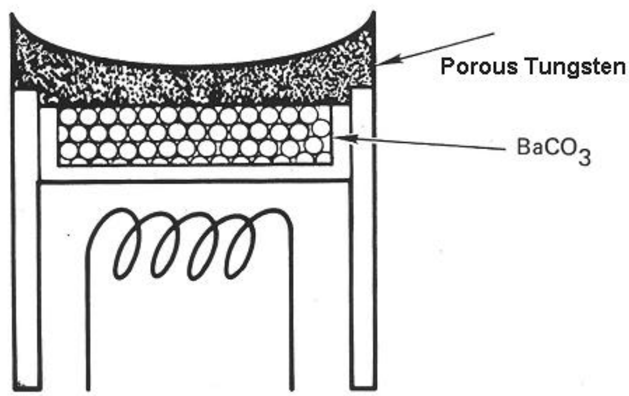
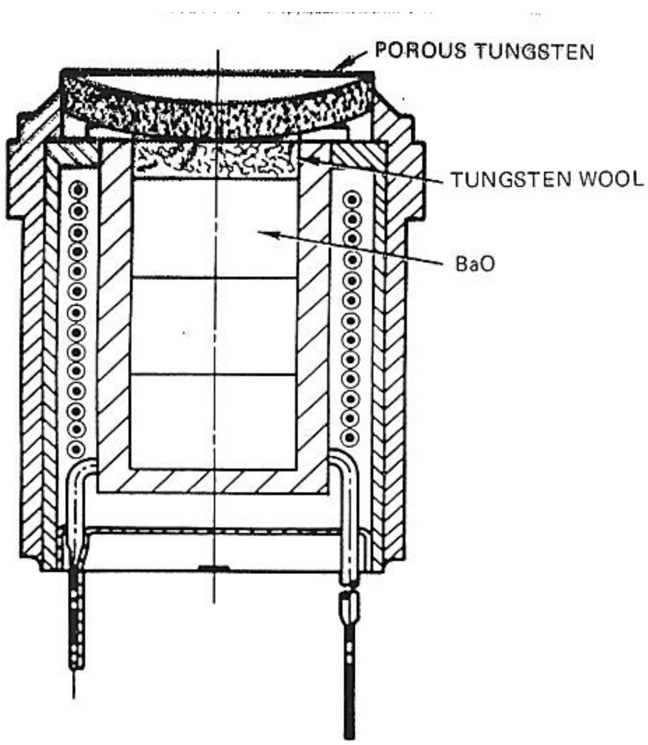


Fig. 14. Cross section of Philips "top layer" scandate cathode.







CRT REQUIREMENTS ELECTRON SOURCES

- HIGH RESOLUTION
- SMALL SPOT SIZE
- HIGH BRIGHTNESS

CRT DEMANDS ON CATHODES

- HIGH CURRENT DENSITY
- UNIFORM EMISSION
- LONG LIFE

OXIDE CATHODES

- DIELECTRIC COATING – “CHARGES UP”
- LIMITED TO SHORT PULSE LENGTHS FOR HIGHO URRE
- SUSCEPTIBLE TO POISONING
- DIFFICULT PROCESSING
- LIMITED LIFE AT HIGH CURRENT DENSITY

