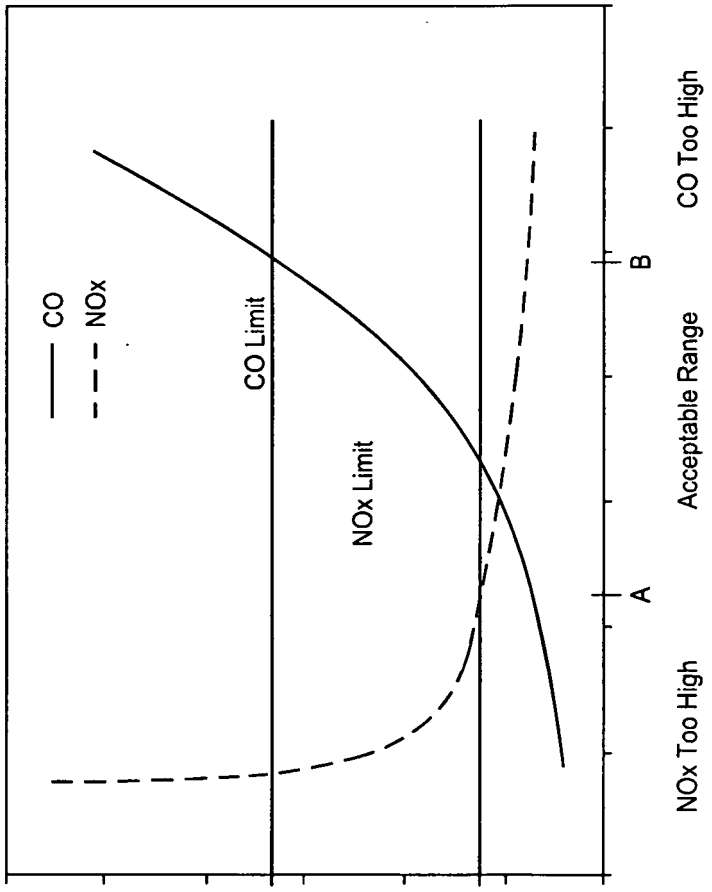
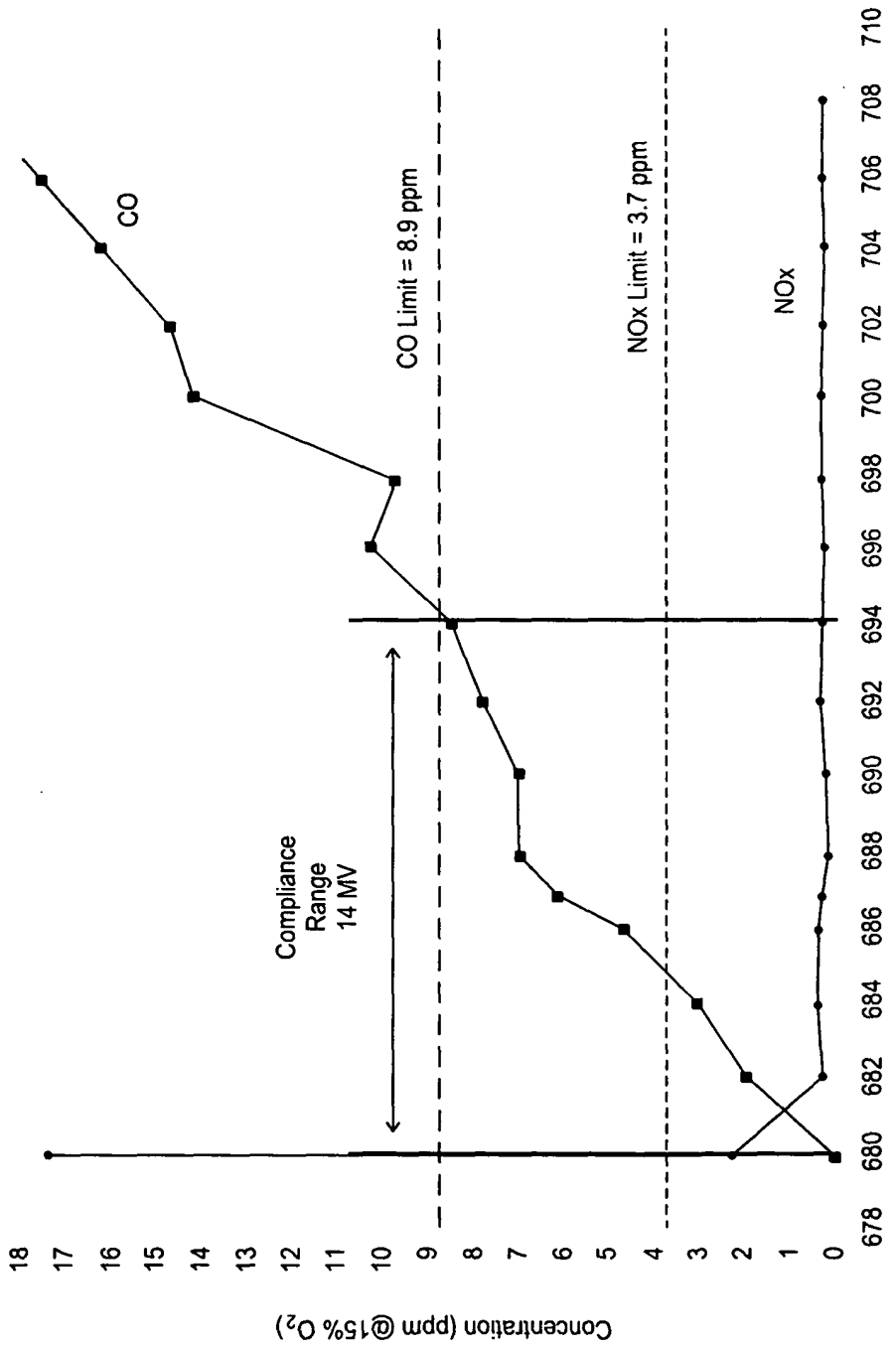



