



NANMAC is

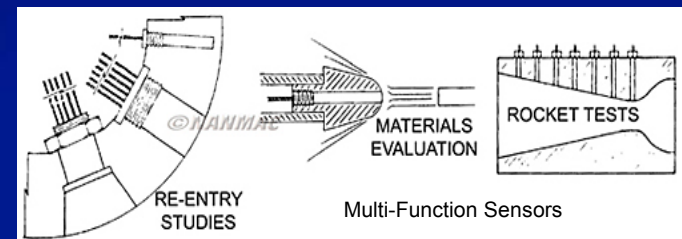
QUALITY

PERFORMANCE

SOLUTIONS

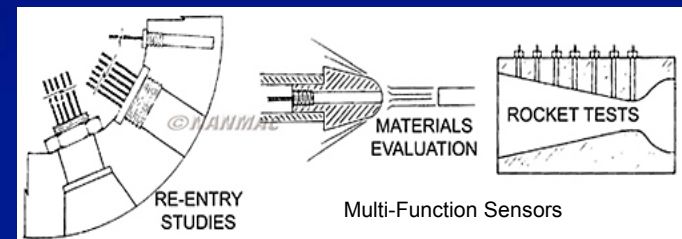


- Nanmac Corp. was established in 1956 by a group of scientists to develop high-performance temperature sensors



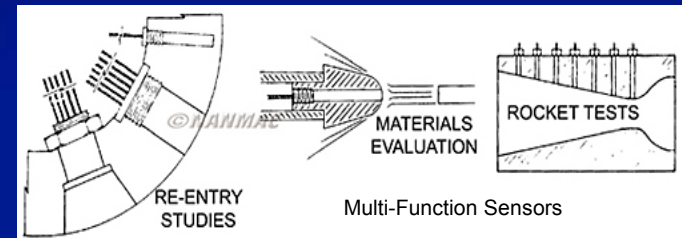


- Nanmac Corp. was established in 1956 by a group of scientists to develop high-performance temperature sensors
- Initial focus was on Government research & Military applications.



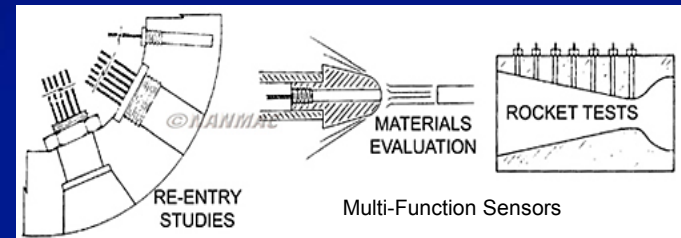


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- Initial focus was on Government research & Military applications.
- Many of these have become commercial applications – plastics, materials evaluation, heat transfer studies, incineration





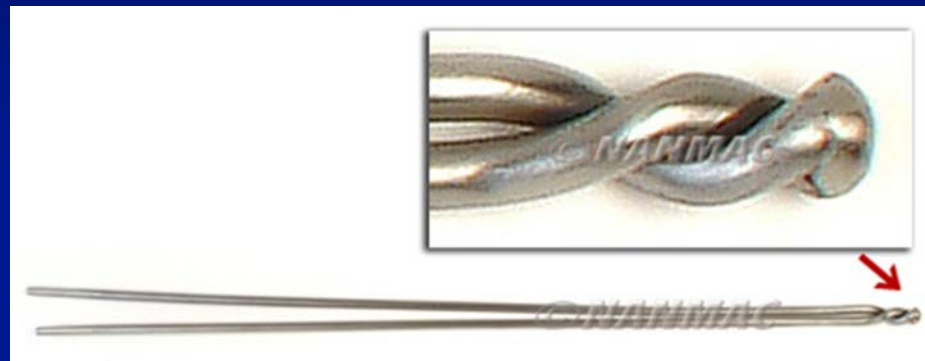
- Nanmac Corp. was established in 1956 by a group of scientists to develop high-performance temperature sensors
- Initial focus was on Government research & Military applications.
- Many of these have become commercial applications – plastics, materials evaluation, heat transfer studies, incineration
- Nanmac holds various patents on temperature sensors, erosion gages and “multi-function” sensors





General Thermocouple Theory

- Thermocouple circuit is made from two metals of different materials being electrically connected. This connection is called the thermocouple junction.



- The output of a thermocouple is a millivolt signal. The higher the temperature, the higher the millivolt output, this is called Electro Motive Force (EMF).



General Thermocouple Theory

- The type of metals used to make the thermocouple element determines the temperature range of the thermocouple.
- Each thermocouple “Type”, has a specific accuracy as determined by the US National Institute of Standards (NIST). Accuracy is based on a percentage of the temperature being measured.



