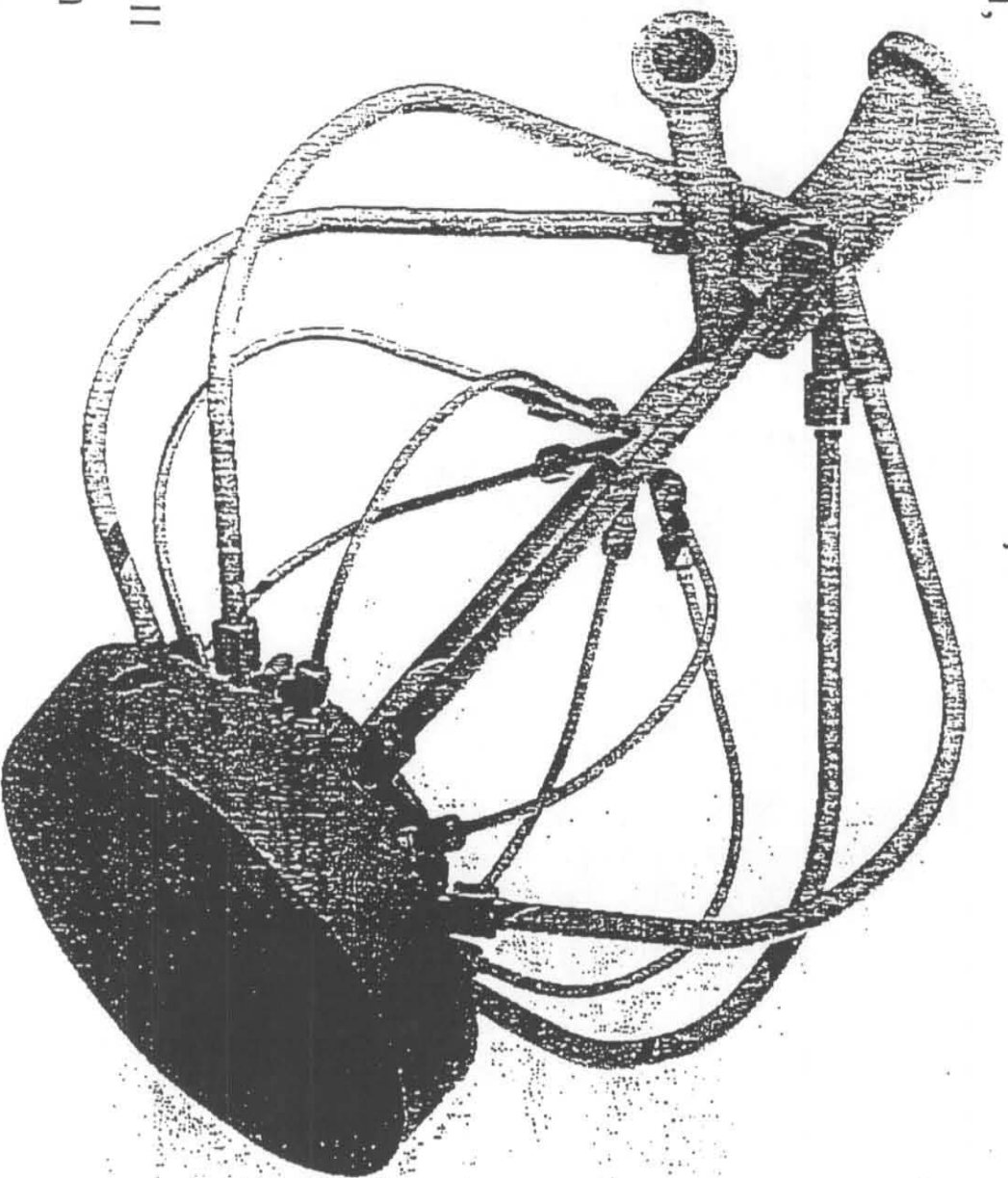




Clean
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CES Proprietary
Injector Design Details

- Machined Inconel 600 Manifold, Inconel 600 diffusion bonded platelets
- 1.5" Schedule 40 O₂ Grayloc Inlet
- .75" Schedule 40 CH₄ Grayloc Inlet
- Inlet lines split into 6 separate injector inlets for each injector circuit to provide even flow distribution into the injector.
 - CH₄ line size - .25" OD, .035 Wall
 - O₂ line size - .50" OD, .049 Wall
- H₂O enters injector directly from the chamber



