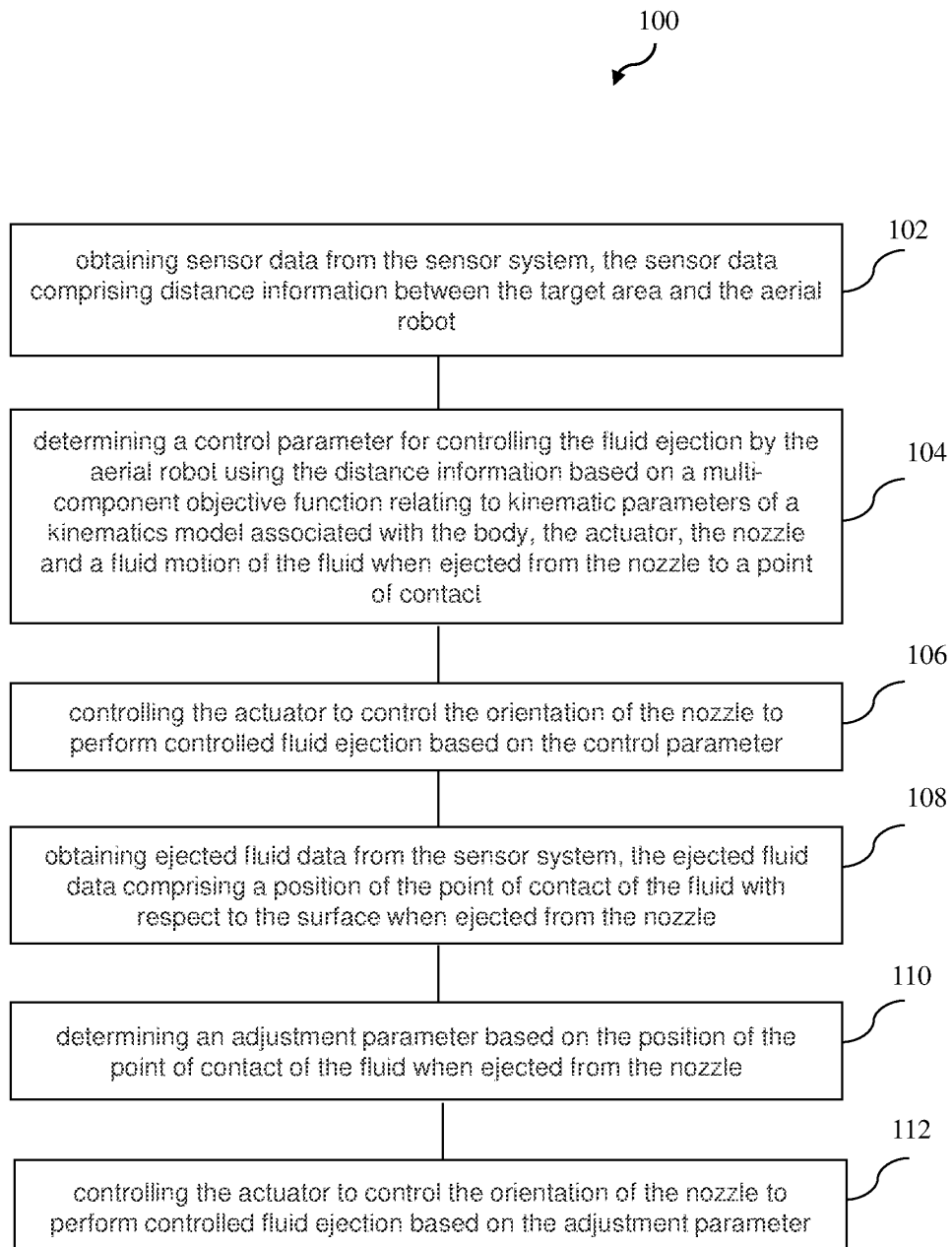
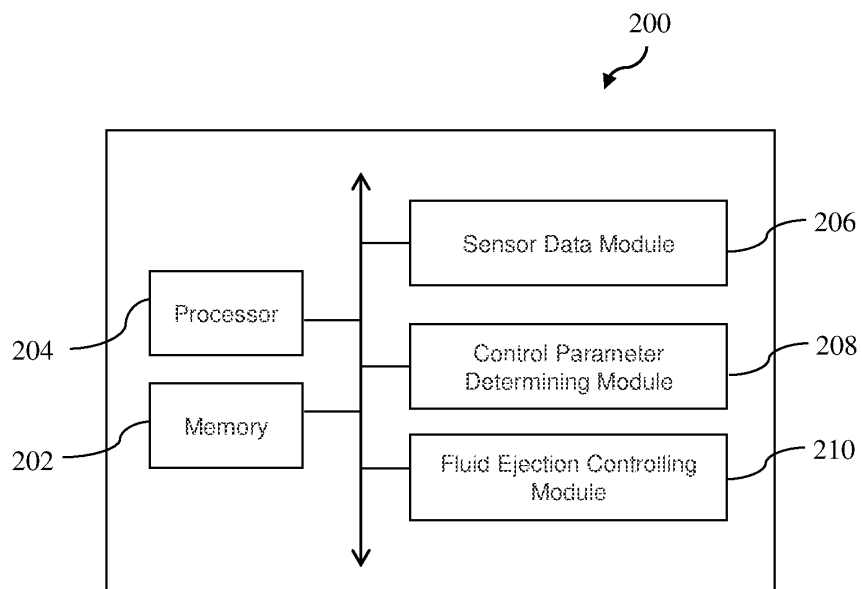
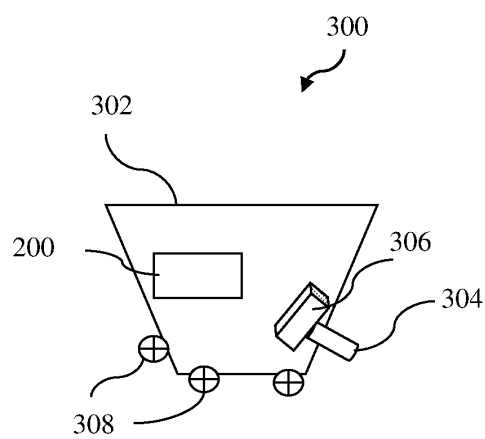