General Thermocouple Theory

ANSI Code	Alloy Materials	Range
Type J	Iron/Constantan	0 to 750 C
Type K	Chromel/Alumel	0 to 1250 C
Type T	Copper/Constantan	0 to 350 C
Type E	Chromel/Constantan	0 to 900 C
Type N	Nicrosil/Nisil	0 to 1300 C
Type R	Pt-13%Rh/Pt	0 to 1450 C
Type S	Pt-10%Rh/Pt	0 to 1450 C
Type B	Pt-30%Rh/Pt-6%Rh	870 to 1820 C
Type C	W-5%Re/W-26%Re	426 to 2320 C
Type G	W/W-26%Re	950 to 3100 C



General Thermocouple Theory

American Limits of Error

ANSI Code	Standard	Special
Type J	2.2 C or 0.75 %	1.1 or 0.4%
Type K	2.2 C or 0.75 %	1.1 or 0.4%
Type T	1.0 C or 0.75 %	0.5 or 0.4%
Type E	1.7 C or 0.5 %	1.0 or 0.4%
Type N	2.2 C or 0.75 %	1.1 or 0.4%
Type R S	1.5 C or 0.25 %	1.1 or 0.4%
Type B	0.5 %	Not Established
Type C G	4.5 C or 1.0 %	Not Established



General Thermocouple Theory

ANSI Color codes for Thermocouple, Wire and Connectors

TYPE	COLOR
B	GRAY
C	BROWN
D	BROWN
E	PURPLE
G	BROWN
J	BLACK
K	YELLOW
N	ORANGE
R	GREEN
S	BRIGHT GREEN
T	BLUE



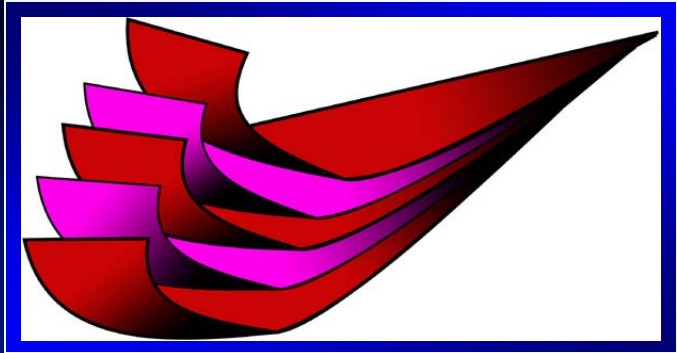


NANMAC

High Performance Thermocouples



“Eroding” Thermocouple



- 5 Layer construction
- 3 layers are very thin electrical insulators
- 2 layers are thermocouple alloy ribbon

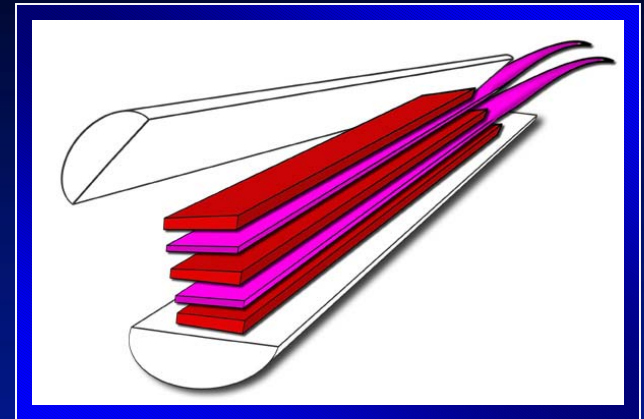


“Eroding” Thermocouple



- 5 Layer construction
- 3 layers are very thin electrical insulators
- 2 layers are thermocouple alloy ribbon

- All 5 layers are pressed between a split insert

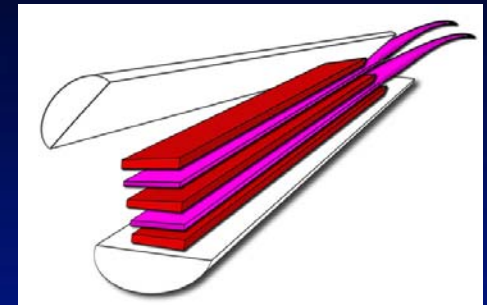




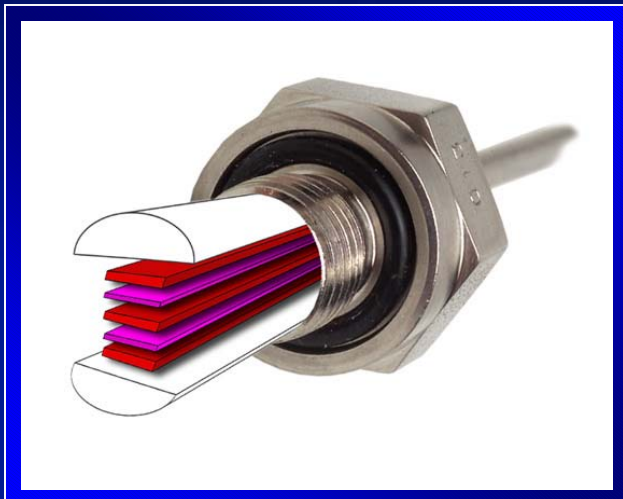
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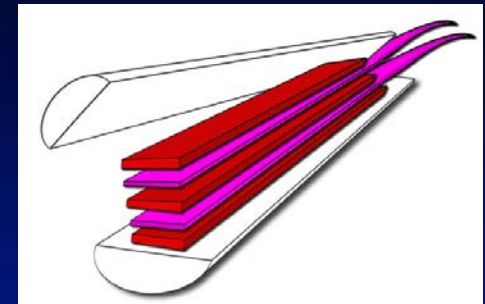
- Entire assembly is then inserted into the required housing