Do Not Duplicate

Fig 1



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10 MWGG Igniter Design

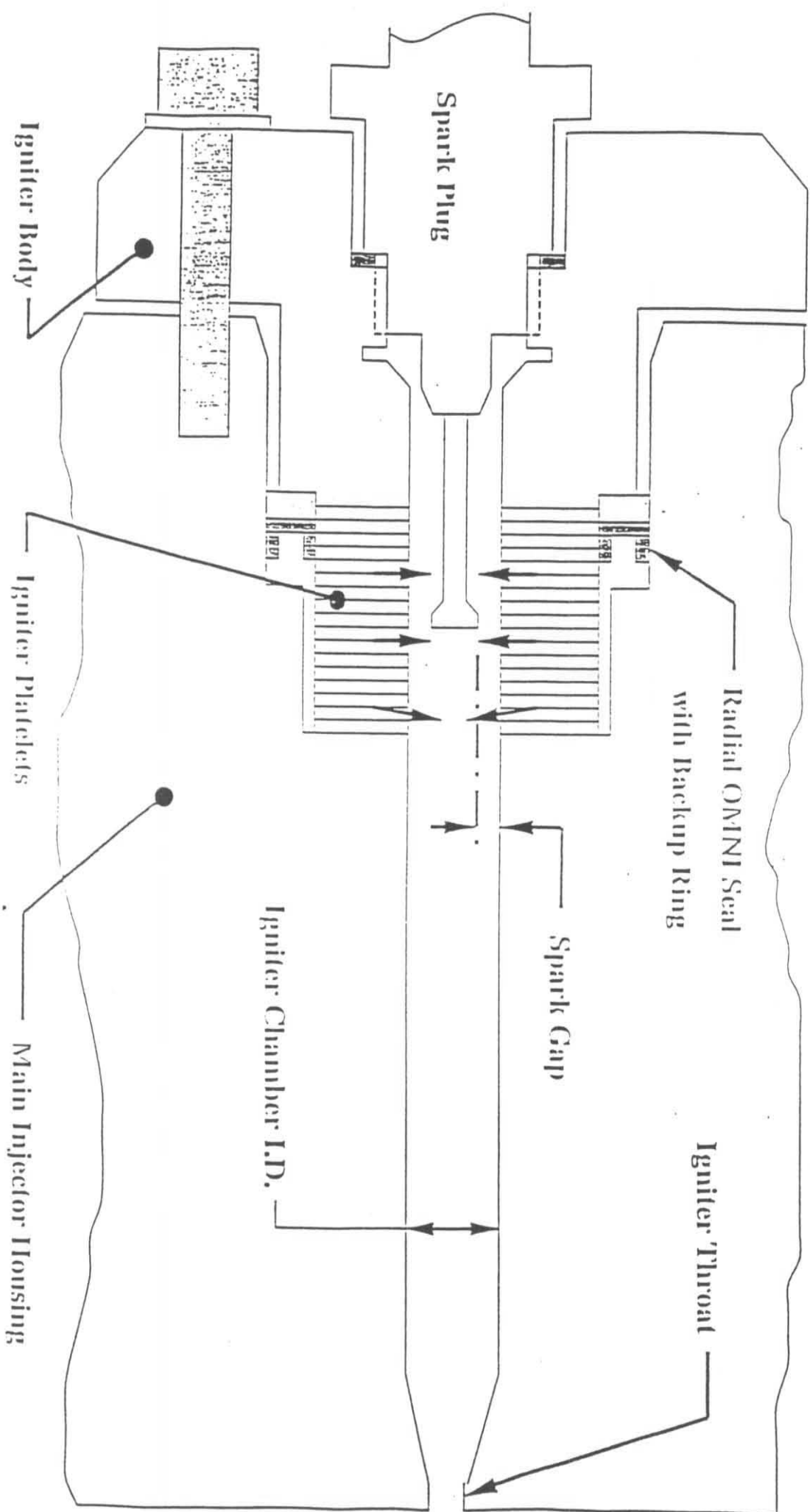


Fig 2



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Injector Houses Many Features

- Internal filters built into injector platelets for each circuit
- Igniter positioned through center of injector body
- Dual-tuned acoustic cavities using removable .3 thick cavity plate
- Pressure ports for all three circuits
- Temperature measurement in resonator cavity
- Water bypass circuit
- Filter backflush port

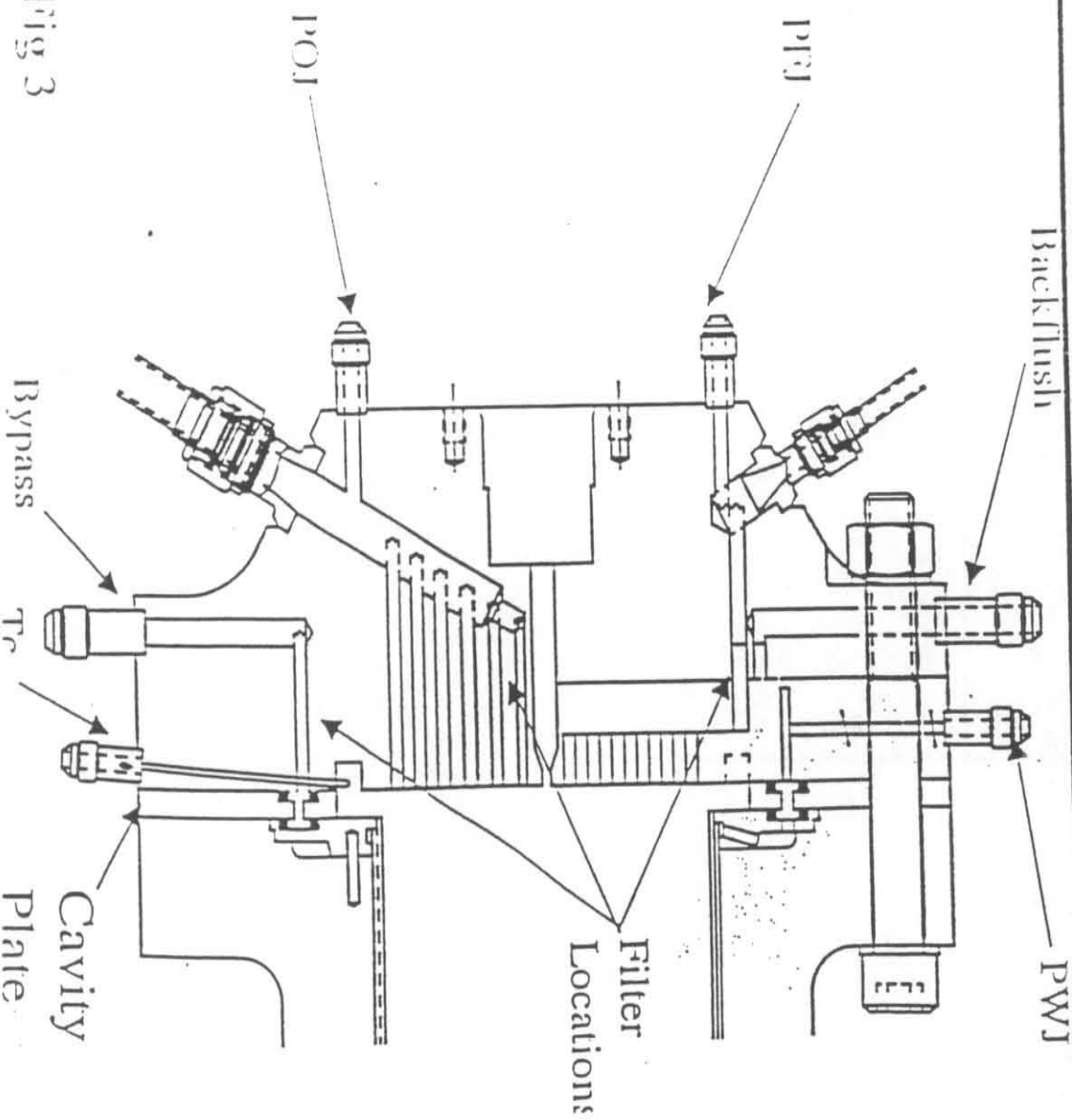


Fig 3



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Injector Details

Figure 4
Three injector pattern designs have
been selected:

Pattern "A":