**FIG. 1**

**FIG. 2****FIG. 3**

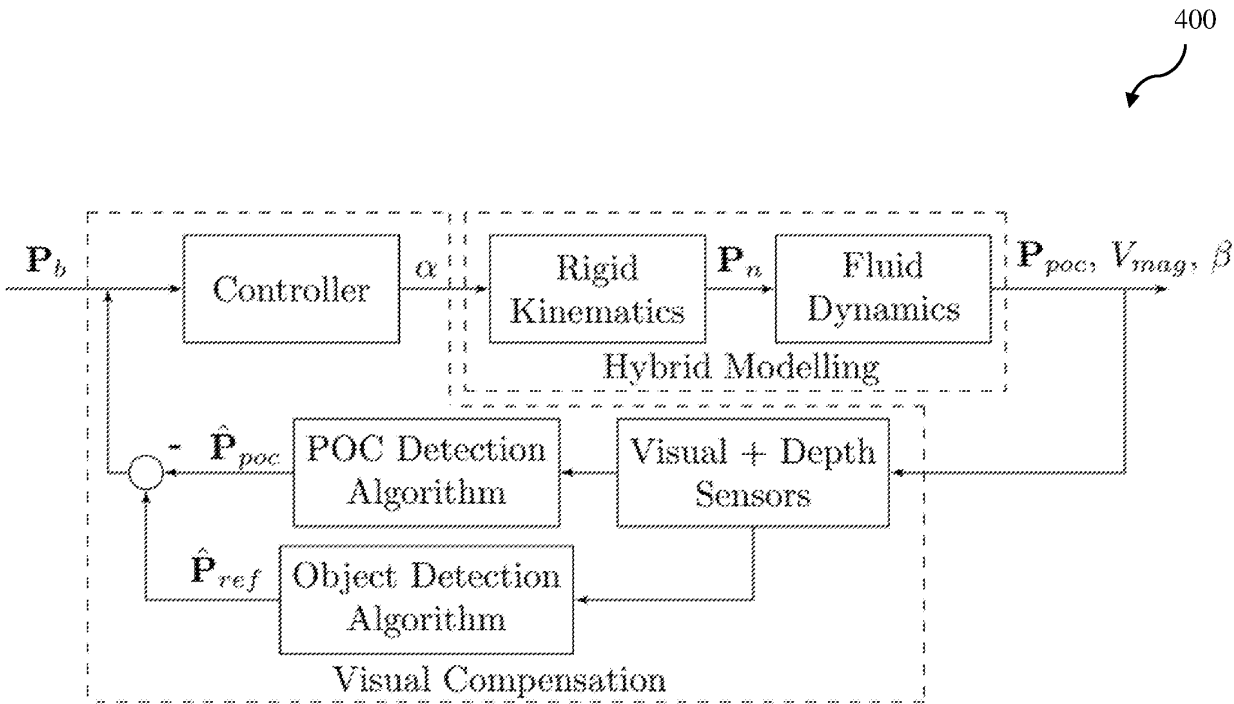