FIG. 1
(PRIOR ART)




1/AFR as Measured by Output of Automotive-Style Oxygen Sensor in Exhuast Flow Duct Upstream of Catalyst After Treatment (millivolts). Higher Values Indicate Richer Mixtures.

FIG. 2
(PRIOR ART)

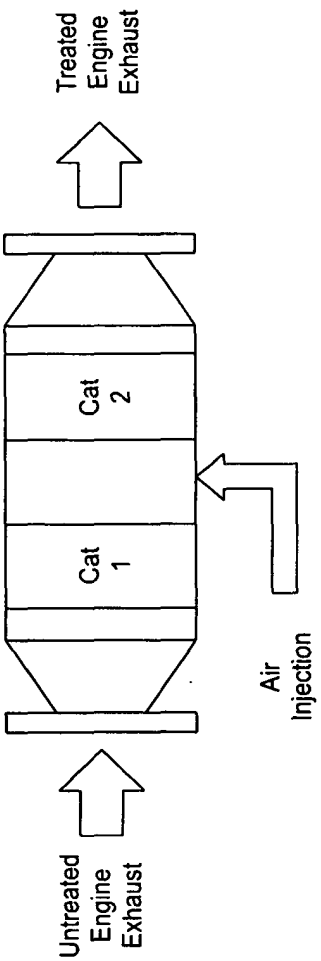



FIG. 3
(PRIOR ART)