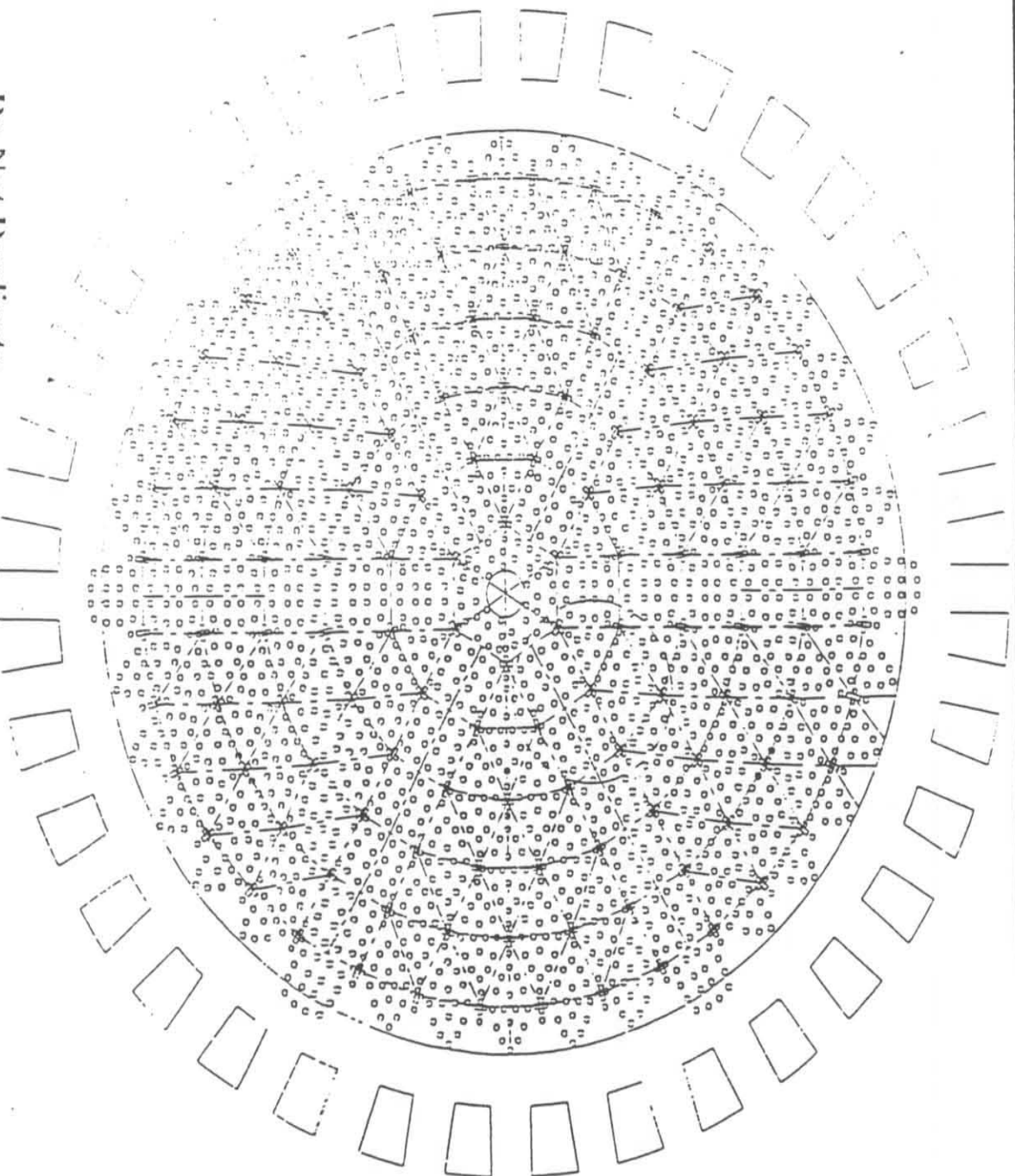
Fuel x-doublet under
oxidizer doublet, 90% H2O
face weep cooling, 10%
H2O chamber film cooling

Pattern "B":

Vortex elements including
11% H2O, 79% H2O face
swirl cups, 10% H2O chamber
film cooling

Pattern "C":

Dual vortex elements including
22% H2O, 68% H2O weep cooling,
10% H2O chamber film cooling