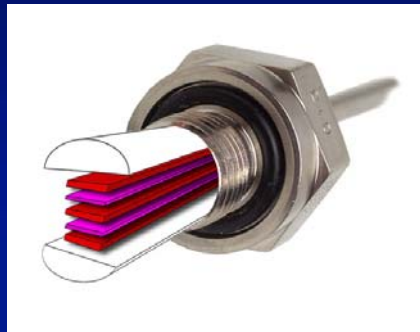
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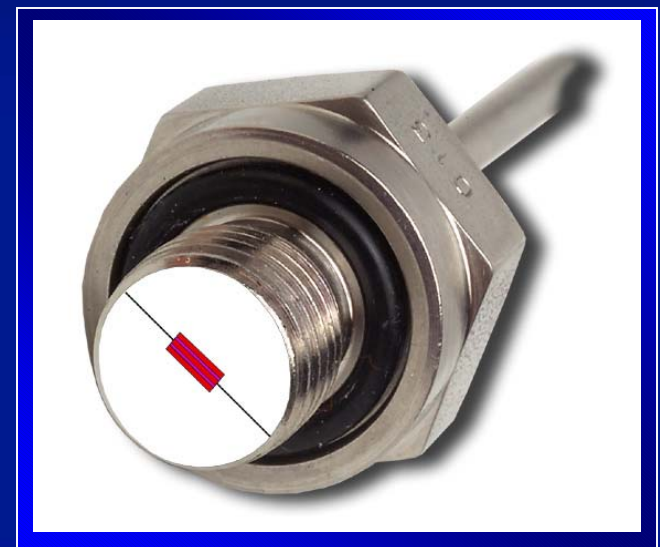


- All 5 layers are pressed between a split insert



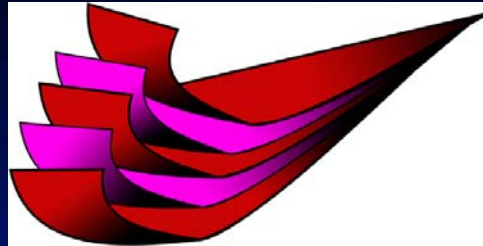
- Entire assembly is then inserted into the required housing

- Housing can be made from any material to match the thermal properties of the test material – in almost any shape

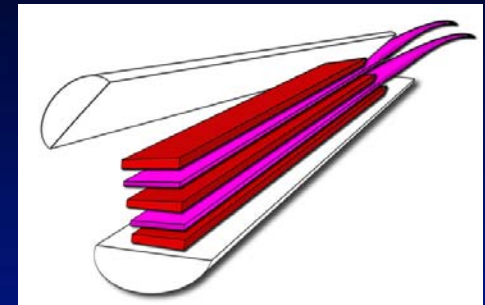




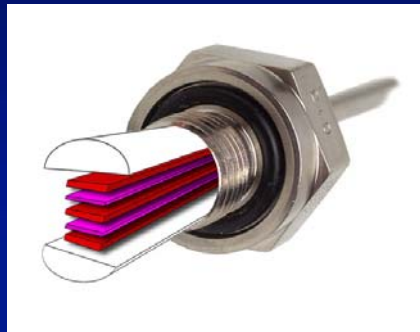
“Eroding” Thermocouple



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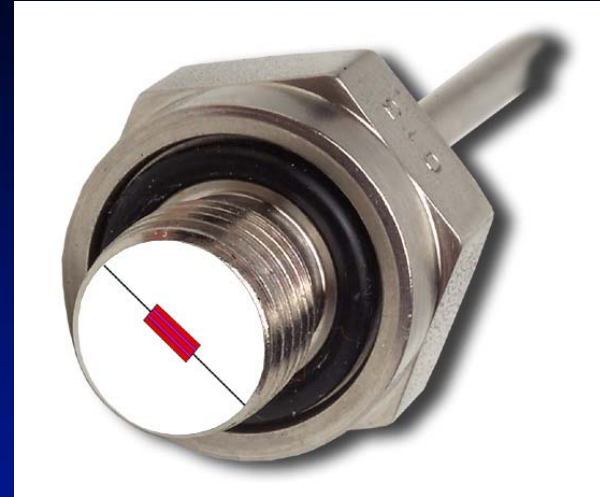


*Thermocouple junction is formed by grinding motion across the layers
Junction is microscopic, continued grinding forms new junctions
Grinding motion can be from shaping, ablation, wear, etc...*



“Eroding” Thermocouple

- Patented design





“Eroding” Thermocouple

- Patented design
- Microsecond response time





“Eroding” Thermocouple

- Patented design
- Microsecond response time
- Thermal device can be made from most any material, in most any shape: Graphite, steel, plastic, phenolic, rubber, wood





