

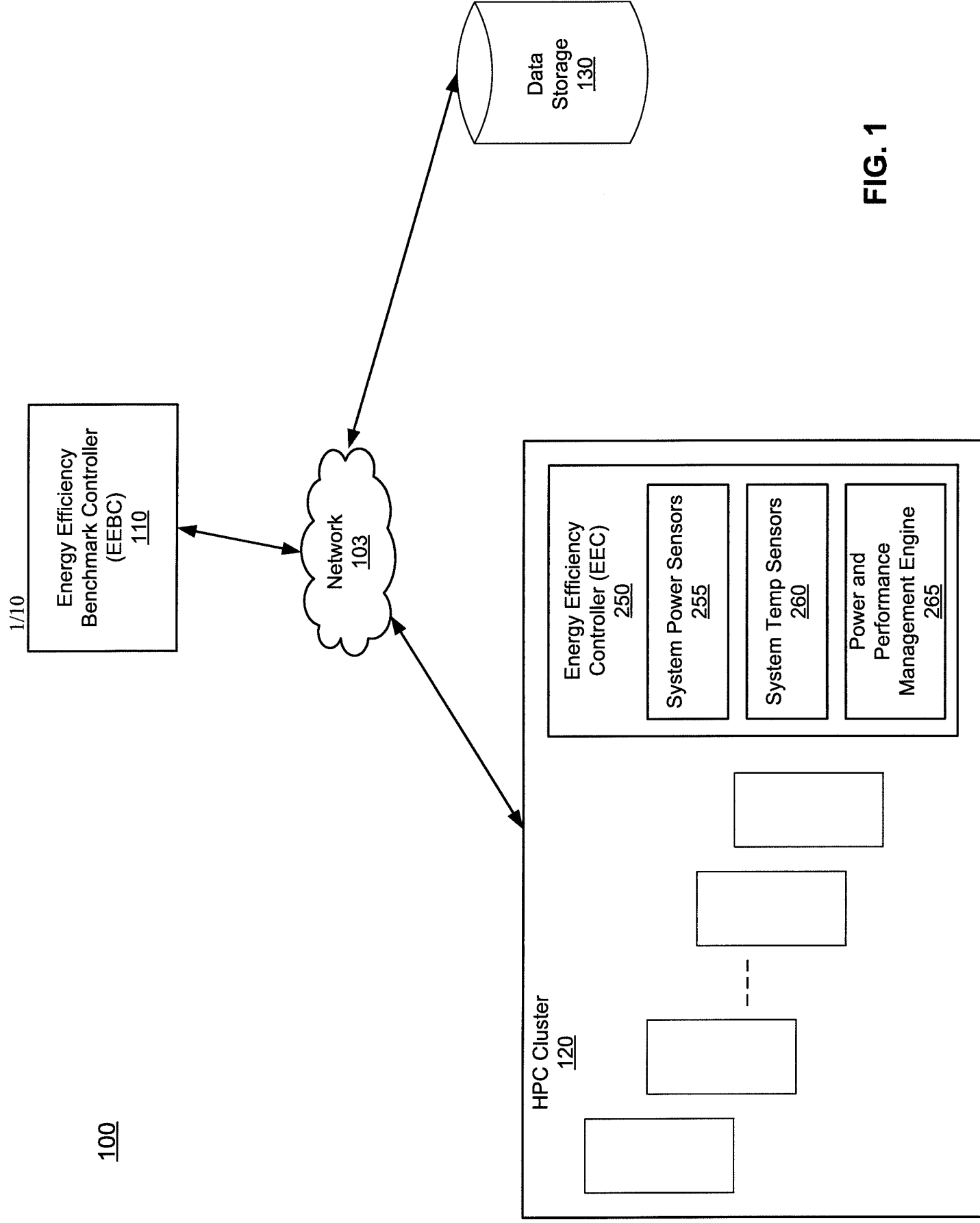


FIG. 1