Do Not Duplicate

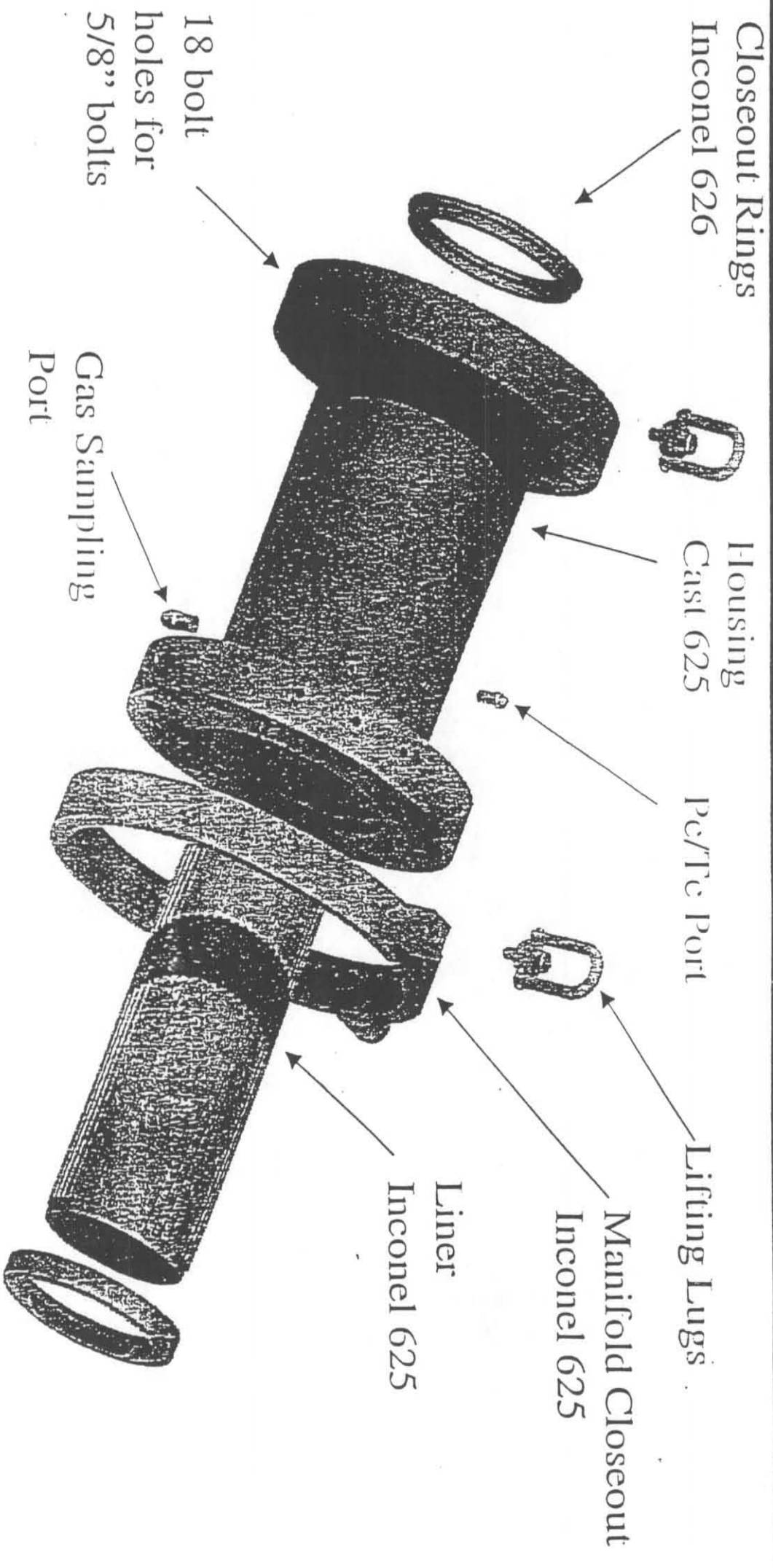
Fig 4



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Combustion Chamber



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Fig 5



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Combustion Chamber CX

- Liner Brazed into Housing
- Close out rings brazed on both ends
- Inlet manifold brazed onto housing flange
- Gas probe port and Pe/Tc port welded onto housing

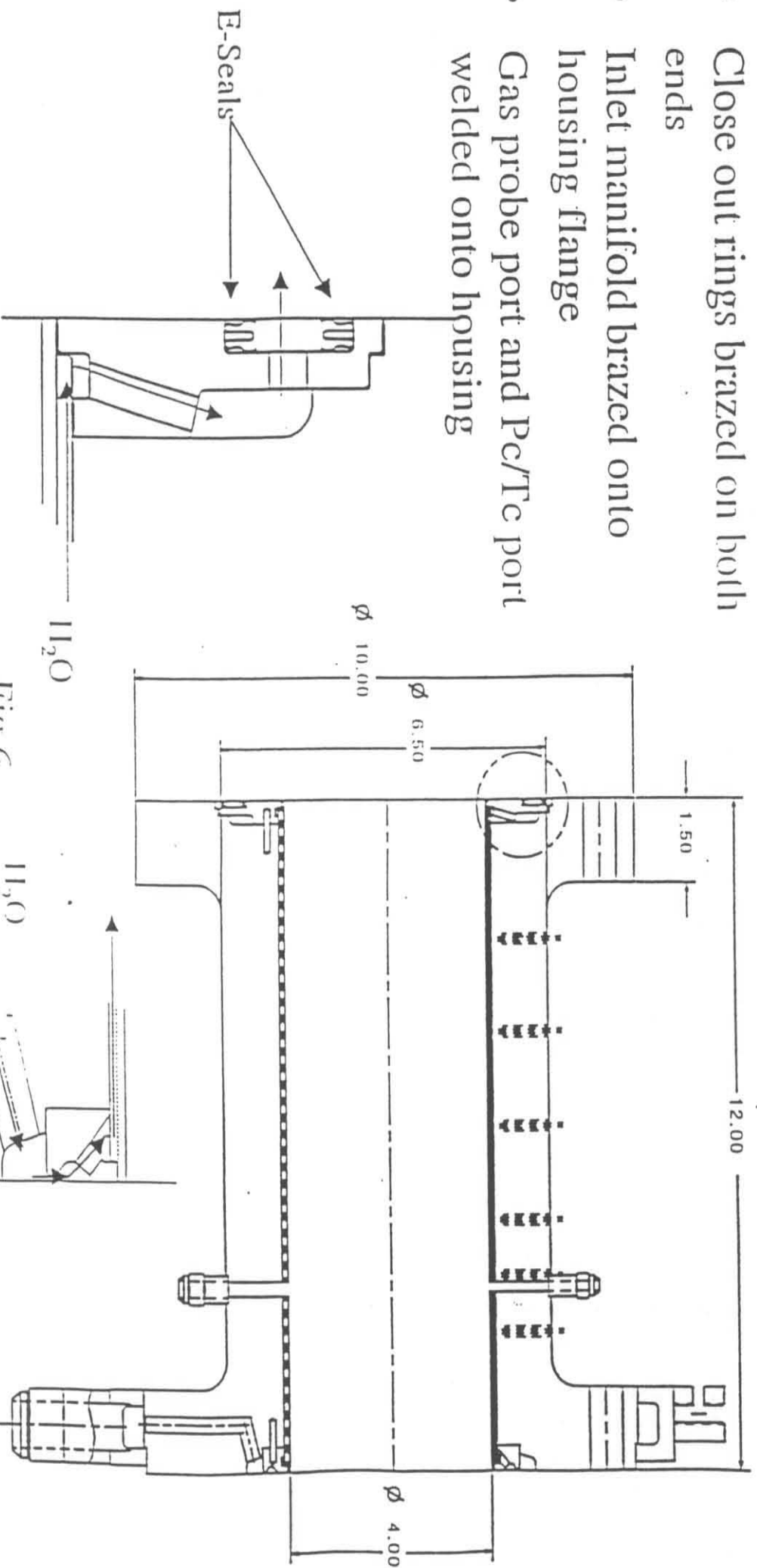


Fig 6

H₂O

H₂O

Do Not Horizontal



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CES Proprietary
Cool Down Chamber