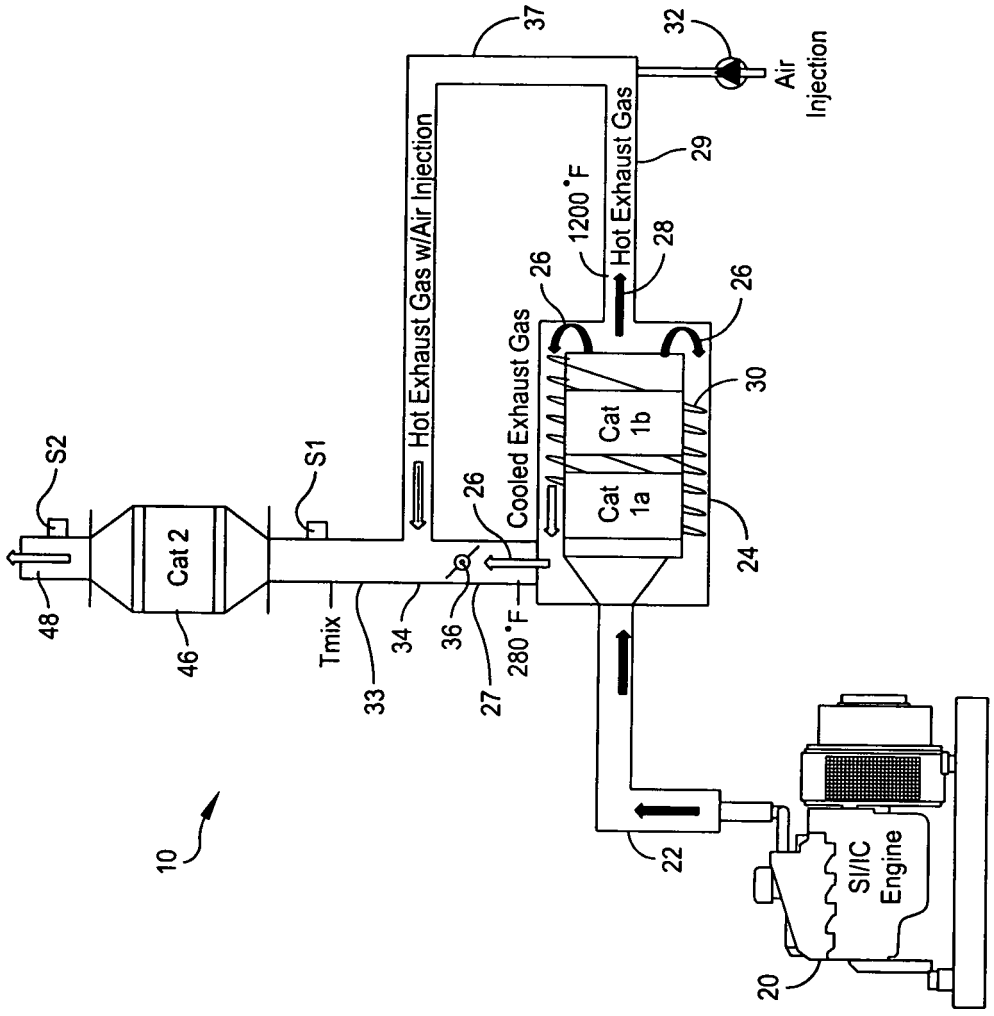

37
32
Air Injection
Hot Exhaust Gas w/Air Injection
29
1200 °F
Hot Exhaust Gas
28
26
26
Cooled Exhaust Gas
30
Cat 1b
Cat 1a
24
S2
S1
26
Cat 2
48
46
Tmix
33
34
36
27
280 °F
22
SI/IC Engine
20
10