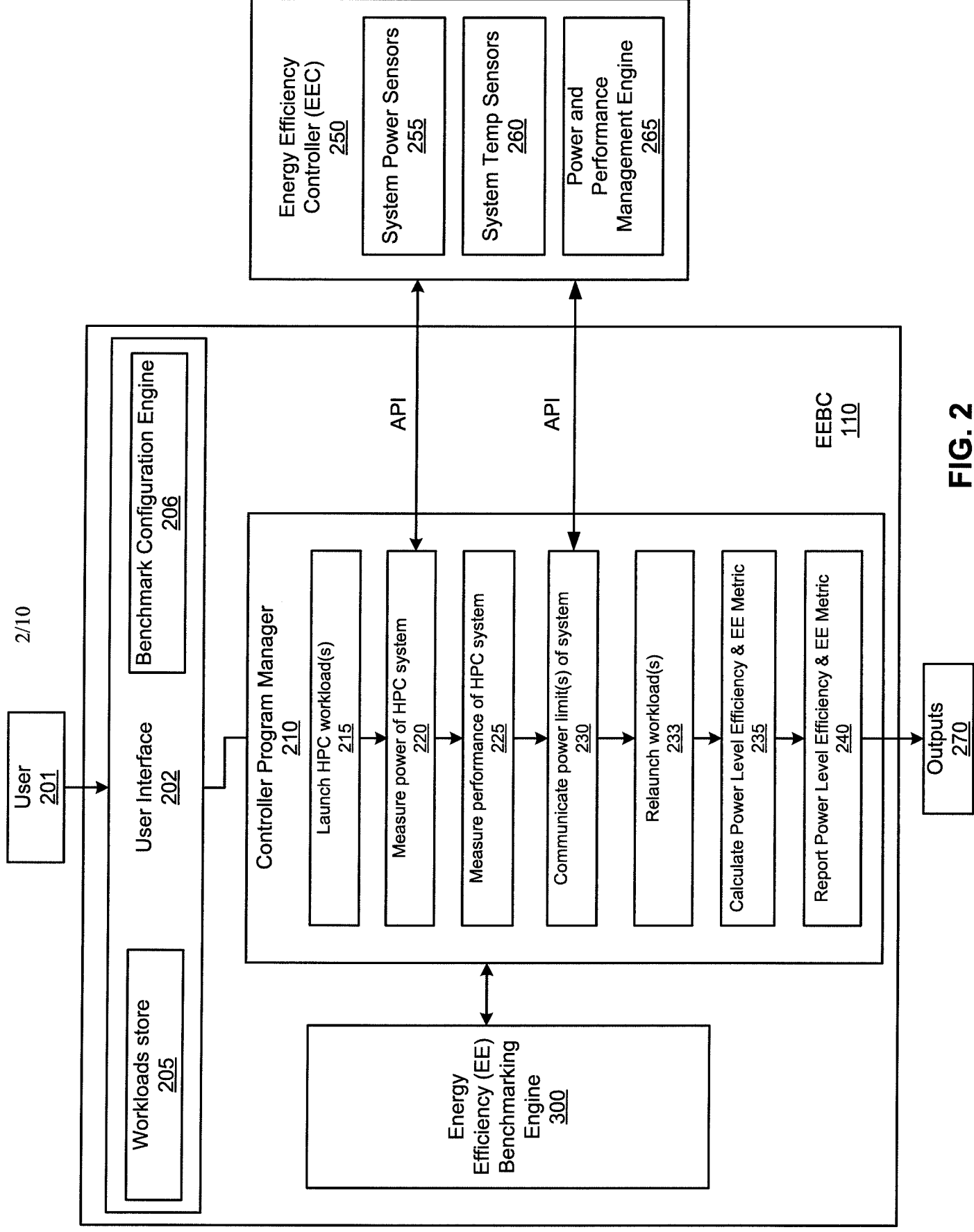


FIG. 2

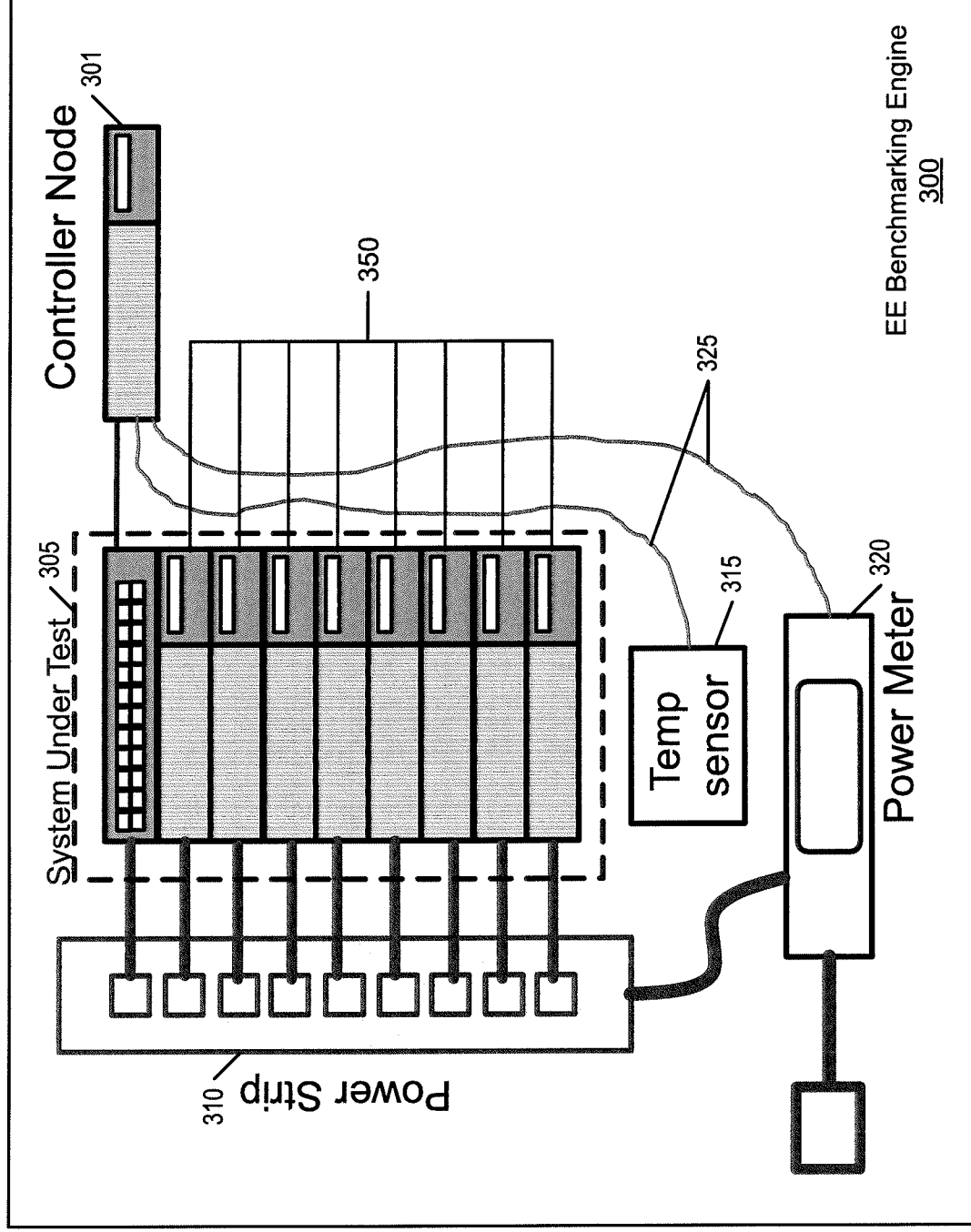