“Eroding” Thermocouple

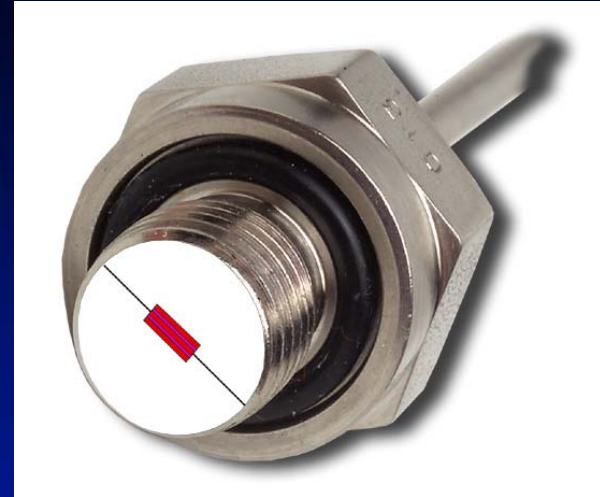
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- Temperatures to over 3100°C





“Eroding” Thermocouple

- Patented design
- Microsecond response time
- Thermal device can be made from most any material, in most any shape: Graphite, steel, plastic, phenolic, rubber, wood
- Temperatures to over 3100°C
Pressures to over 25,000 psi





“Eroding” Thermocouple

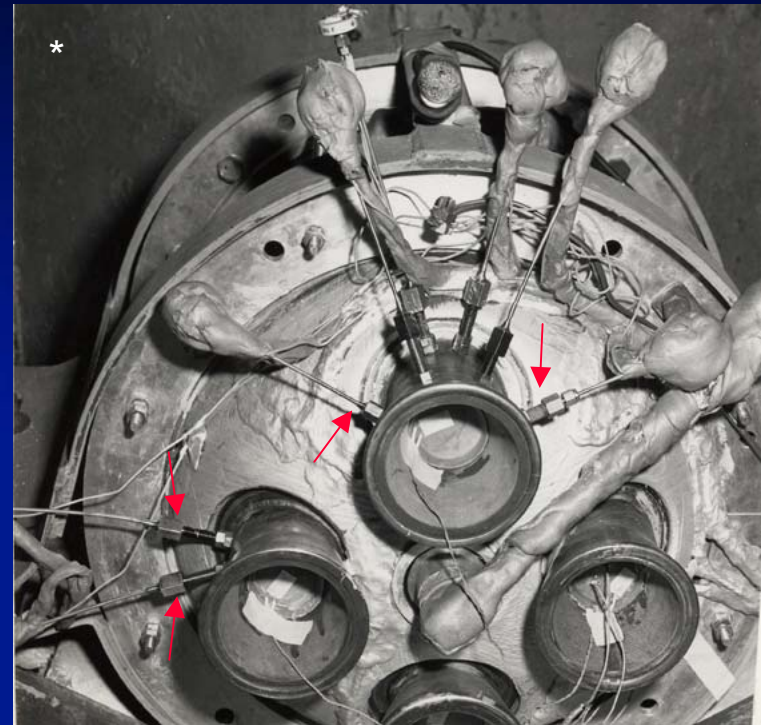
- Patented design
- Microsecond response time
- Thermal device can be made from most any material, in most any shape: Graphite, steel, plastic, phenolic, rubber, wood
- Temperatures to over 3100°C
Pressures to over 25,000 psi
- Available in all thermocouple calibrations, including Type C & G





“Eroding” Thermocouples for Research

- Research applications include:
 - Rocket nozzle blast temperatures *
 - Interface measurements between moving surfaces – brake pads, piston walls, bearings
 - Ablation studies
- Unique performance characteristics
 - Millisecond & Microsecond response time
 - 2 dimension thermal junction, exact location placement
 - Sensing device can wear or “erode” up to 0.375” and continue to measure – even during erosion



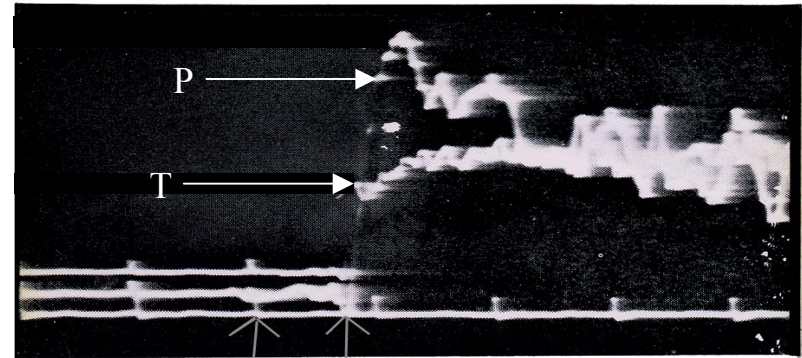
4 of 7 “Eroding” thermocouples – all 7 mounted flush to inside of nozzle



“Eroding” Thermocouples for Research

- Additional research applications include:
 - Shockwave measurements **
 - Projectiles and Gun barrel breaches
 - Explosions
 - Squibs and Igniters
- Unique performance characteristics
 - Sensing device can be machined to match wall contours
 - Distinct temperature of interest can be provided: the wall surface temperature (thermally grounded), or the interface {gas, flame, friction} temperature at the wall surface (thermally isolated)