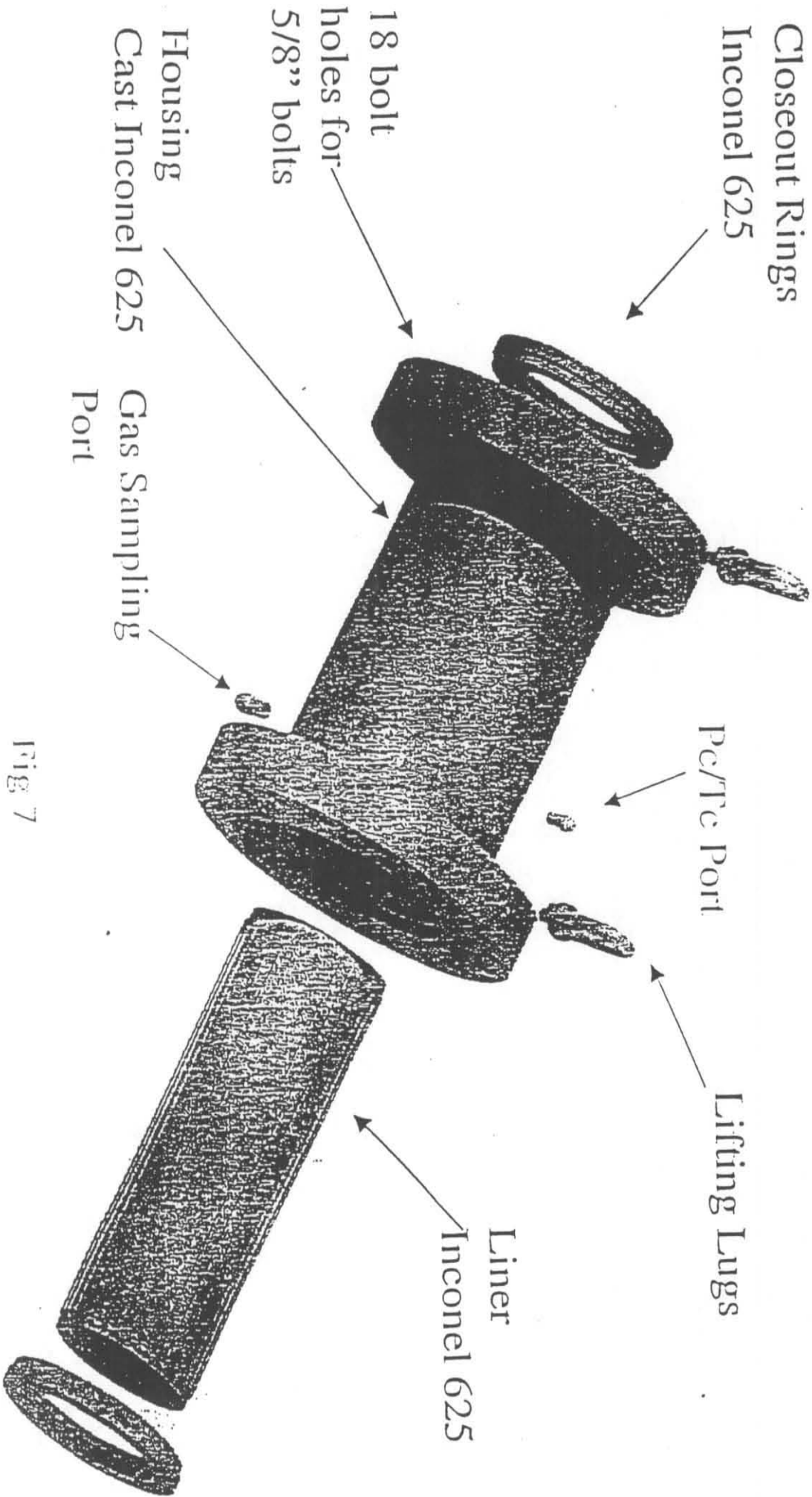


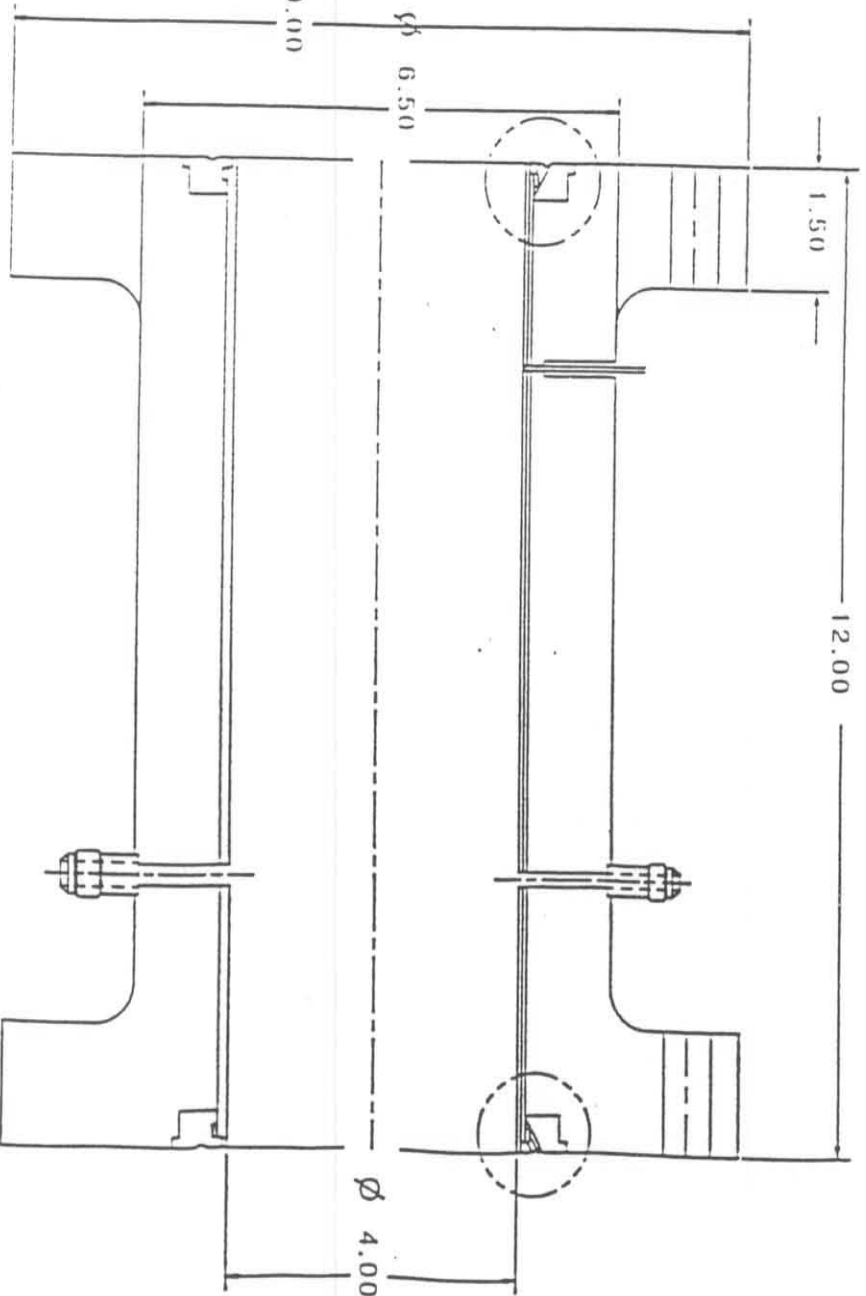
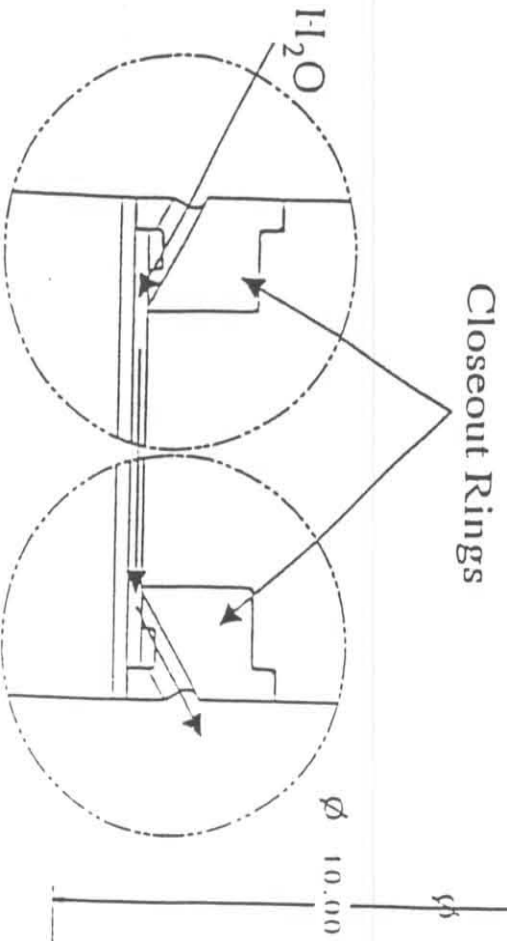
Fig 7