DISPENSER CATHODES

- HIGH CURRENT
- HIGH OPERATING TEMPERATURE

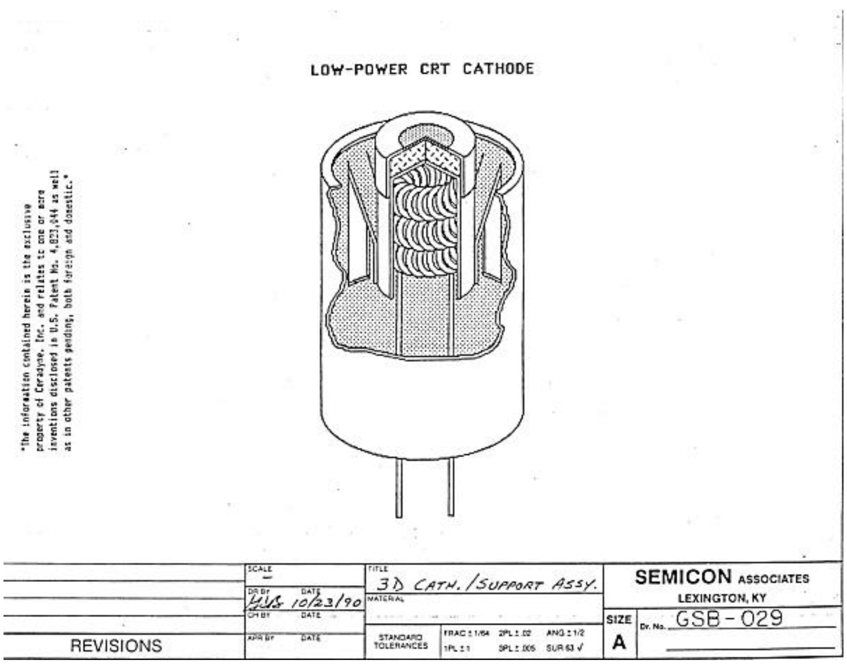
- LONG ACTIVATION CYCLE
- HIGH INITIAL BARIUM EVAPORATION
- CURRENT STEADILY DECREASES WITH LIFE

DISPENSER CATHODE HISTORY

- RESERVOIR TYPE (L) DEVELOPED BY PHILIPS IN 1940's
- RESERVOIR TYPE (MK) DEVELOPED BY SIEMENS IN 1950
- IMPREGNATED TYPE (B) DEVELOPED BY PHILIPS IN 1950's
  M-TYPE - IMPREGNATED CATHODE COATED WITH OS/RU DEVELOPED BY PHILIPS IN 1960'S
- MIXED METAL IMPREGNATED CATHODE DEVELOPED BY VARIAN IN 1970'S
  CPD CATHODE DEVELOPED BY NRL/VARIAN/HUGHES[..... CERADYNE - SEMICON STARTING IN 1975 TO PRESENT

CPD CATHODE

- RESERVOIR CATHODE
- THIN ALLOY SHEET DISPENSER I EMITTING SURFACE
- POROSITY CREATED BY LASER DRILLED HOLES
- IN CRT GUN HOLES ARE DIRECTLY BEHIND G-I APERTURE
  - UNIFORM EMISSION
  - REDUCED BARIUM EVAPORATION
  - INCREASED LIFE TIME