FIG. 4

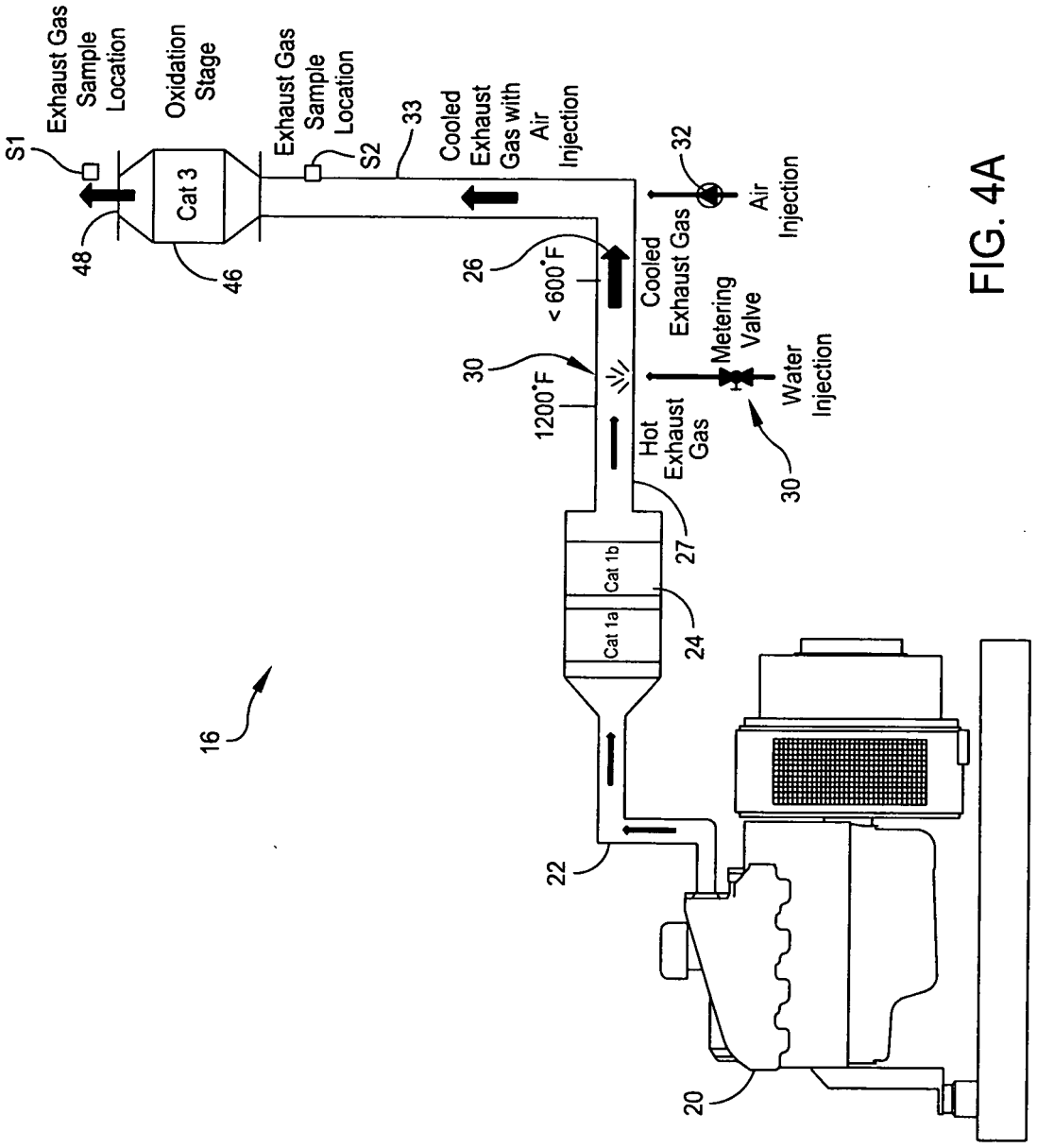

S1
Exhaust Gas Sample Location
Oxidation Stage
Cat 3
Exhaust Gas Sample Location
S2
33
Cooled Exhaust Gas with Air Injection
32
Air Injection
48
46
26
< 600°F
Cooled Exhaust Gas
Metering Valve
Water Injection
30
1200°F
Hot Exhaust Gas
30
27
Cat 1b
Cat 1a
24
16
22
20