Clean
Energy
Systems

CES Proprietary
Cool Down Chamber CX

- Liner Brazed into Housing
- Close out rings brazed on both ends
- Gas probe port and Pc/Tc port welded onto housing



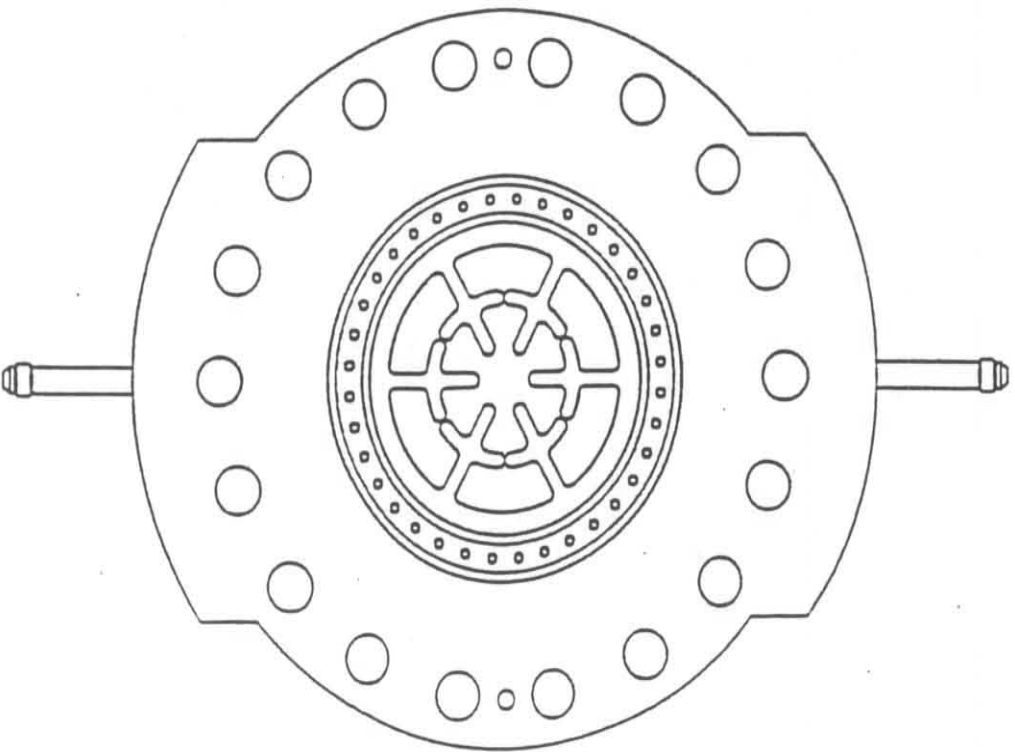
Do Not Duplicate
Fig 8



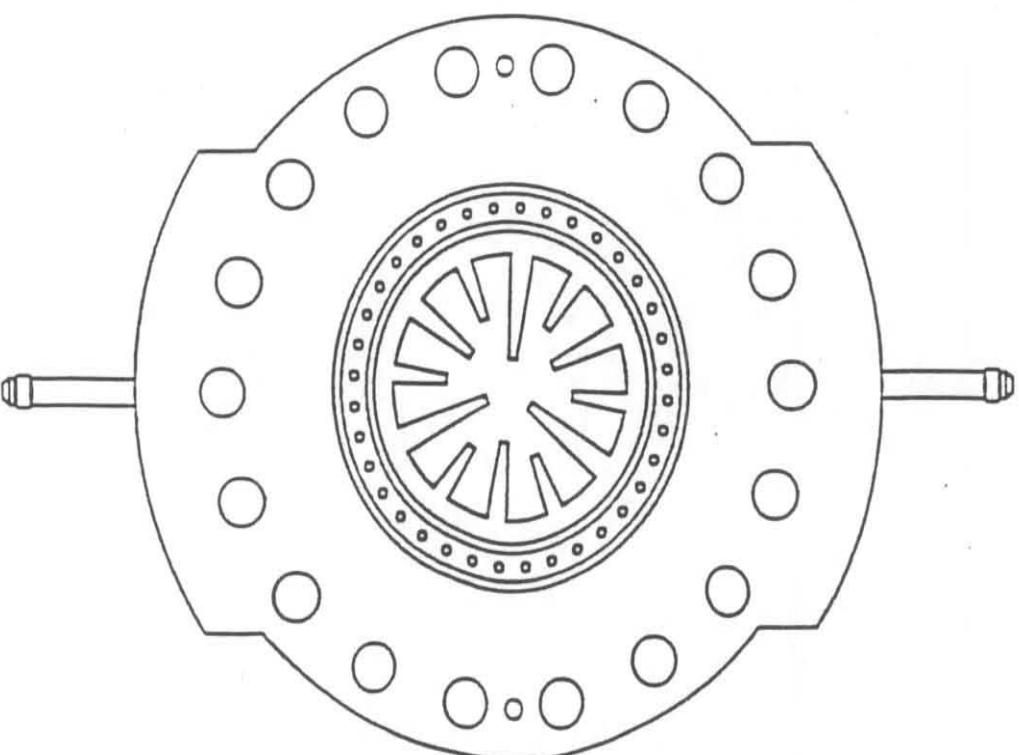
Clean
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Diluent Injector Detail