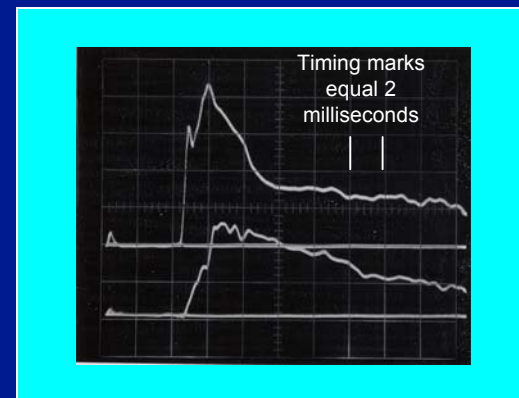
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Time Marker At 100 Microsecond Intervals

P = pressure, ~ 1000 psi

T = temperature, ~ 650 Deg F





“Eroding” Thermocouples for Industry

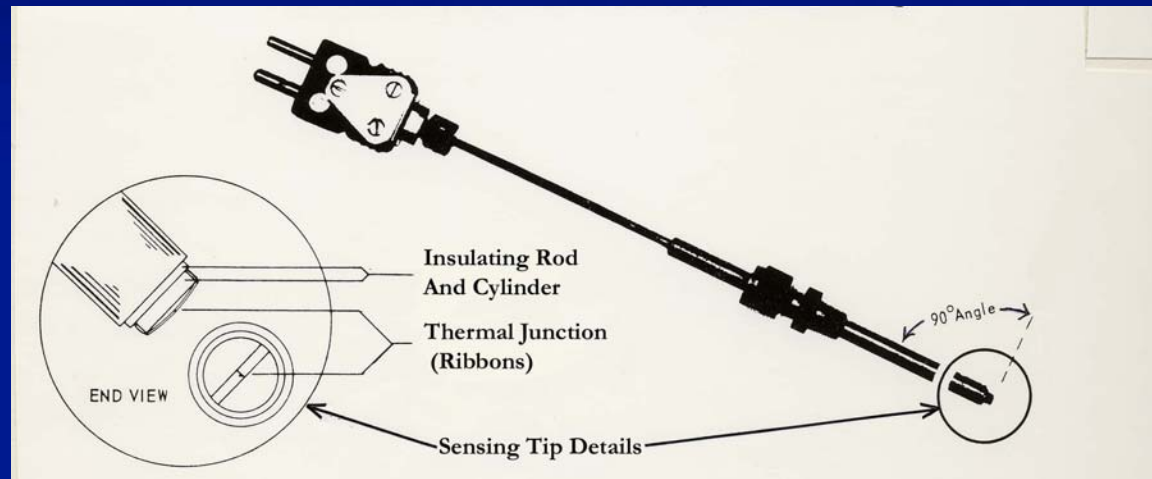
- Industrial applications include:
 - Plastic processing
 - Thermal modeling
 - Combustion gases in diesel engines
 - Moving wires or textiles
 - Brake lining interface temps
- Unique performance characteristics
 - True plastic temperatures, unaffected by mold wall heat-sink
 - Sensor can be shaped or machined to match wall surface contours – Mold walls, cylinder, manifolds, bearings
 - Multiple sensors can be located within a single housing with exact positioning