FIG. 4

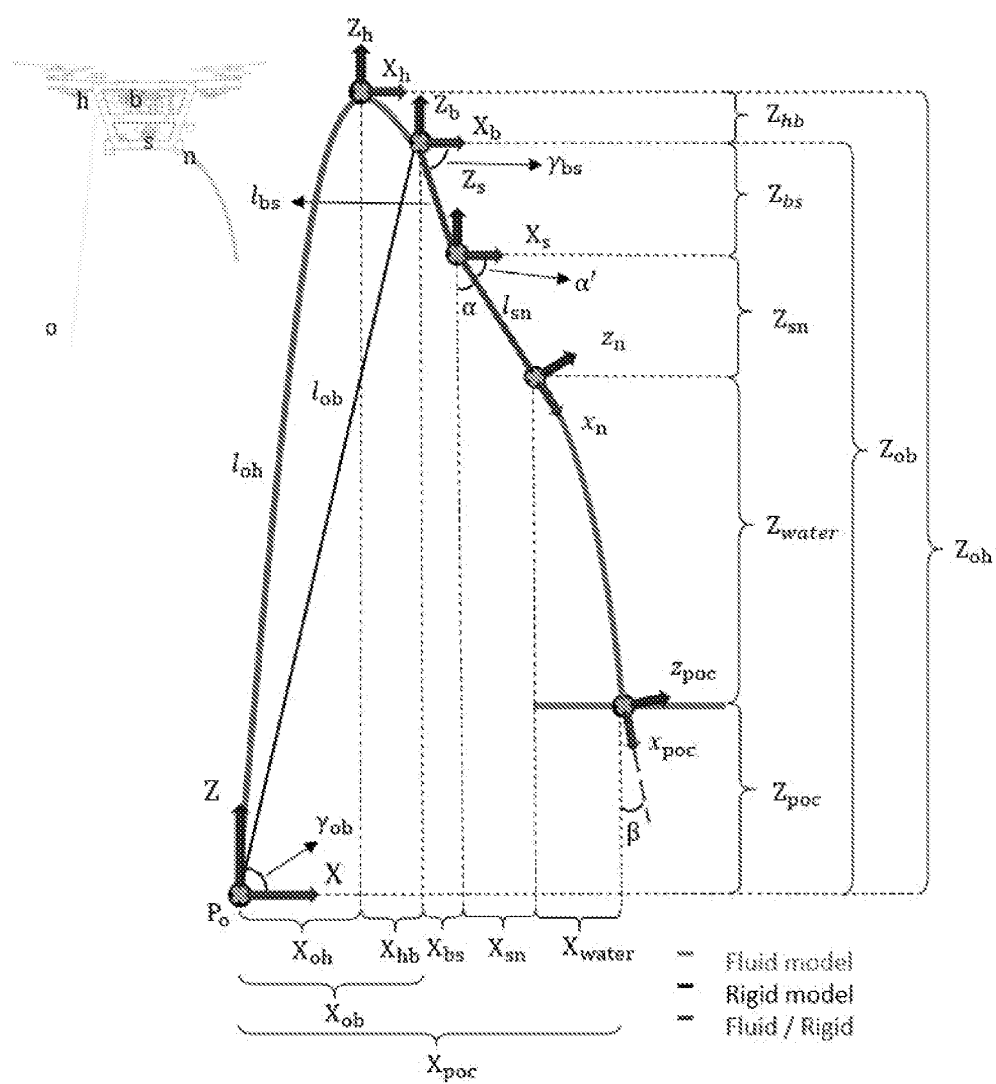


FIG. 5