FIG. 3

400

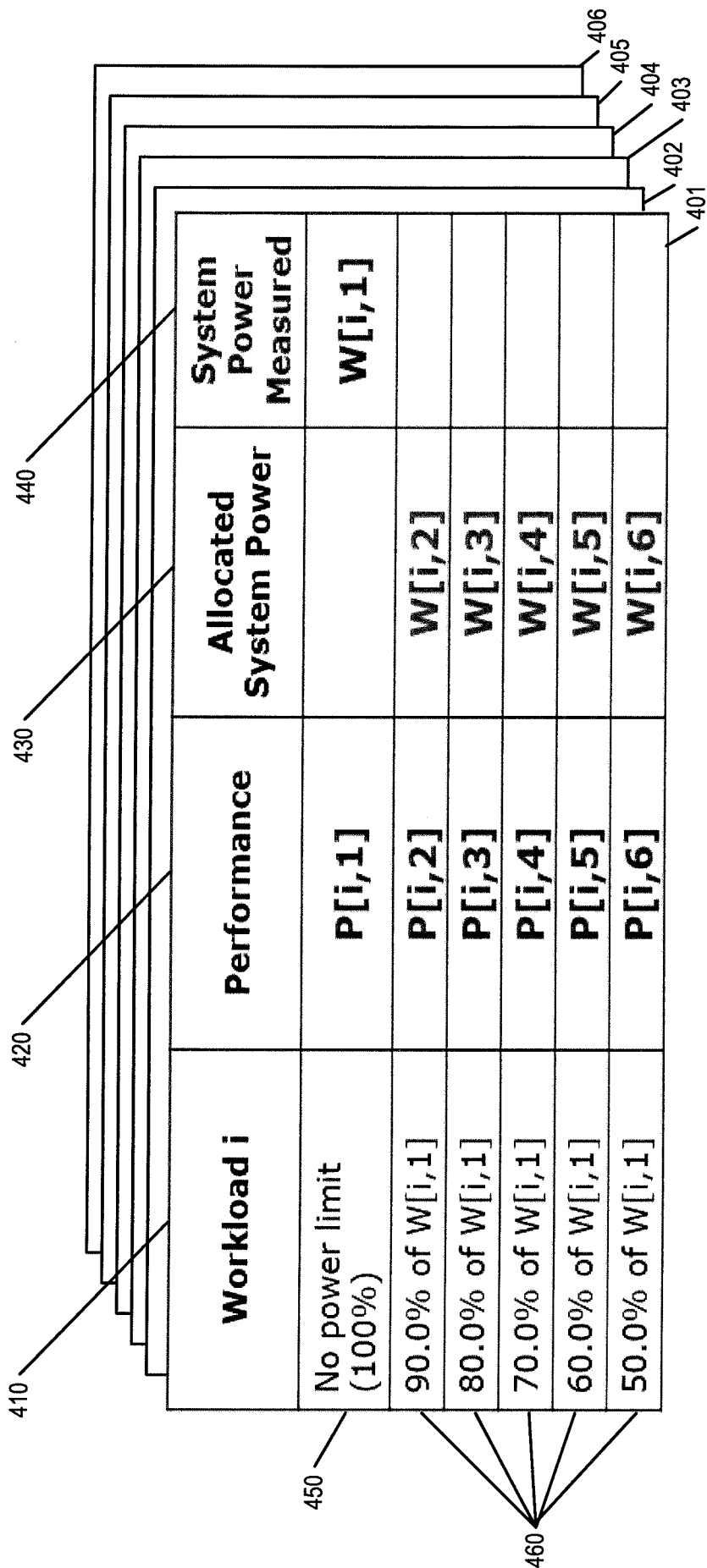