“Right-Angle” Ribbon Thermocouple

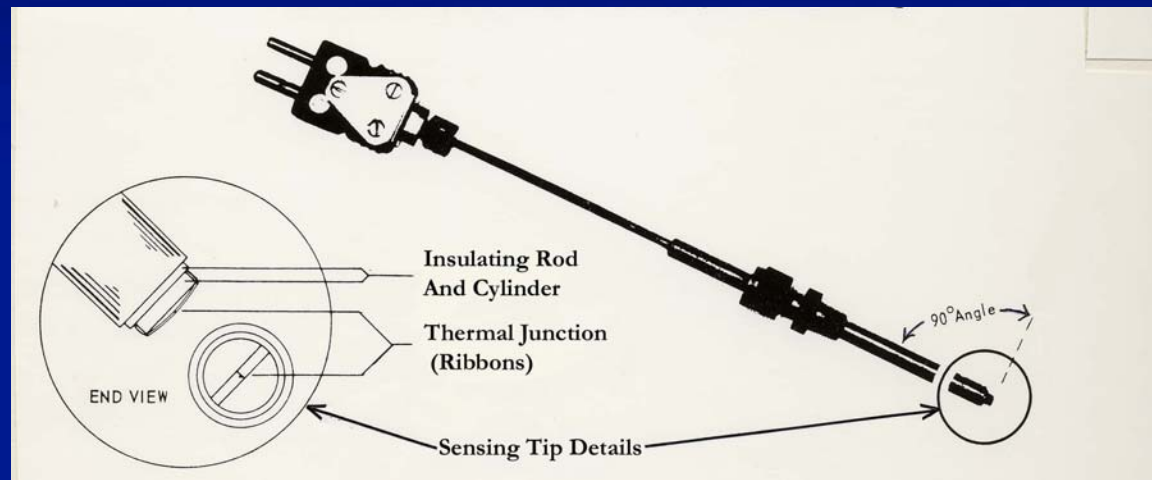
- Patented design





“Right-Angle” Ribbon Thermocouple

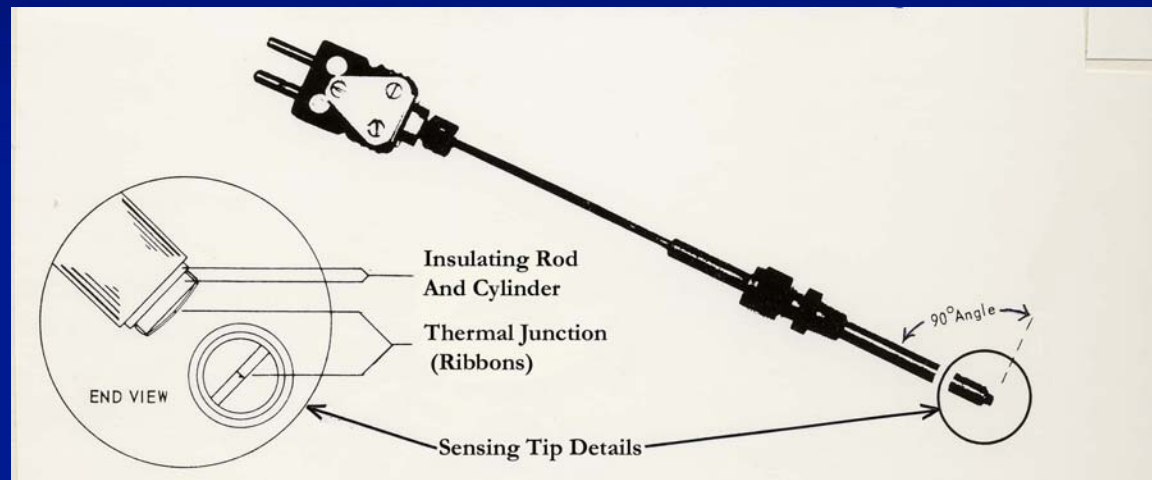
- Patented design
- Millisecond Response time





“Right-Angle” Ribbon Thermocouple

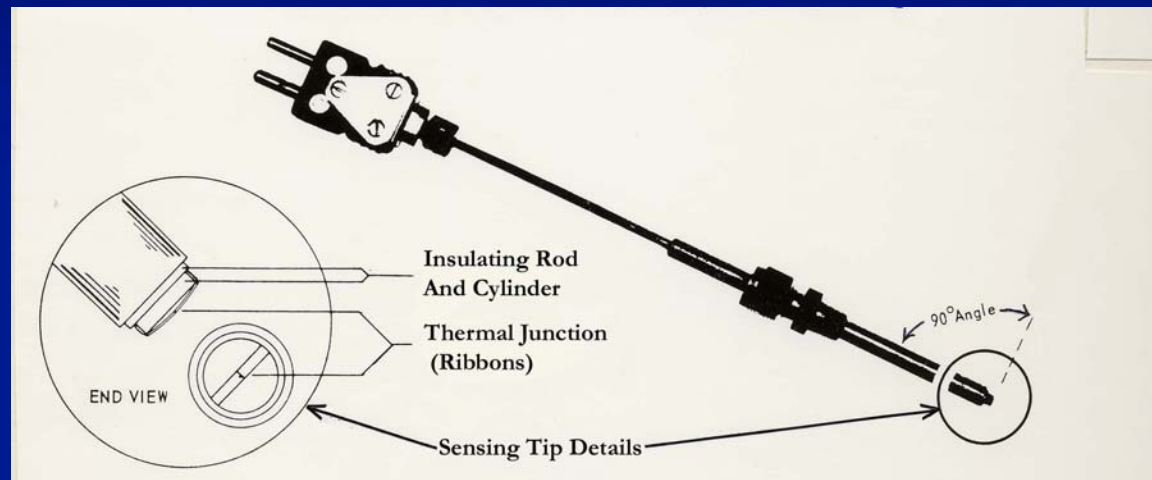
- Patented design
- Millisecond Response time
- Pressures to over 10,000 psi.





“Right-Angle” Ribbon Thermocouple

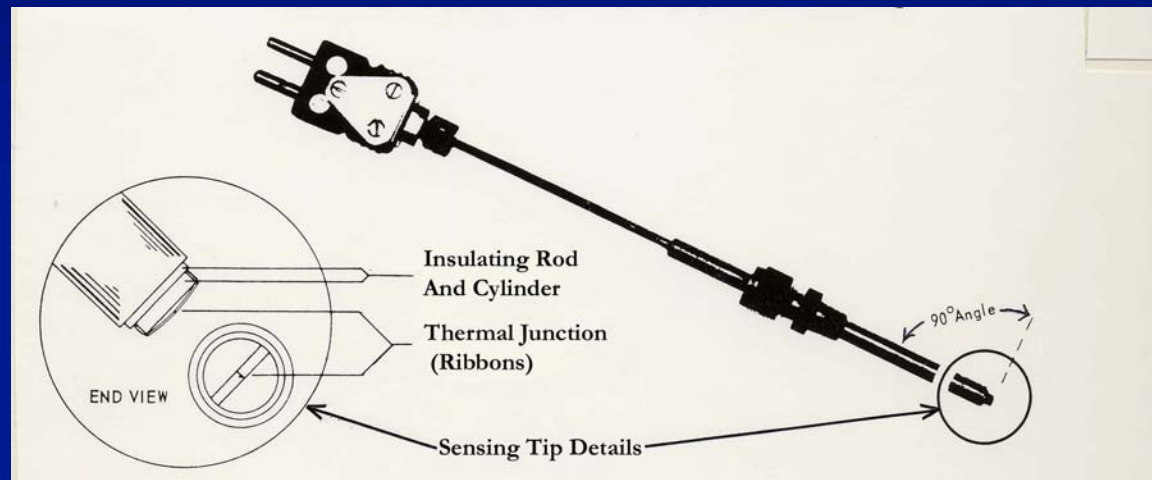
- Patented design
- Millisecond Response time
- Pressures to over 10,000 psi.
- No conduction Error – provides absolute temperature