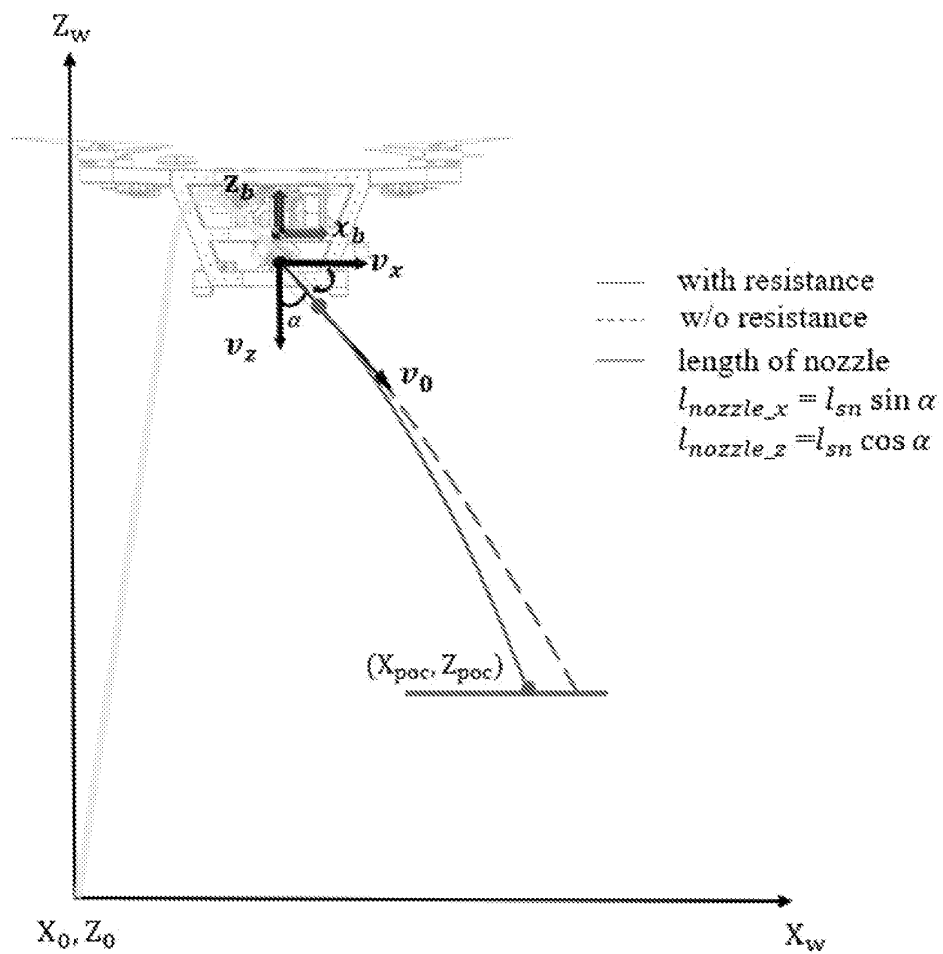


FIG. 6

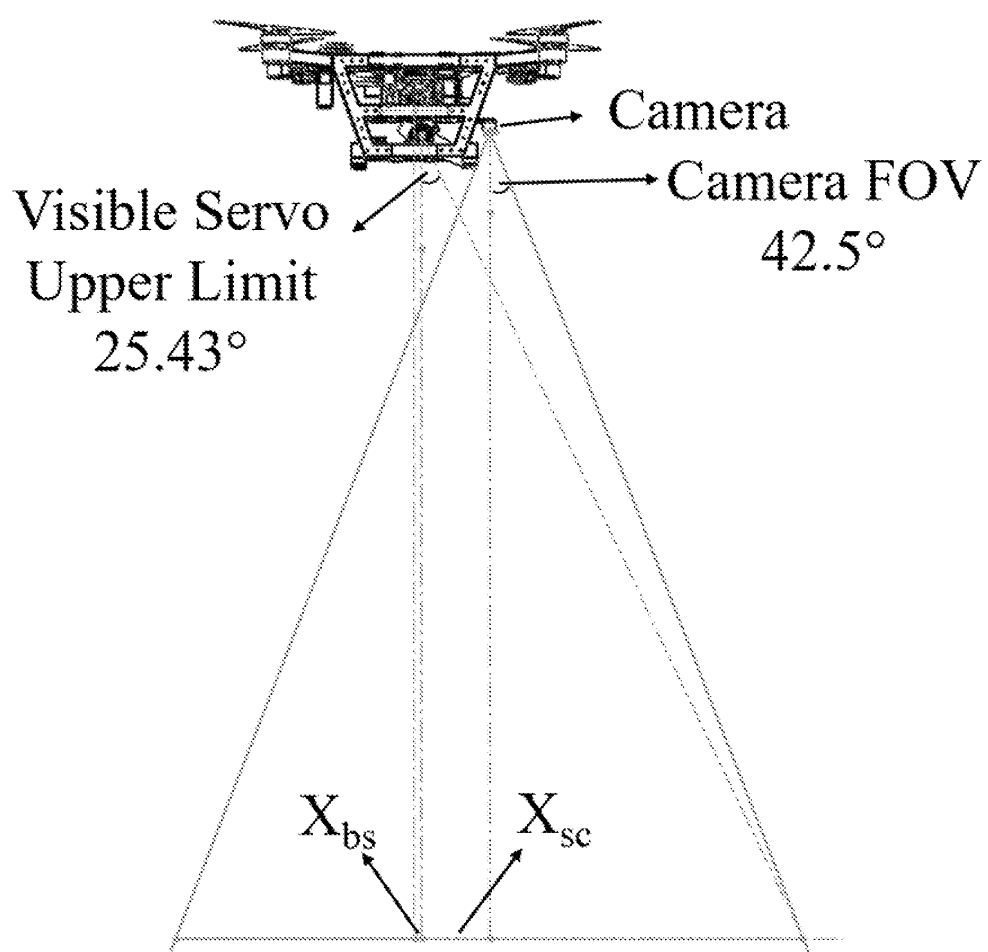