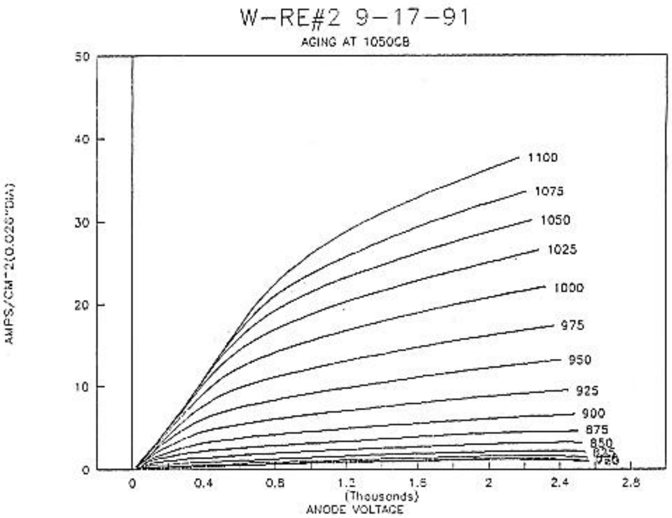


THERMALLY EFFICIENT STRUCTURE

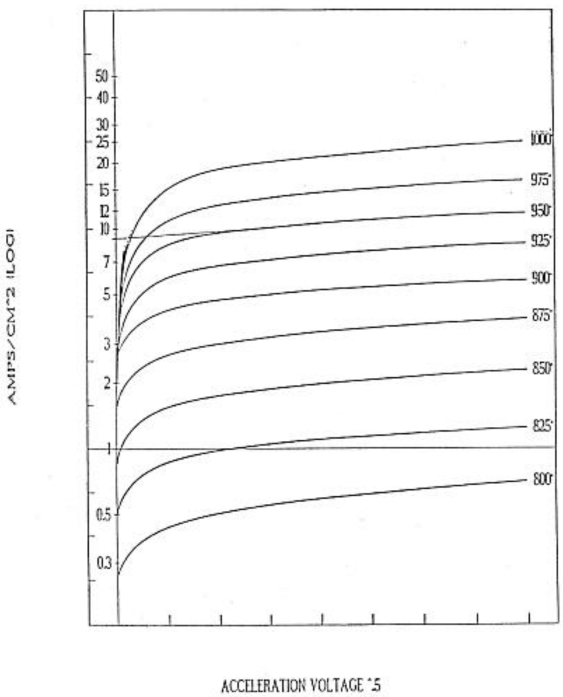
- LOW HEATER INPUT POWER - LESS THAN 143 WATTS FOR OVER 3 Nom CURRENT DENSITY
- INNER CATHODE SUBASSEMBLY
  - W-RE ALLOY CAP - LASER DRILLED LASER WELDED TO MO HEATER CUP
  - PELLET CONTAINING BARIUM COMPOUND CAPTURED BETWEEN
  - RADIATION LOSSES CUT BY LIMITING TOTAL SURFACE AREA
  - COILED COIL HEATER - MAXIMUM AMOUNT OF WIRE MASS. DARK COATED

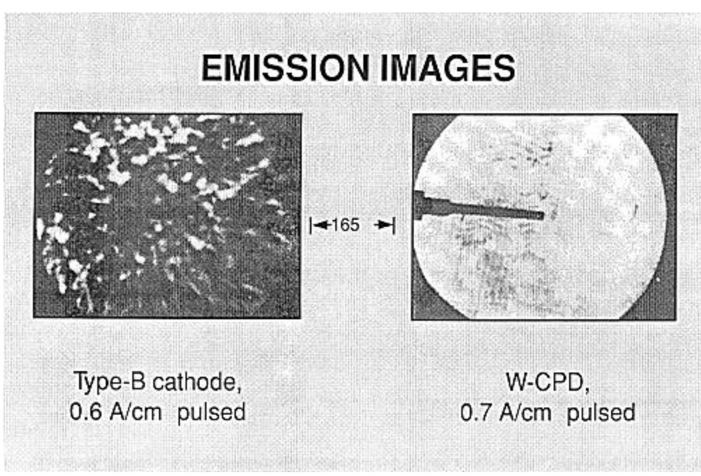
THERMALLY EFFICIENT STRUCTURE (CONT)

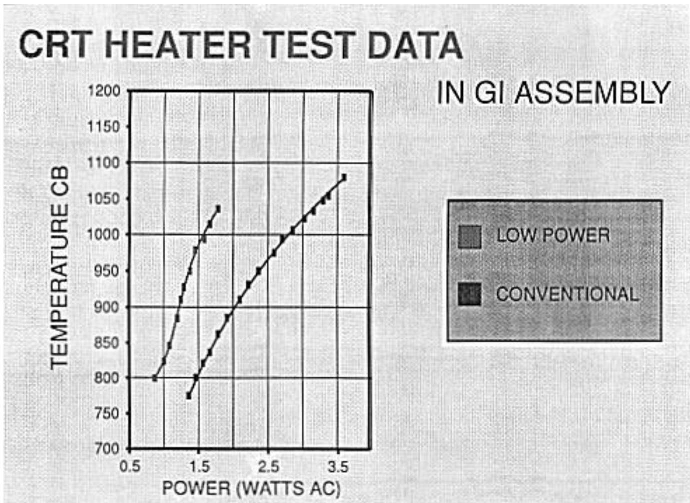
- OUTER SUPPORT STRUCTURE UTILIZES THREE POINT SUSPENSION
- SEAMLESS TANTALUM TUBING-LANCED TABS
- LASER SPOT WELDED TO MO HEATER CUP
- TANTALUM IS POOR THERMAL CONDUCTOR REDUCES POWER LOSS TO SUPPORT STRUCTURE
- INVERTED TAB STUCTURE PROVIDES RIGID MECHANICAL SUPPORT
- REFLECTIVE HEAT SHIELD - BLANKETS INNER ASSEMBLY
- LINEAR EXPANSION OFFSET