“Right-Angle” Ribbon Thermocouple

- Patented design
- Millisecond Response time
- Pressures to over 10,000 psi.
- No conduction Error – provides absolute temperature
- Temperatures > 2300°C





“Right-Angle” Thermocouples for Research

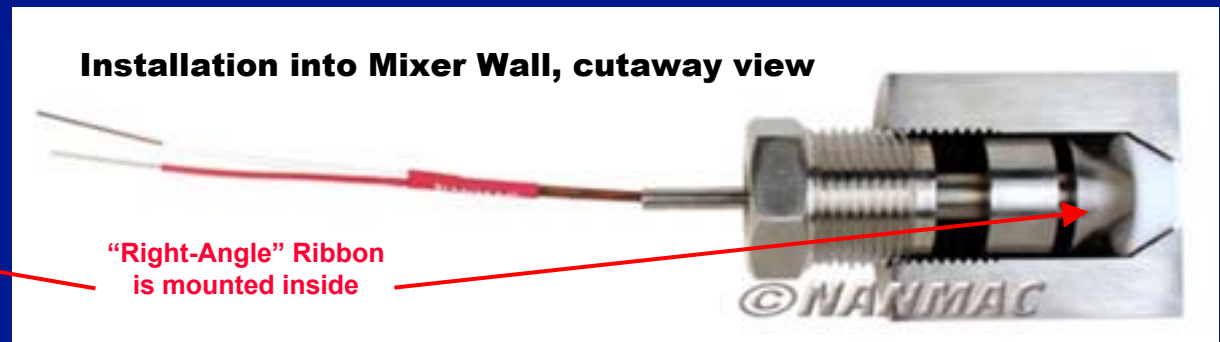
- Research applications include:
 - Rocket nozzle exhaust gases
 - Profile temperatures within chambers or pipelines
 - Flat-bottom, bored holes within walls
- Unique performance characteristics
 - Thermocouple junction is thermally isolated from the thermowell / mounting fixture
 - Thermowell can be designed with “radiation shield” for specific gas temperatures that are unaffected by chamber wall heating
 - Thermall junction (ribbon) is parallel to isotherm





“Right-Angle” Thermocouples for Industry

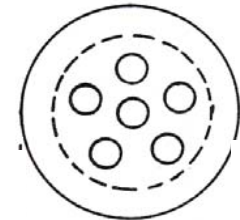
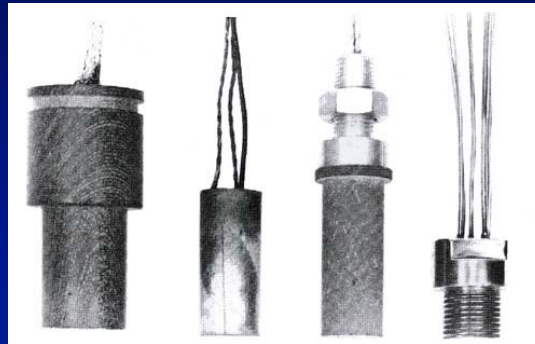
- Industrial applications include:
 - Gases or liquids in pipelines
 - Mixers for food, propellant or pharmaceutical process
 - Petrochemical systems
 - Smoke stacks and exhaust pipes
- Unique performance characteristics
 - Thermal sensor can be “Isolated” for sanitary applications
 - Various mounting configurations: In-wall, in-stream, adjustable immersion
 - Cryogenic temperatures



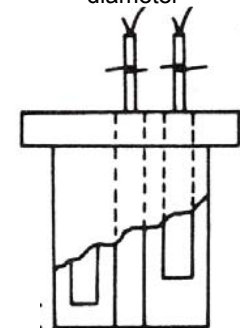


“Multi-Function” Thermocouples for Research

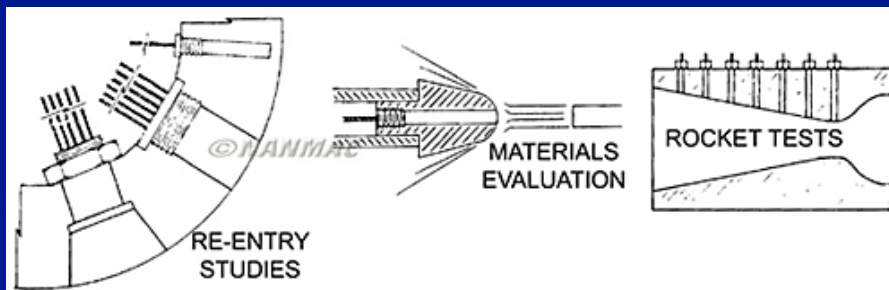
- Combine multiple **Eroding** & **Right-Angle** thermocouples within a single housing
- Thermocouple housing made from test-wall material to replicate exact thermal properties
- Heat flux & heat transfer studies, Ablative materials research
- Surface measurements and in-wall temperatures at the same time