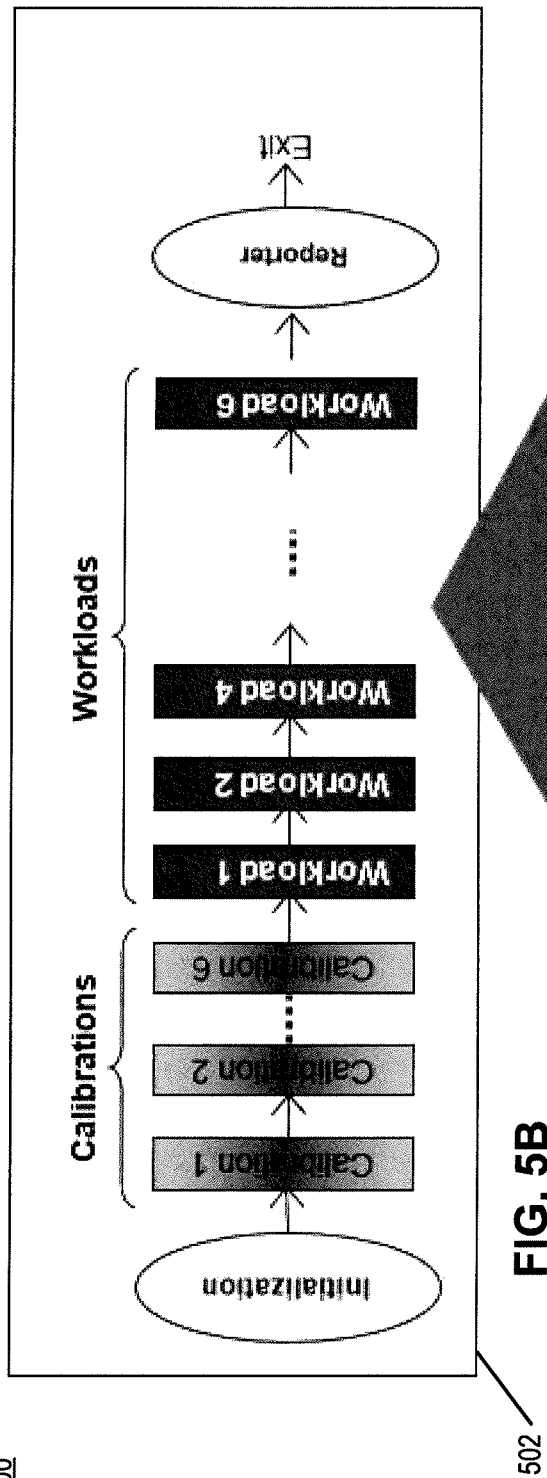
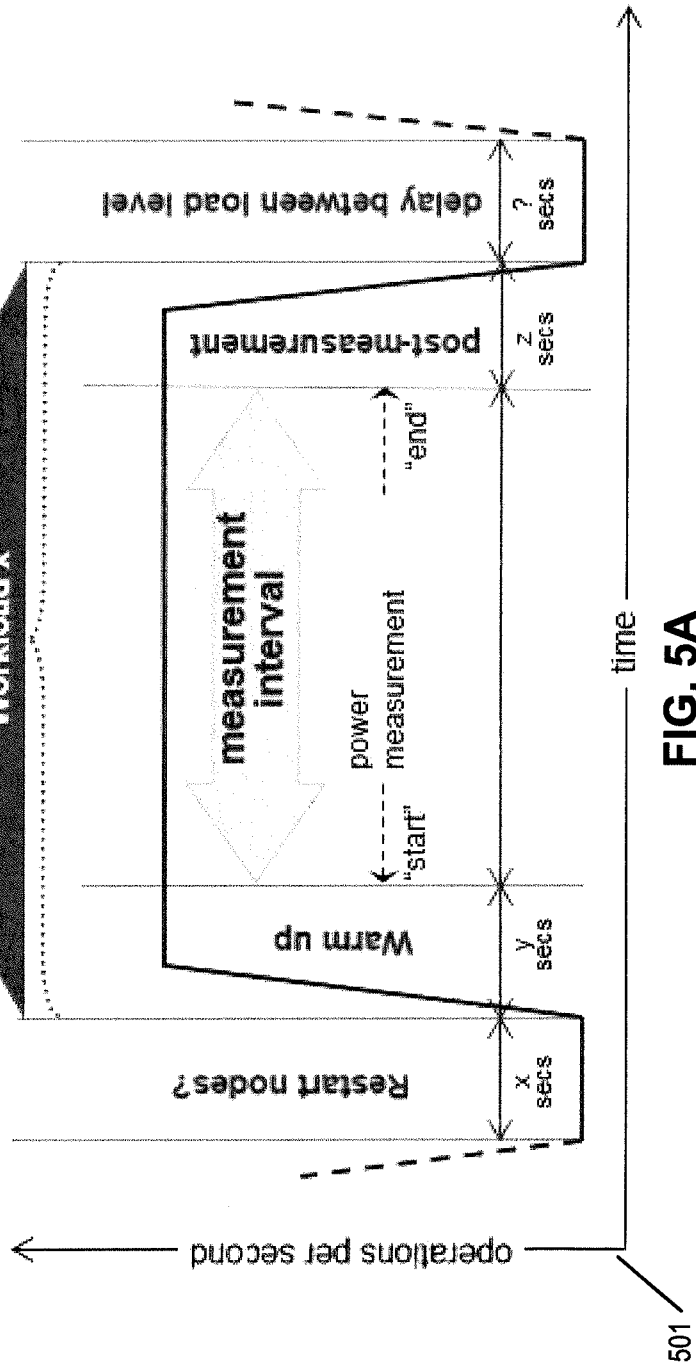