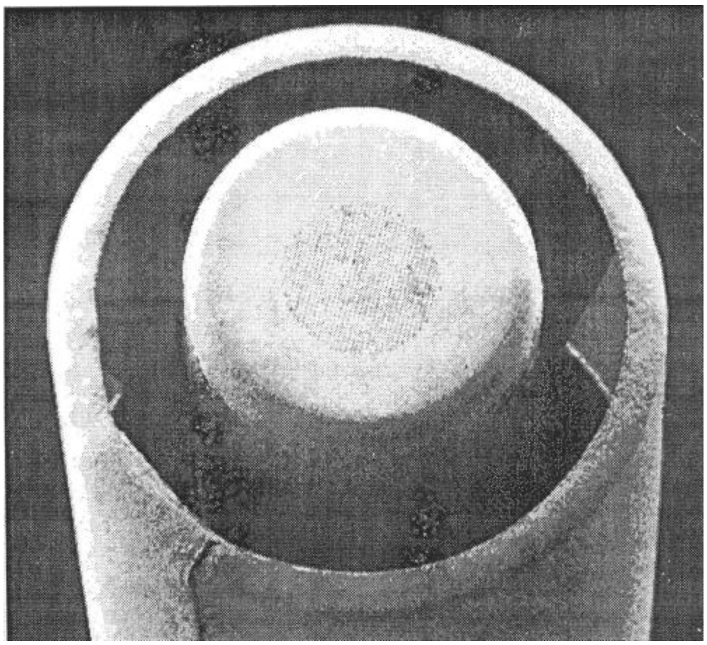


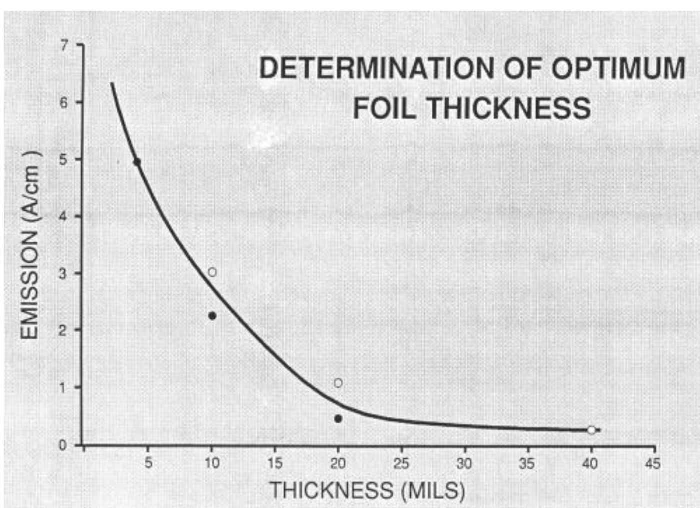
CURRENT DENSITY VS SQUARE ROOT OF VOLTAGE (SCHOTTKY PLOTS) FOR THE SEMICON CPD CRT CATHODE






CRT HEATER TEST DATA
IN GI ASSEMBLY
TEMPERATURE CB
1200
1150
1100
1050
1000
950
900
850
800
750
700
0.5
1.5
2.5
3.5
POWER (WATTS AC)
LOW POWER
CONVENTIONAL