FIG. 7

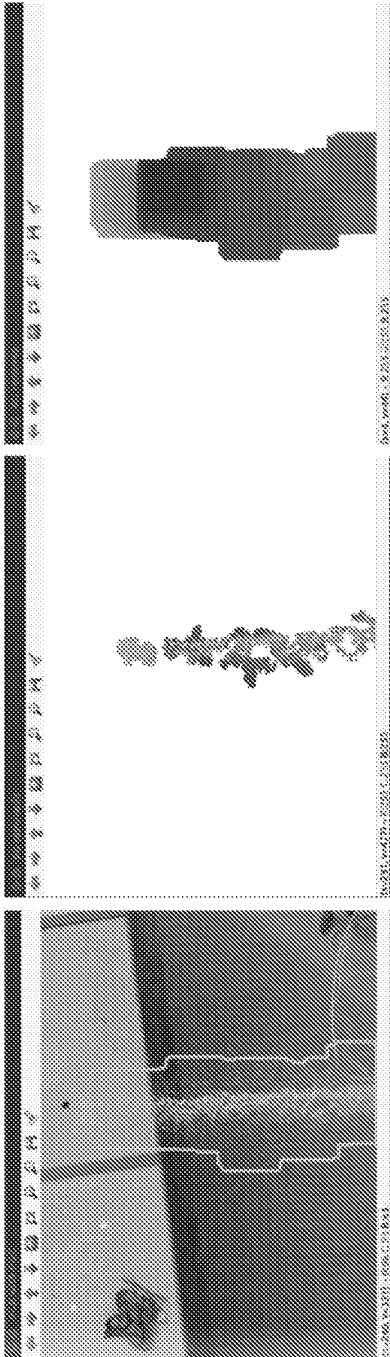


FIG. 8