FIG. 4

500



501

HPL (i=1)		Cluster power	Performance	Perf/watt	Normalized Perf/watt
System Under Test		W(1,j)	P(1,j)	P(1,j)/W(1,j)	S(1,j)
100% no power limit (j=1)		3250	7930	2.44	1.08
90% (j=2)		2925	7200	2.46	1.09
80% (j=3)		2600	6740	2.59	1.15
70% (j=4)		2275	5390	2.37	1.05
60% (j=5)		1950	4360	2.24	0.99
50% (j=6)		1625	2800	1.72	0.76
Worldload efficiency				E(i) -->	1.01

UMT (i=4)		Cluster power	Performance	Perf/watt	Normalized Perf/watt
		W(4,j)	P(4,j)	P(4,j)/W(4,j)	S(4,j)
100% (j=1)		3000	21.4	0.01	0.93
90% (j=2)		2700	19	0.01	0.92
80% (j=3)		2400	16.5	0.01	0.90
70% (j=4)		2100	15	0.01	0.93
60% (j=5)		1800	12.6	0.01	0.92
50% (j=6)		1500	10	0.01	0.87
				E(i) -->	0.91

HPCG (i=2)		Cluster power	Performance	Perf/watt	Normalized Perf/watt
		W(2,j)	P(2,j)	P(2,j)/W(2,j)	S(2,j)
100% (j=1)		3000	1300	0.43	1.01
90% (j=2)		2700	1130	0.42	0.97
80% (j=3)		2400	1005	0.42	0.98
70% (j=4)		2100	850	0.40	0.94
60% (j=5)		1800	720	0.40	0.93
50% (j=6)		1500	600	0.40	0.93
				E(i) -->	0.96

MiniGhost (i=3)		Cluster power	Performance	Perf/watt	Normalized Perf/watt
		W(3,j)	P(3,j)	P(3,j)/W(3,j)	S(3,j)
100% (j=1)		3300	8.54E+03	2.59	0.98
90% (j=2)		2970	8.20E+03	2.76	1.05
80% (j=3)		2640	7.50E+03	2.84	1.08
70% (j=4)		2310	5.70E+03	2.47	0.93
60% (j=5)		1980	4.70E+03	2.37	0.90
50% (j=6)		1650	3.00E+03	1.82	0.69
				E(i) -->	0.93