DETERMINATION OF OPTIMUM
FOIL THICKNESS
EMISSION (A/cm)
7
6
5
4
3
2
1
0
5
10
15
20
25
30
35
40
45
THICKNESS (MILS)

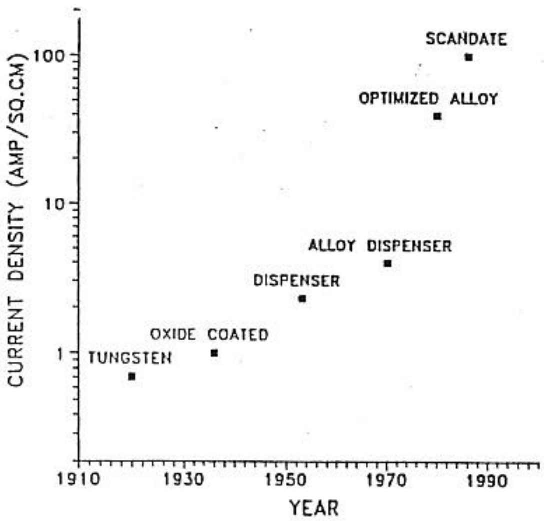
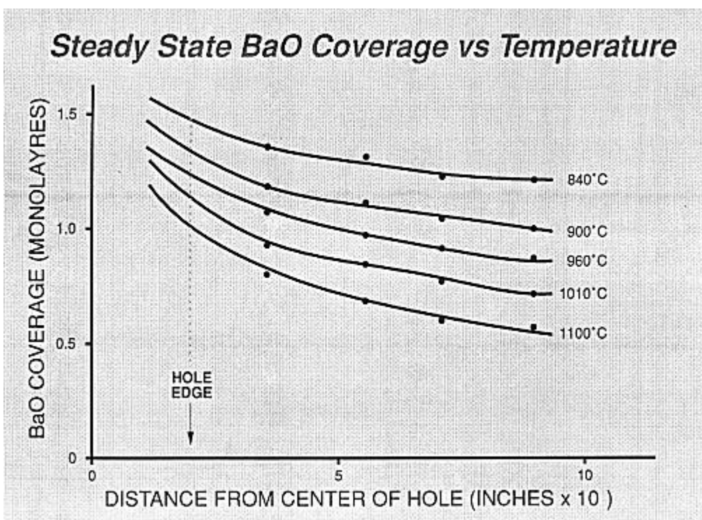
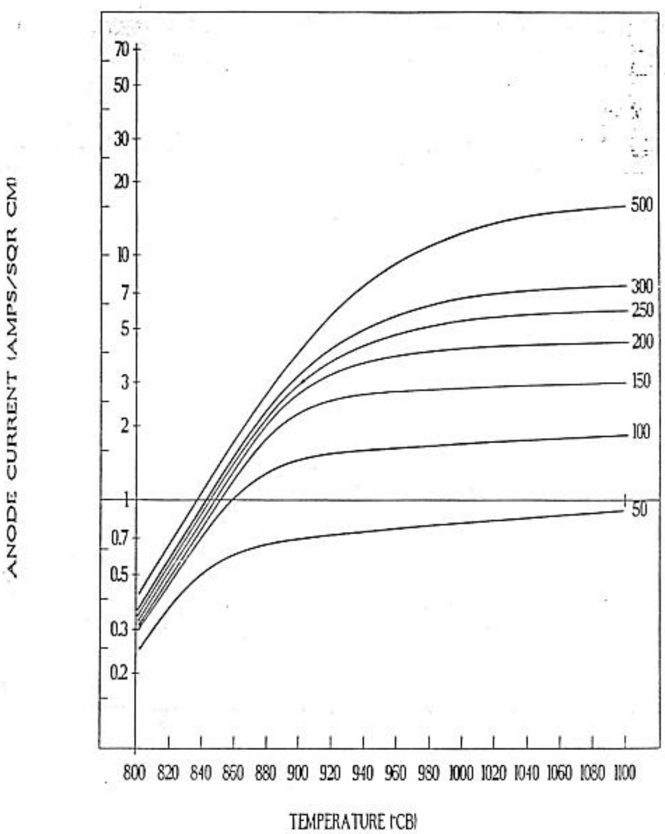
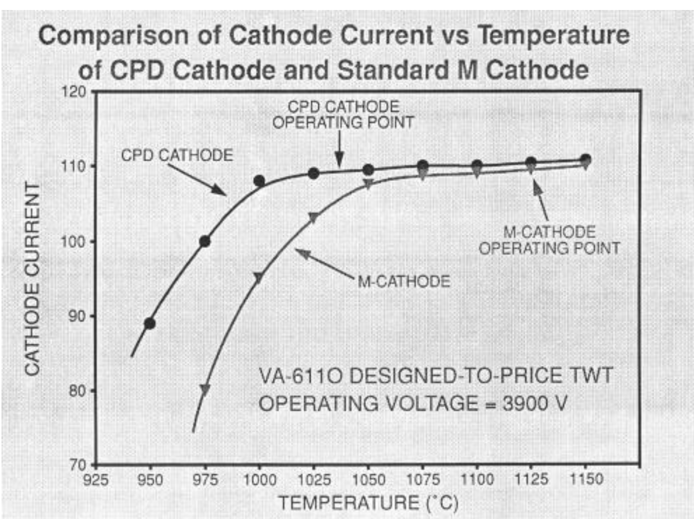