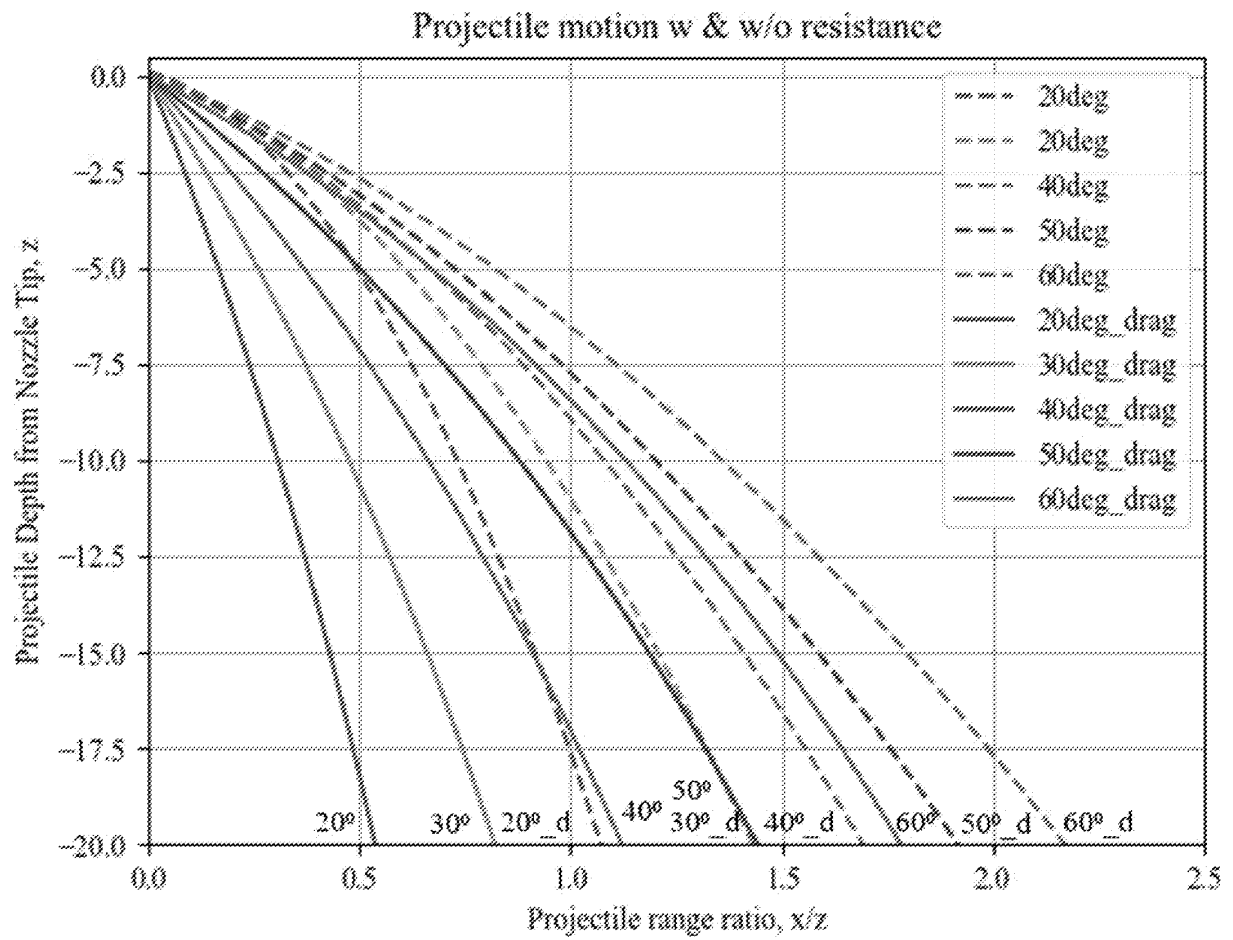


FIG. 9

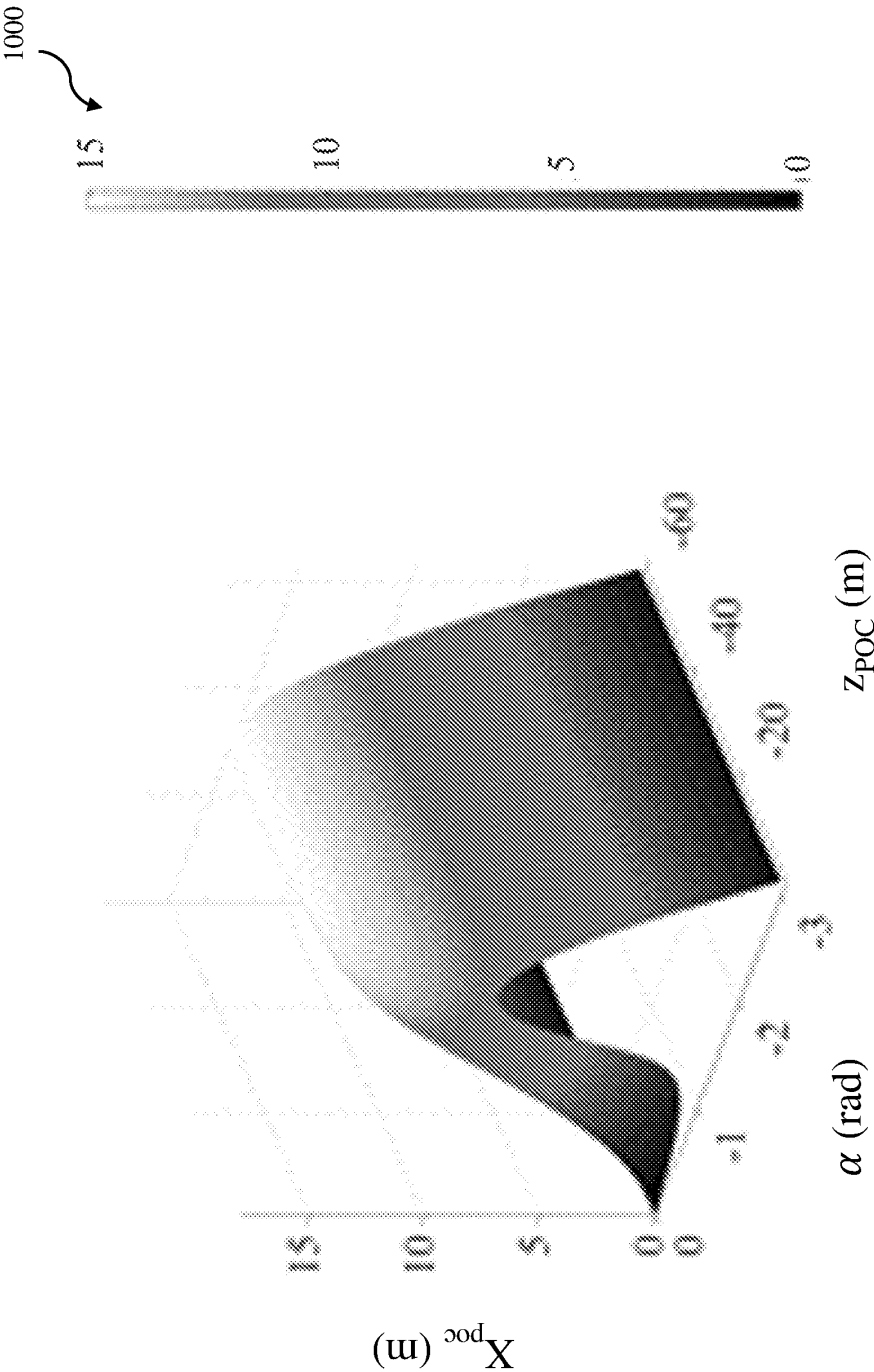