FIG. 4A

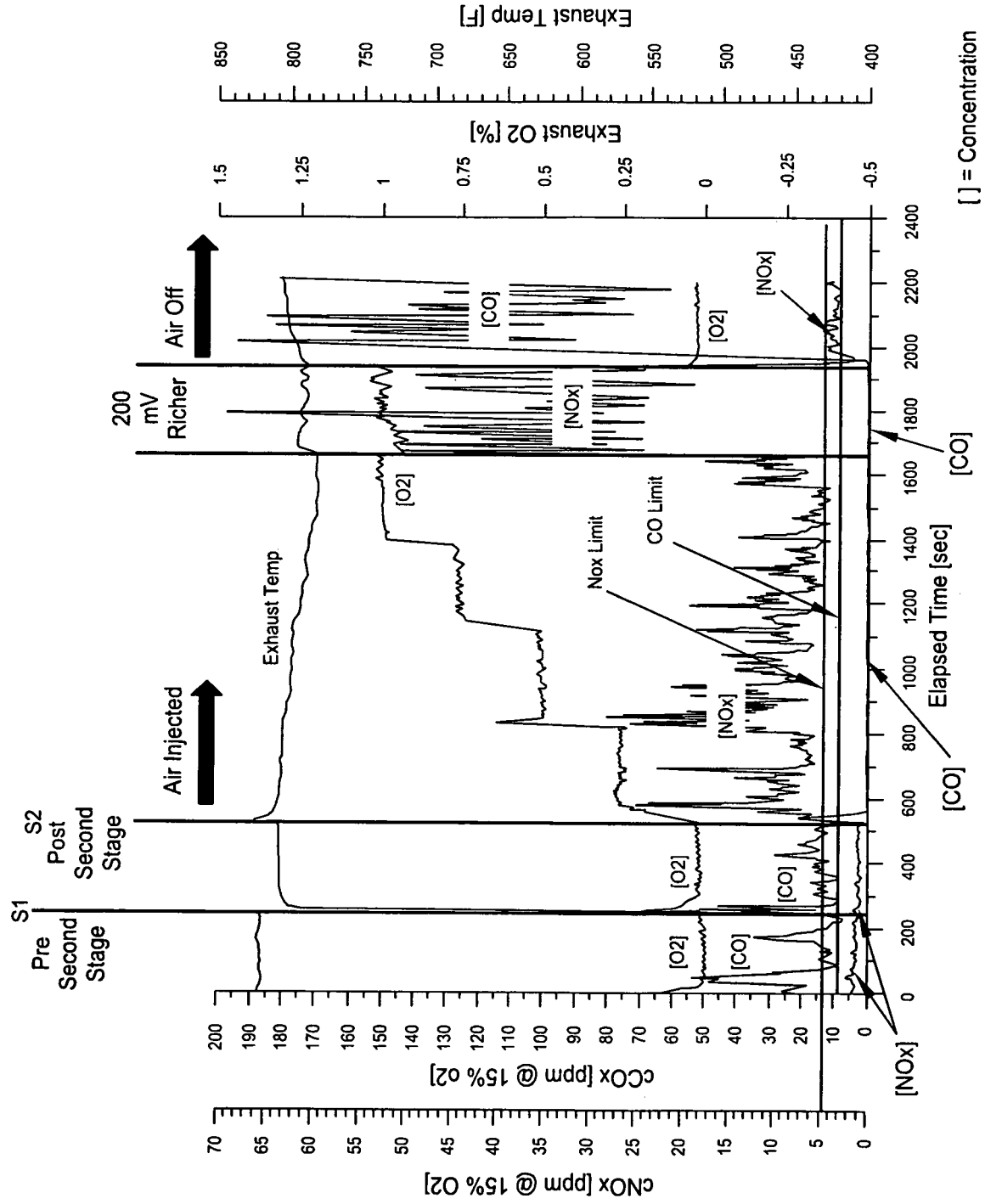

cNOx [ppm @ 15% O2]
cCOx [ppm @ 15% o2]
Exhaust Temp [F]
Exhaust O2 [%]
Elapsed Time [sec]
[ ] = Concentration
S1
Pre Second Stage
S2
Post Second Stage
Air Injected
Air Off
200 mV Richer
Exhaust Temp
Nox Limit
CO Limit
[NOx]
[CO]
[O2]