- Two Injector Injection Patterns Are Being Considered.
- The 0.2 in Wide Rim and Spokes Obstruct About 40 % of the Flow Area
- Injector Thickness Is .5"
- Two 3/8" Inlet Lines



Do Not Duplicate

Fig 9



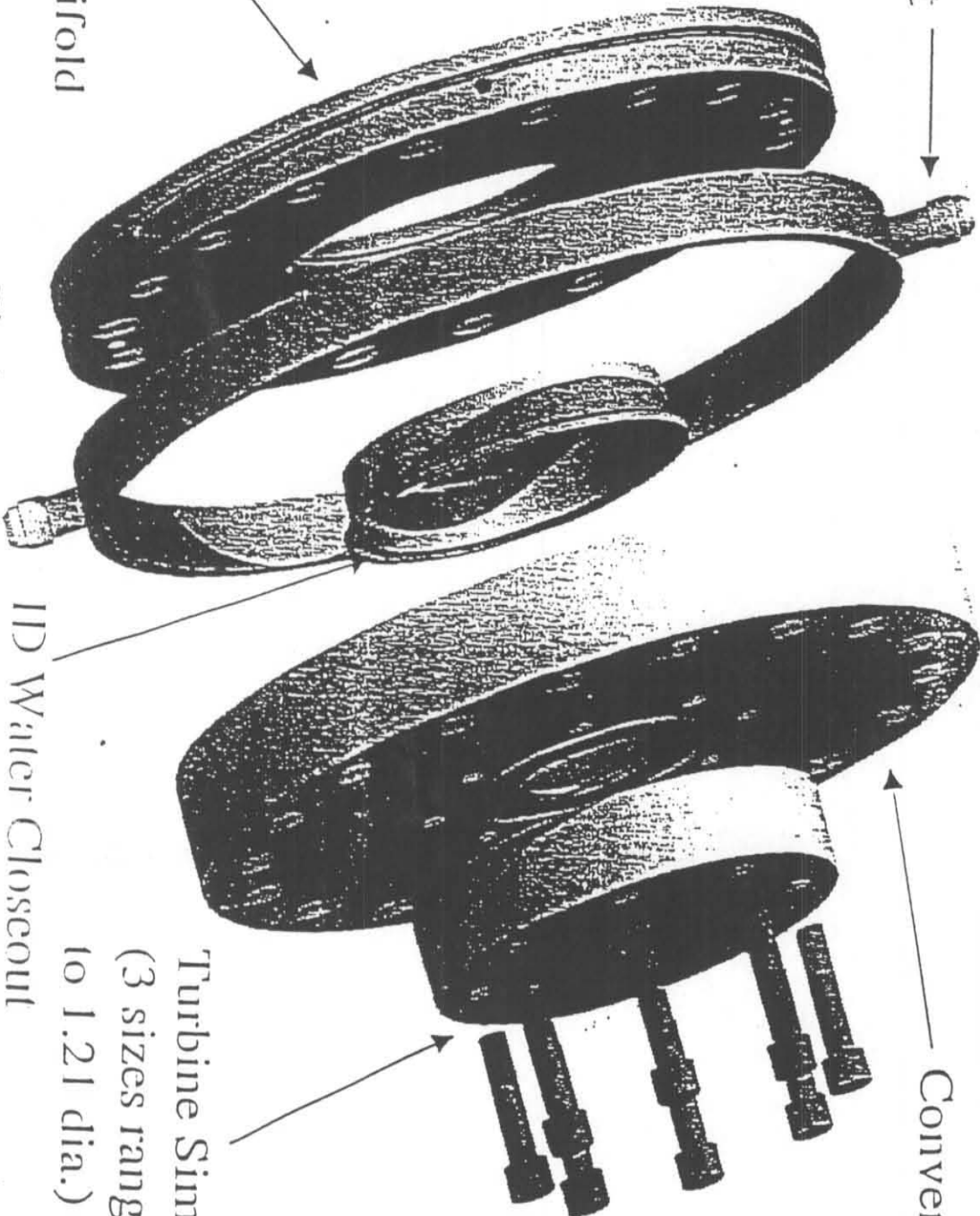
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**Turbine Back Pressure
Simulator Detail**

Manifold Inlet →

→ Convergent Section

Distribution Manifold



Turbine Simulator Orifice
(3 sizes ranging from 1.03
to 1.21 dia.)