Fig. 1. Historical perspective of thermionic cathode emission capabilities.



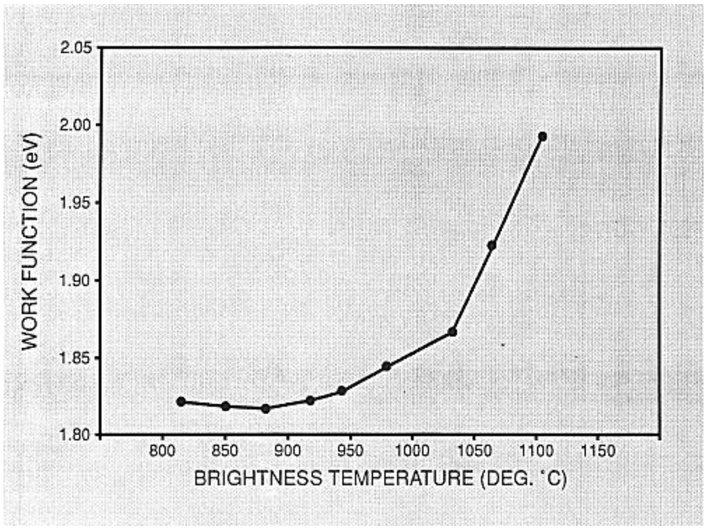
CURRENT DENSITY VS TEMPERATURE FOR
THE SEMICON CPD CRT CATHODE

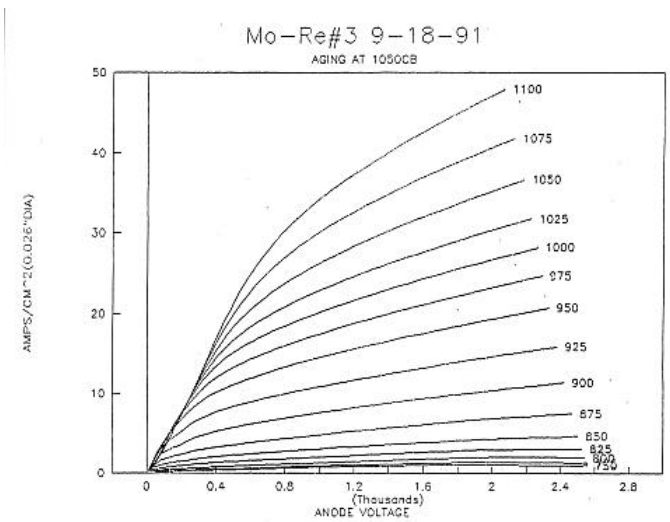


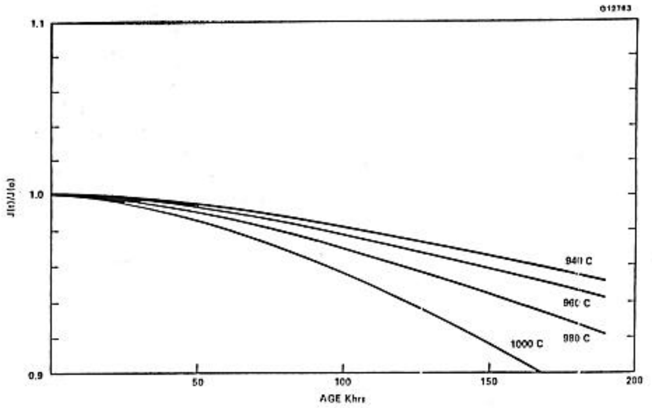


ACCELERATING FACTOR FOR VARIOUS TEMPERATURES (4% DEGRADATION).

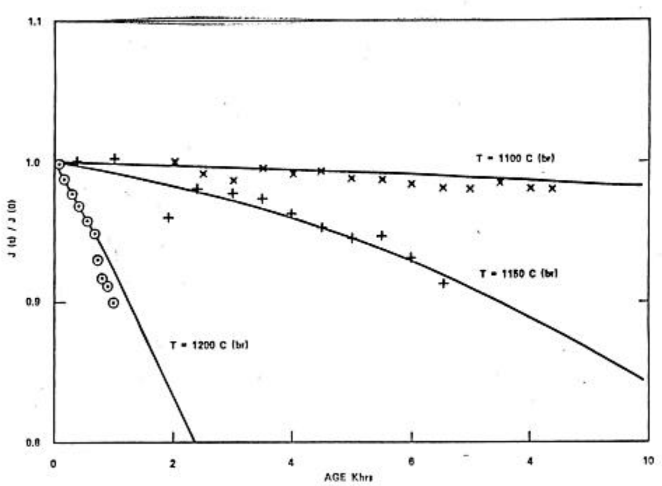
Temperature °C (Br)	Acceleration Factor	KHrs	Years
900	0.76	190.8	21.8
920	0.81	179.0	20.4