FIG. 5

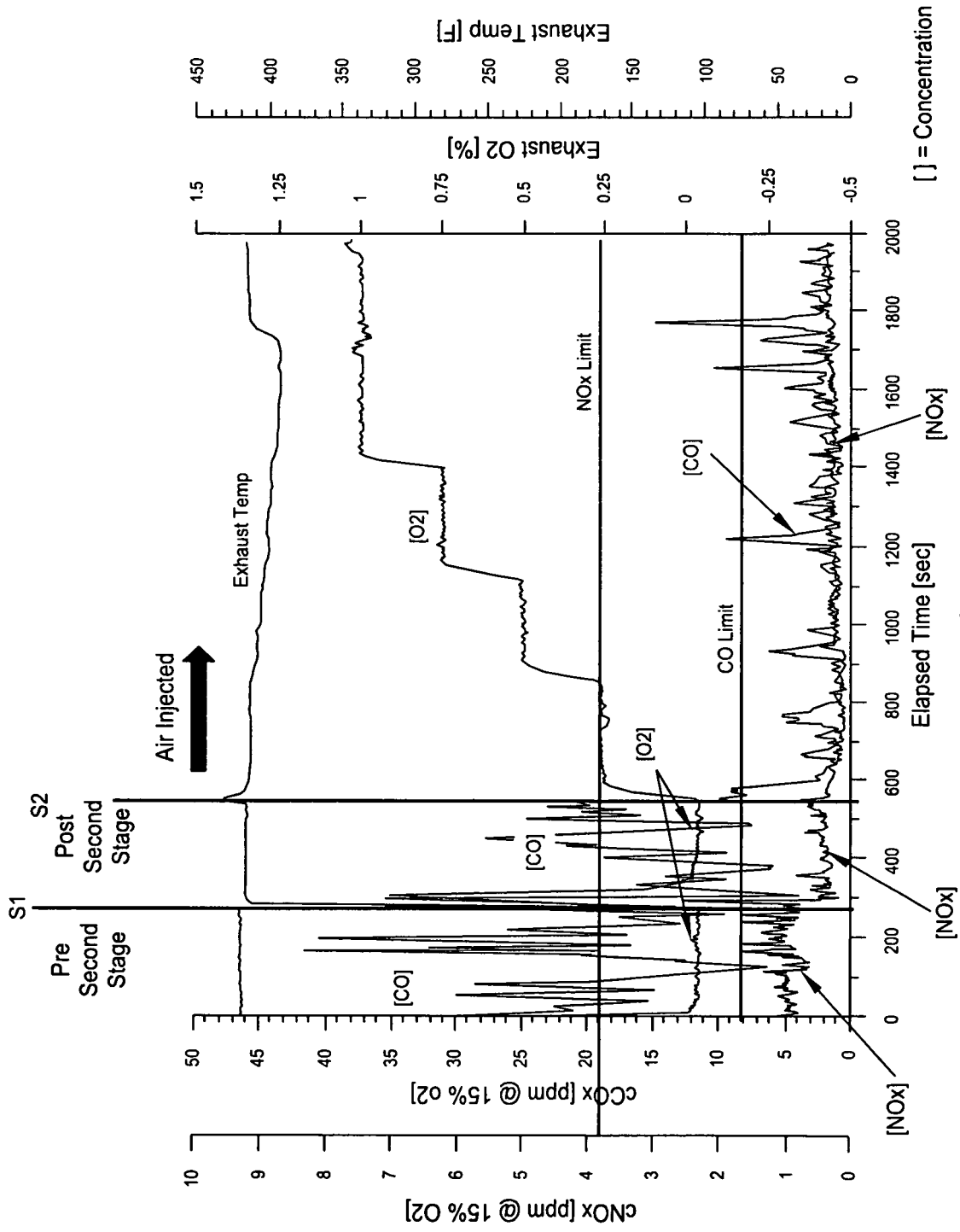

cNOx [ppm @ 15% o2]
cCOx [ppm @ 15% o2]
Exhaust O2 [%]
Exhaust Temp [F]
[ ] = Concentration
Elapsed Time [sec]
Exhaust Temp
[O2]
[CO]
[NOx]
NOx Limit
CO Limit
Air Injected
S1
Pre Second Stage
S2
Post Second Stage