Ptrans (i=5)		Cluster power	Performance	Perf/watt	Normalized Perf/watt
		W(5,j)	P(5,j)	P(5,j)/W(5,j)	S(5,j)
100% (j=1)		2100	20	0.01	1.00
90% (j=2)		1890	18	0.01	1.00
80% (j=3)		1680	16.4	0.01	1.03
70% (j=4)		1470	15	0.01	1.07
60% (j=5)		1260	13.4	0.01	1.12
50% (j=6)		1050	11	0.01	1.10
				E(i) -->	1.05

miniMD (i=6)		Cluster power	Performance	Perf/watt	Normalized Perf/watt
		W(6,j)	P(6,j)	P(6,j)/W(6,j)	S(6,j)
100% (j=1)		2100	105	0.05	1.05
90% (j=2)		1890	84	0.04	0.93
80% (j=3)		1680	72	0.04	0.90
70% (j=4)		1470	60	0.04	0.86
60% (j=5)		1260	47	0.04	0.78
50% (j=6)		1050	30	0.03	0.60
				E(i) -->	0.84

FIG. 6A

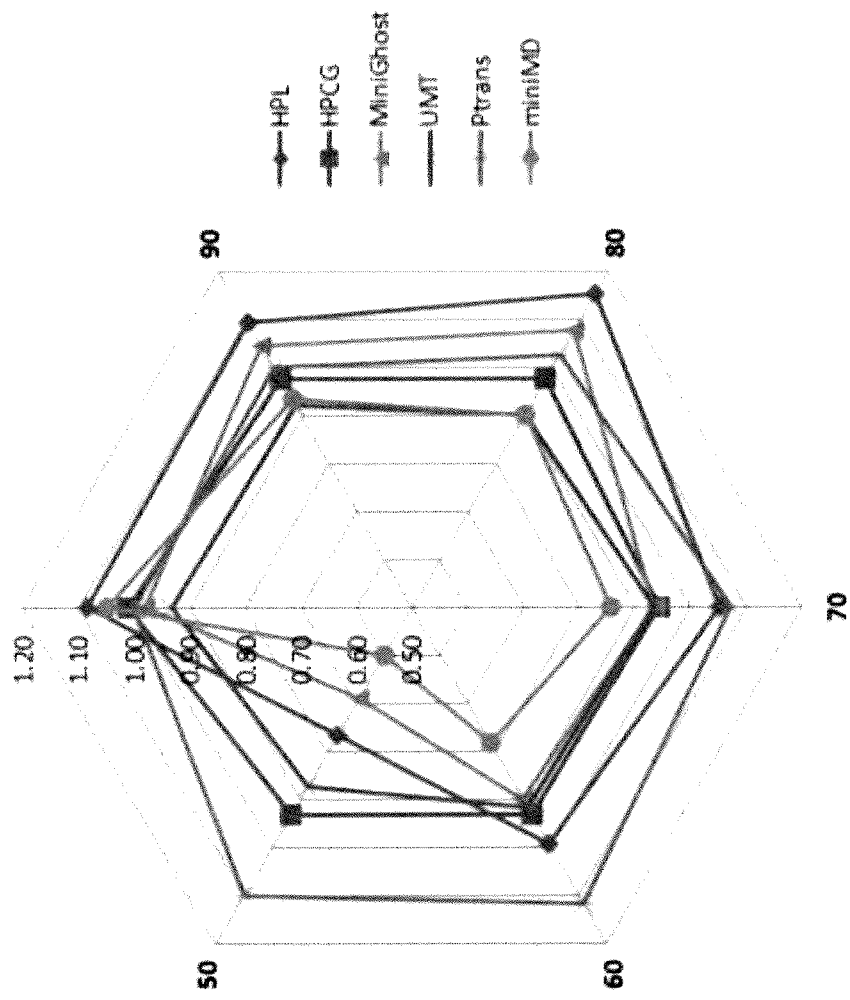


FIG. 6B

610

Energy Efficiency =	0.948715
Level Efficiency	
No power limit level =	1.008092
90% level =	0.992647
80% level =	1.000269
70% level =	0.962469
60% level =	0.934428
50% level =	0.809971