1/2" ID Water Closesout

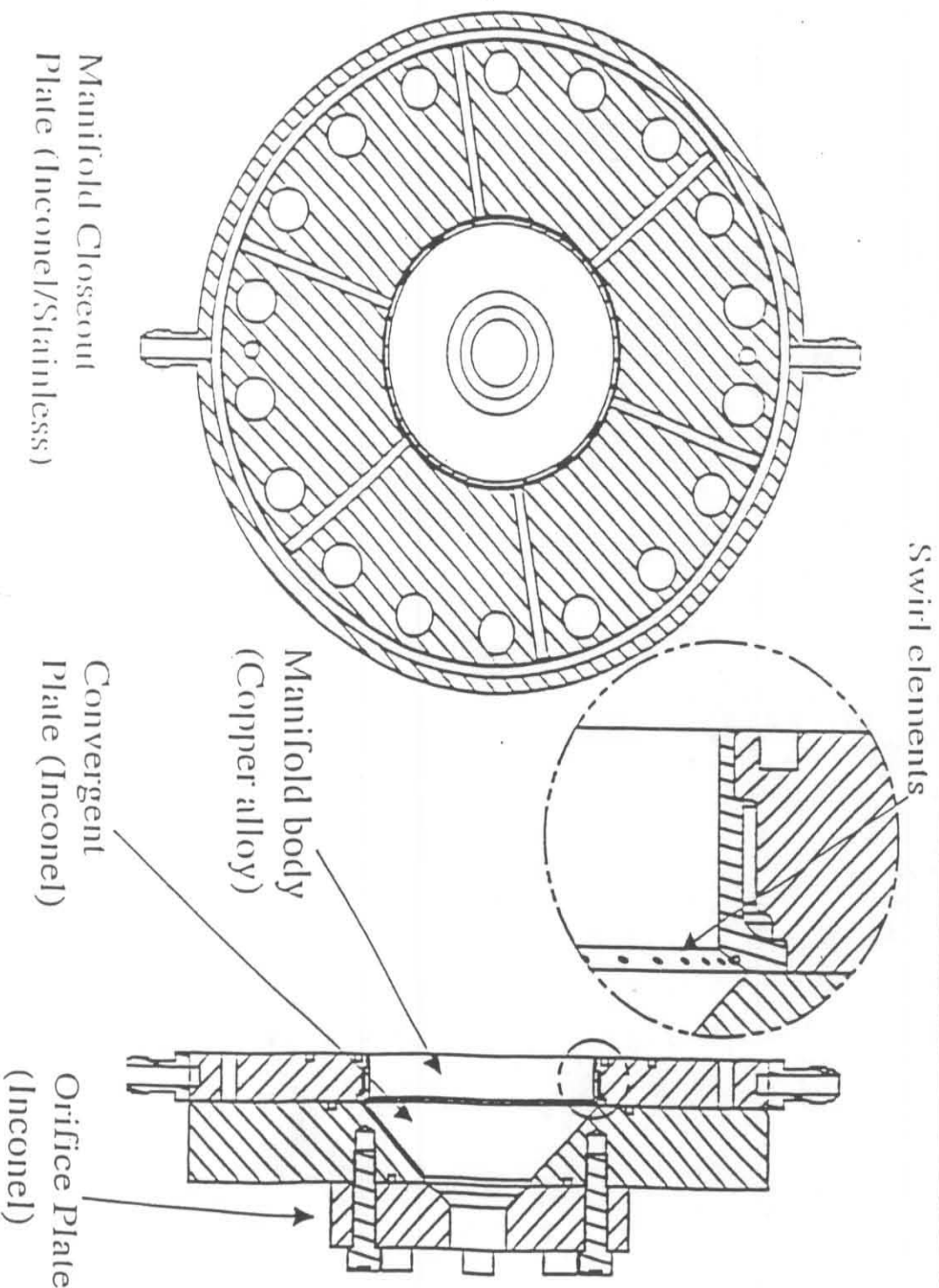
Fig. 10



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**Turbine Back Pressure
Simulator CX**

- Manifold body feeds interior annulus
- Convergent section cooled by 60 .026" dia swirl elements
- Final orifice size built into a replaceable disk.



Manifold Closeout
Plate (Inconel/Stainless)

Do Not Duplicate

Fig 11

UNCOOLED COMBUSTION CHAMBER INSTRUMENTATION LOCATIONS

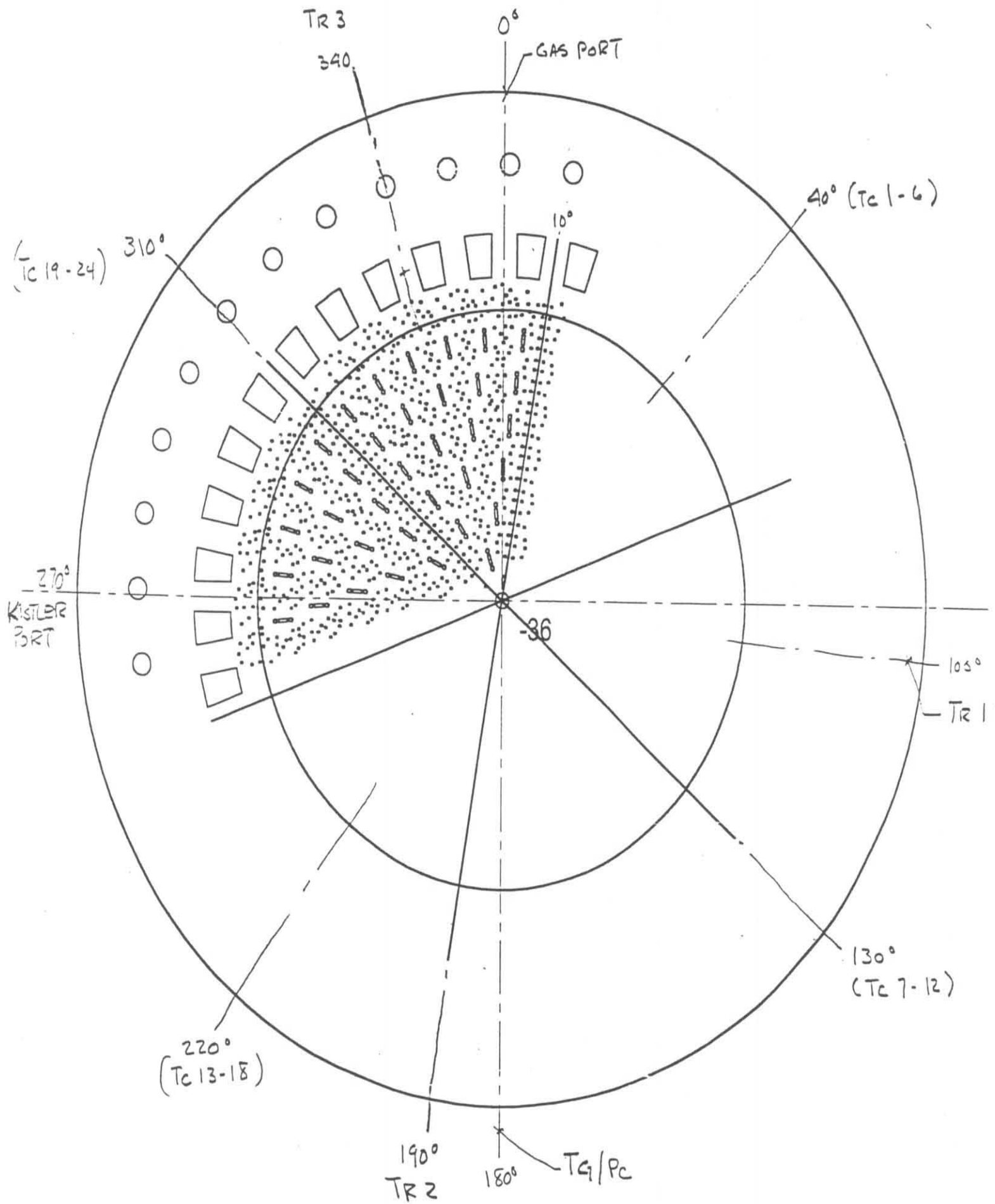


FIGURE 12