940	0.85	170.6	19.5
960	1.00	(= 145 KHrs)	16.6
980	1.21	119.8	13.7
1000	1.53	94.8	10.8
1050	3.30	43.9	5.0
1100	9.06	16.0	1.83
1150	36.25	4.0	0.46
1200	241.7	0.6	0.07



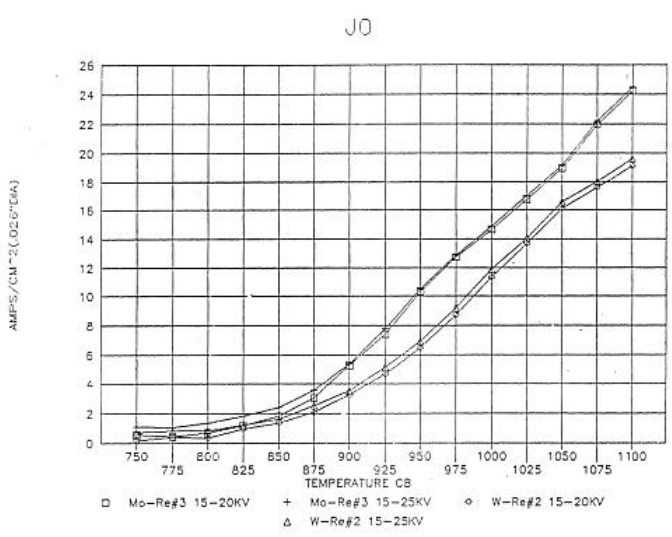




Life prediction at expected operating temperatures.



Accelerated life test data plotted with the life prediction model. All tests were with M-type cathodes (5:3:2) with 1 μ Om:Ru coatings.



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