700

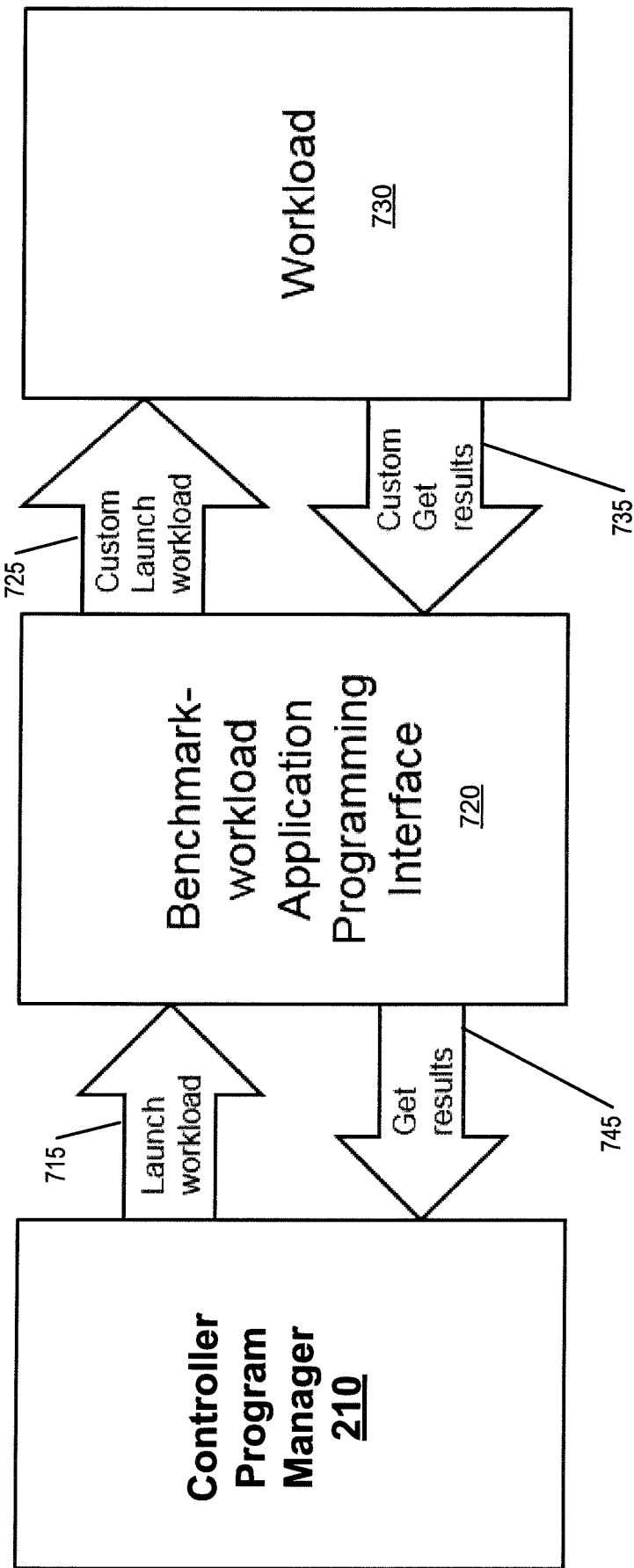


FIG. 7

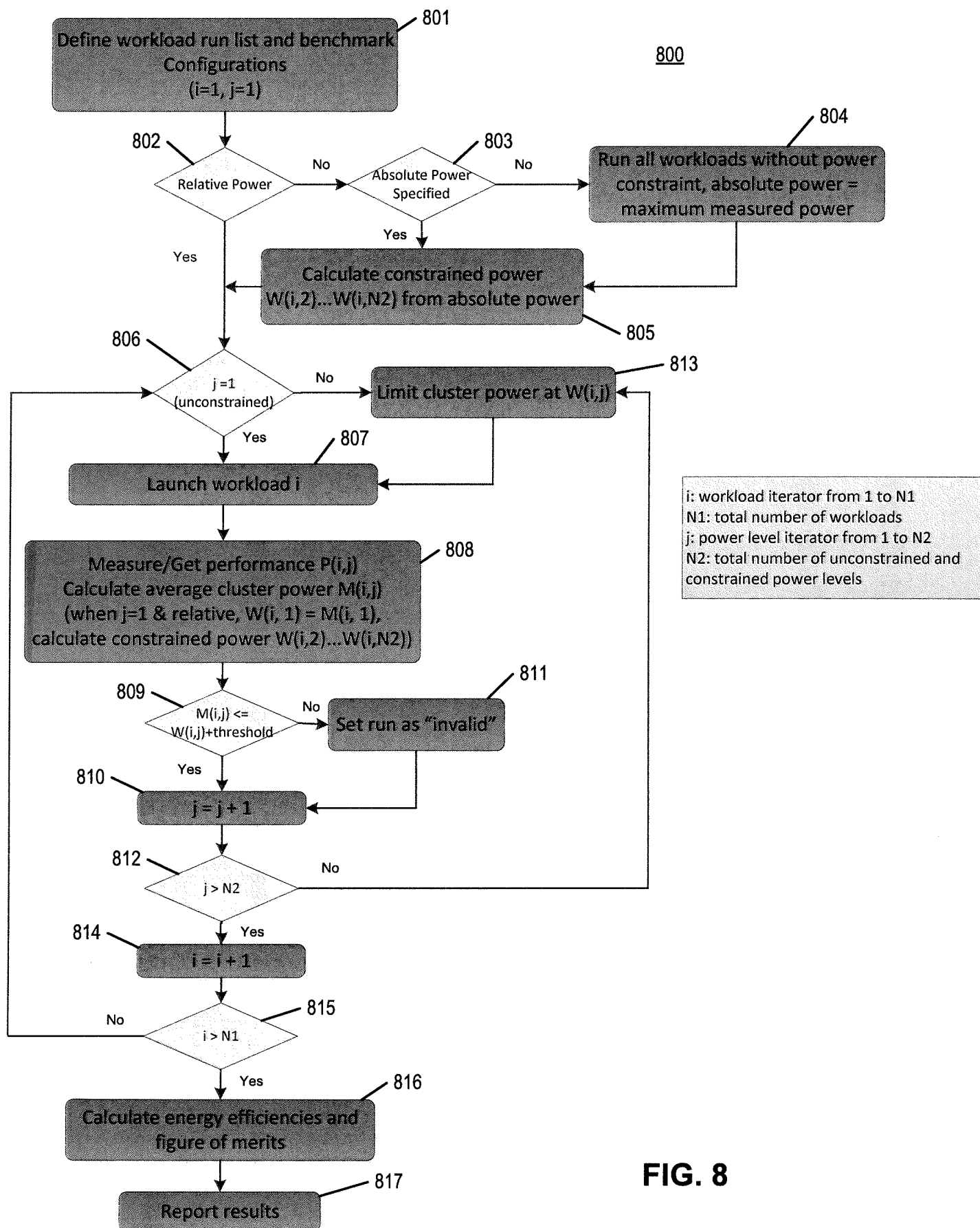
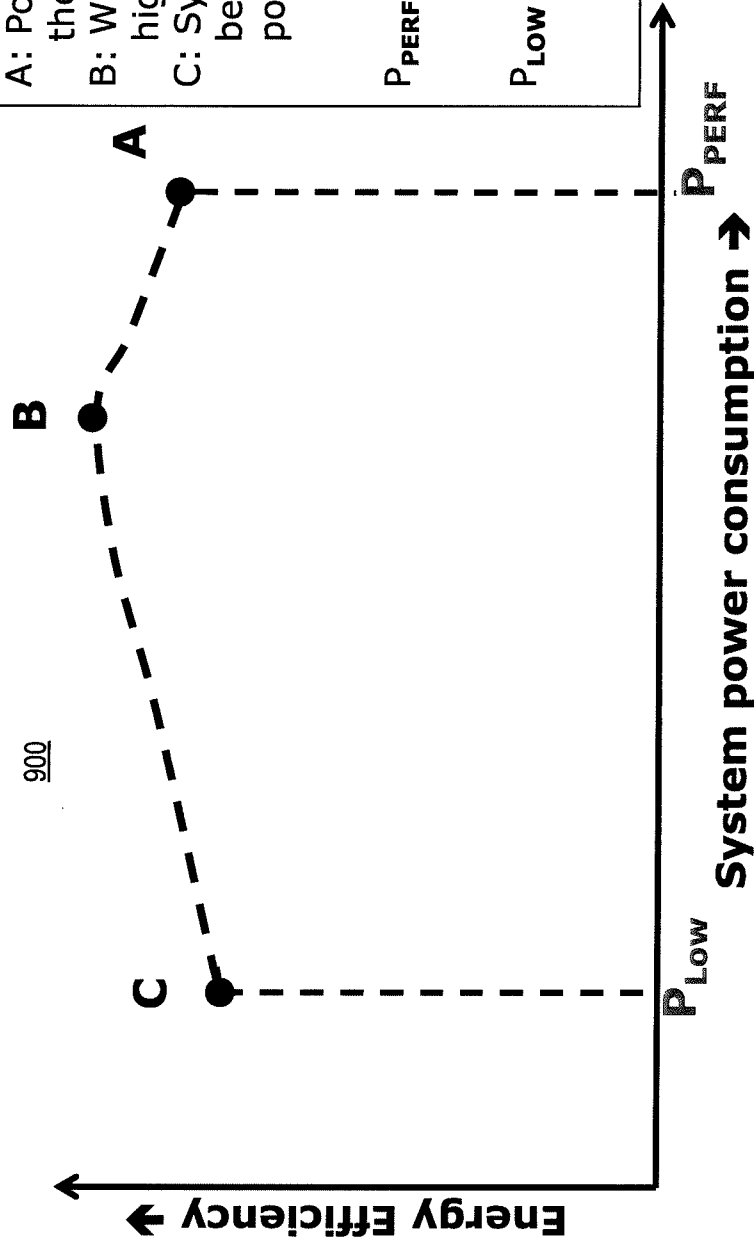


FIG. 8

EE Metric of workload over a range of power operations (EEM_{PO})

$(EEM_{PO}) = \text{Area defined by A-B-C-P}_{LOW}$ - P_{PERF}



System operating point

- A: Power when system delivers the highest performance
- B: When system has the highest energy efficiency
- C: System cannot operate below this point under a power cap

System power

- P_{PERF} : System power when delivers the highest performance
- P_{LOW} : The lowest power level a system can maintain a power limit

FIG. 9