FIG. 6

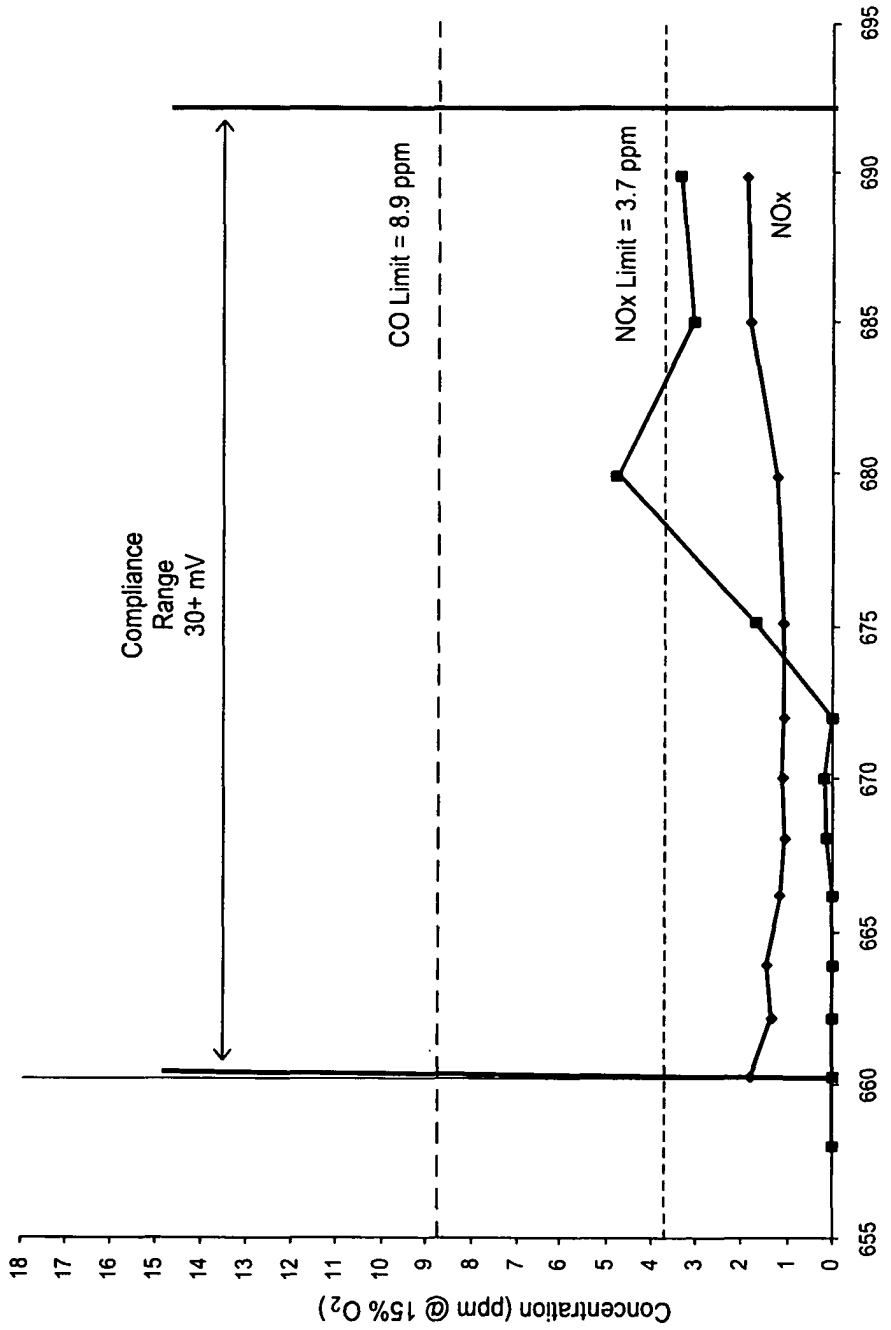

Concentration (ppm @ 15% $O_2$)
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
655
660
665
670
675
680
685
690
695
Compliance Range 30+ mV
CO Limit = 8.9 ppm
NOx Limit = 3.7 ppm
NOx
1/AFR as Measured by Output of Automotive-Style Oxygen Sensor in Exhaust Flow Duct Upstream of First Catalyst Stage (millivolts). Higher Values indicate Richer Mixtures.