As small as 1/2 Inch diameter



Combine Eroding & Right-Angle sensors within one housing





Ultra-High Temperature Thermocouples

- Industrial applications include:
 - Vacuum furnaces
 - Graphite lined furnaces or furnaces with graphite heaters
 - Petrochemical cracking furnace
 - Heat treating and sintering
 - Calibration, drift and uniformity & profile studies
- Unique performance characteristics
 - Temperatures to over 2300°C
 - Accurate to +/- ½ % of reading, even at 2000°C
 - Prolonged life in harsh environments – 10 times the life of standard sensors
 - Up to 70 inches long

A12D Series – Ultra High Temp



- Available in all thermocouple calibrations, including Platinum and Tungsten
- Made to order in less than 3 weeks



Awards & Recognition

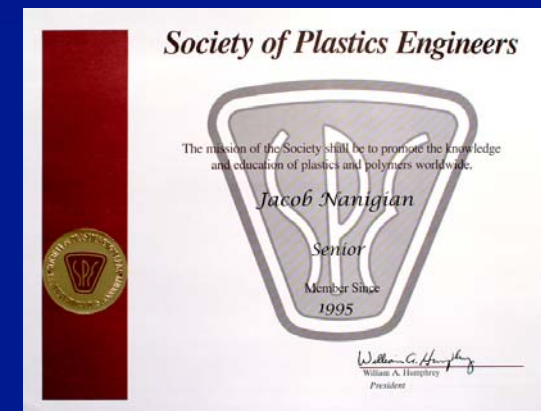
Industry Awards

- *Instrumentation, Systems & Automation Society (ISA)*
... One of the Top 20 New Products of the Year
- *Materials in Design Engineering*
... Best use of Engineering Materials
- *Chemical Equipment Magazine*
... Readers' Choice Award for Editorial Contributions



Publications

- *Process Heating Magazine*
“Selecting the Right Thermocouple”
- *Measurement and Control Magazine*
“Thermal Sensor Characteristics”
- *Industrial Heating Magazine*
“Myths and Facts About Temperature Sensing”





Quality

- Quality program as per US Military Specification 9858-A



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- Certified calibration in accordance with ASTM specification E2181, traceable to National Institute of Standards and Technology (NIST)



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- Calibration process in accordance with NIST *Comparative Method* capable of up to 3100 degrees centigrade



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- Calibration process in accordance with NIST *Comparative Method* capable of up to 3100 degrees centigrade
- All thermocouple outputs certified to conform to IPTS 68



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- Calibration process in accordance with NIST *Comparative Method* capable of up to 3100 degrees centigrade
- All thermocouple outputs certified to conform to IPTS 68
- Pressure test lab utilizing High Pressure Equipment Company, Dynisco and Ashcroft equipment to 50,000 PSI



Quality

- Quality program as per US Military Specification 9858-A
- Certified calibration in accordance with ASTM specification E2181, traceable to National Institute of Standards and Technology (NIST)
- Calibration process in accordance with NIST *Comparative Method* capable of up to 1500 degrees centigrade
- All thermocouple outputs certified to conform to IPTS 68
- Pressure test lab utilizing High Pressure Equipment Company, Dynisco and Ashcroft equipment to 50,000 PSI
- Vacuum leak test utilizing Varian Systems equipment to 10^{-7} Torr



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- Calibration process in accordance with NIST *Comparative Method* capable of up to 3100 degrees centigrade
- All thermocouple outputs certified to conform to IPTS 68
- Pressure test lab utilizing High Pressure Equipment Company, Dynisco and Ashcroft equipment to 50,000 PSI
- Vacuum leak test utilizing Varian Systems equipment to 10^{-7} Torr
- Calibration & Test records on file for minimum of five years after date of manufacture



Some of our customers

3M	Dow Chemical
A1 Carbide	Dupont
ABB Corporate Research	ExxonMobil
Abbott Labs	Ford
Air Liquide America	Jet Propulsion Laboratory (JPL)
Alcoa	Johnson & Johnson
Allied Aerospace	Massachusetts Institute of Technology (MIT)
ATK Thiokol Propulsion	NASA
Bechtel	Namiki Precision Jewel
BF Goodrich	Raytheon
Boeing	Sandvik Hard Materials
BTU Engineering	Union Carbide
Carnegie Mellon Research Institute	US Department of Defense
Caterpillar Inc	US Naval Underwater Research Lab
Coca ~ Cola	Weyerhaeuser
Corning	Worcester Polytechnic Institute (WPI)



We Are NANMAC

QUALITY

PERFORMANCE

SOLUTIONS