FIG. 7

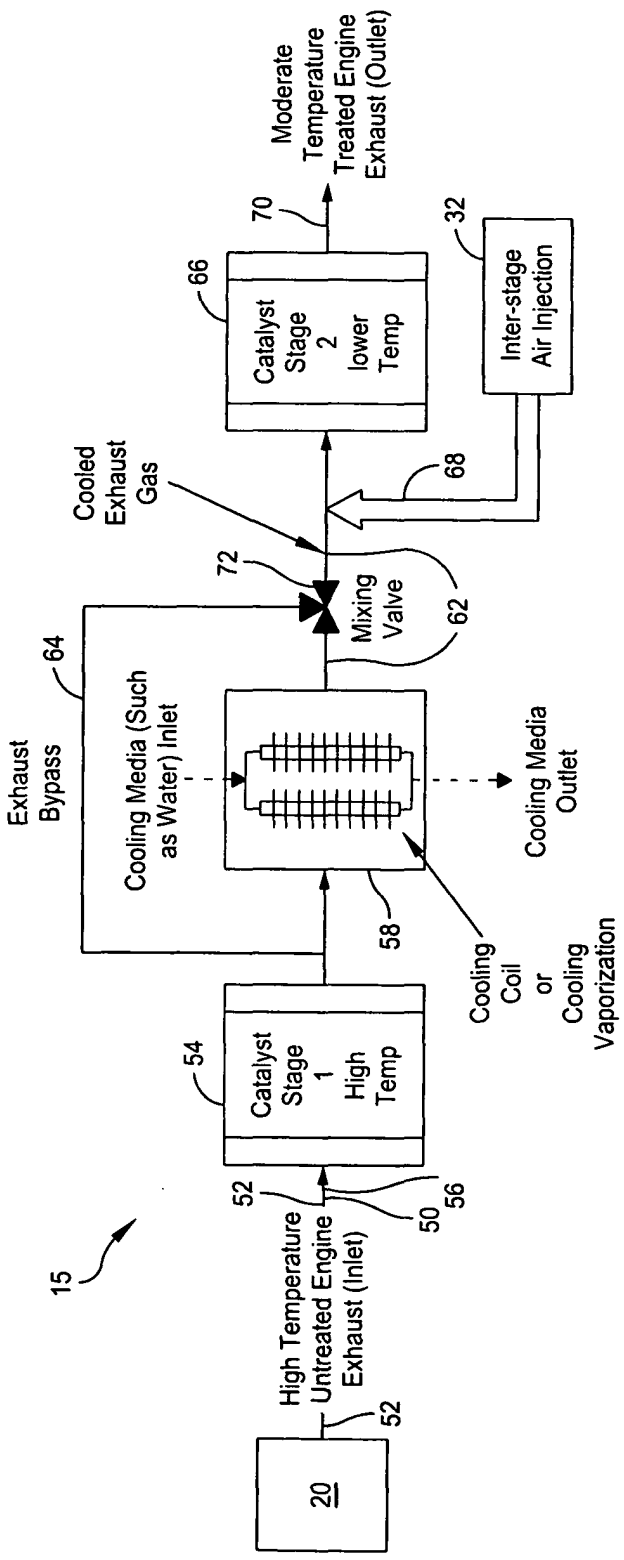

15
20
High Temperature Untreated Engine Exhaust (Inlet)
52
Catalyst Stage 1 High Temp
54
Catalyst Stage 2 lower Temp
66
Moderate Temperature Treated Engine Exhaust (Outlet)
70
Inter-stage Air Injection
32
Cooled Exhaust Gas
Mixing Valve
72
62
68
Exhaust Bypass
64
Cooling Media (Such as Water) Inlet
Cooling Media Outlet
Cooling Coil or Cooling Vaporization
58
50
56

FIG. 8

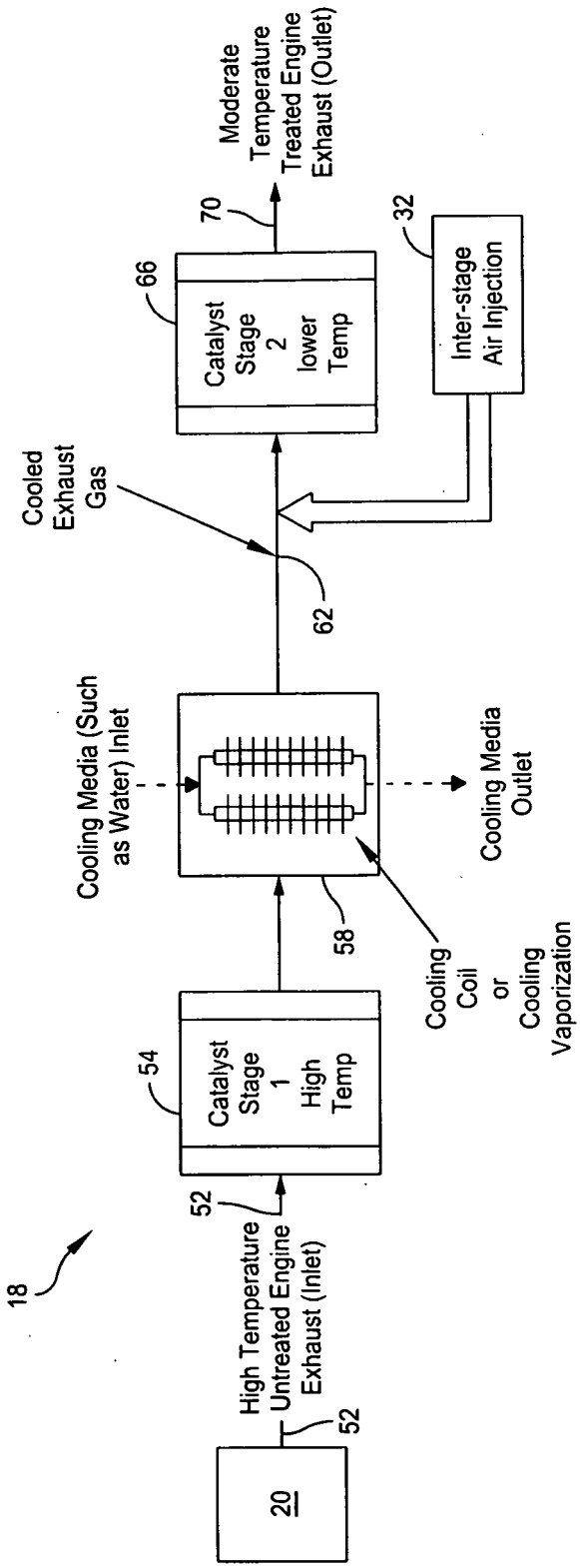

18
20
High Temperature Untreated Engine Exhaust (Inlet)
52
52
Catalyst Stage 1 High Temp
54
58
Cooling Coil or Cooling Vaporization
Cooling Media (Such as Water) Inlet
Cooling Media Outlet
Cooled Exhaust Gas
62
Catalyst Stage 2 lower Temp
66
Inter-stage Air Injection
32
70
Moderate Temperature Treated Engine Exhaust (Outlet)

FIG. 8A