FIG. 10

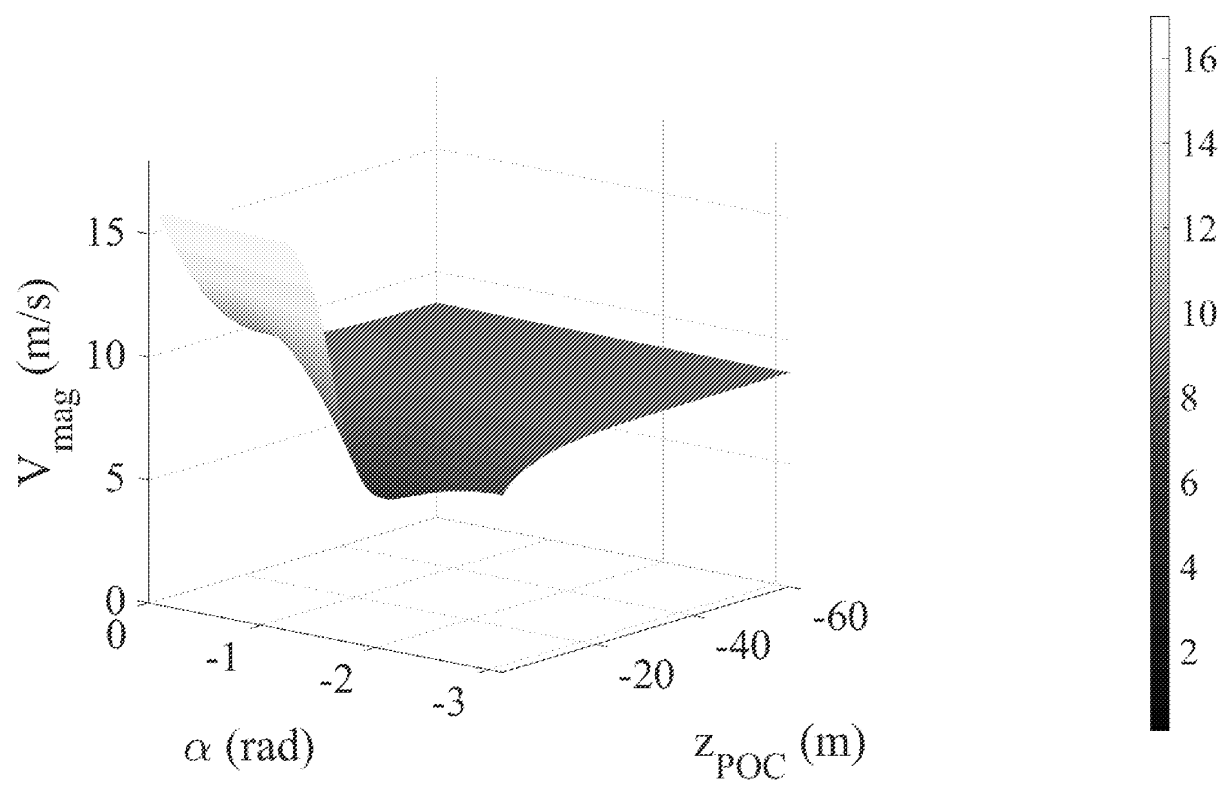


FIG. 11

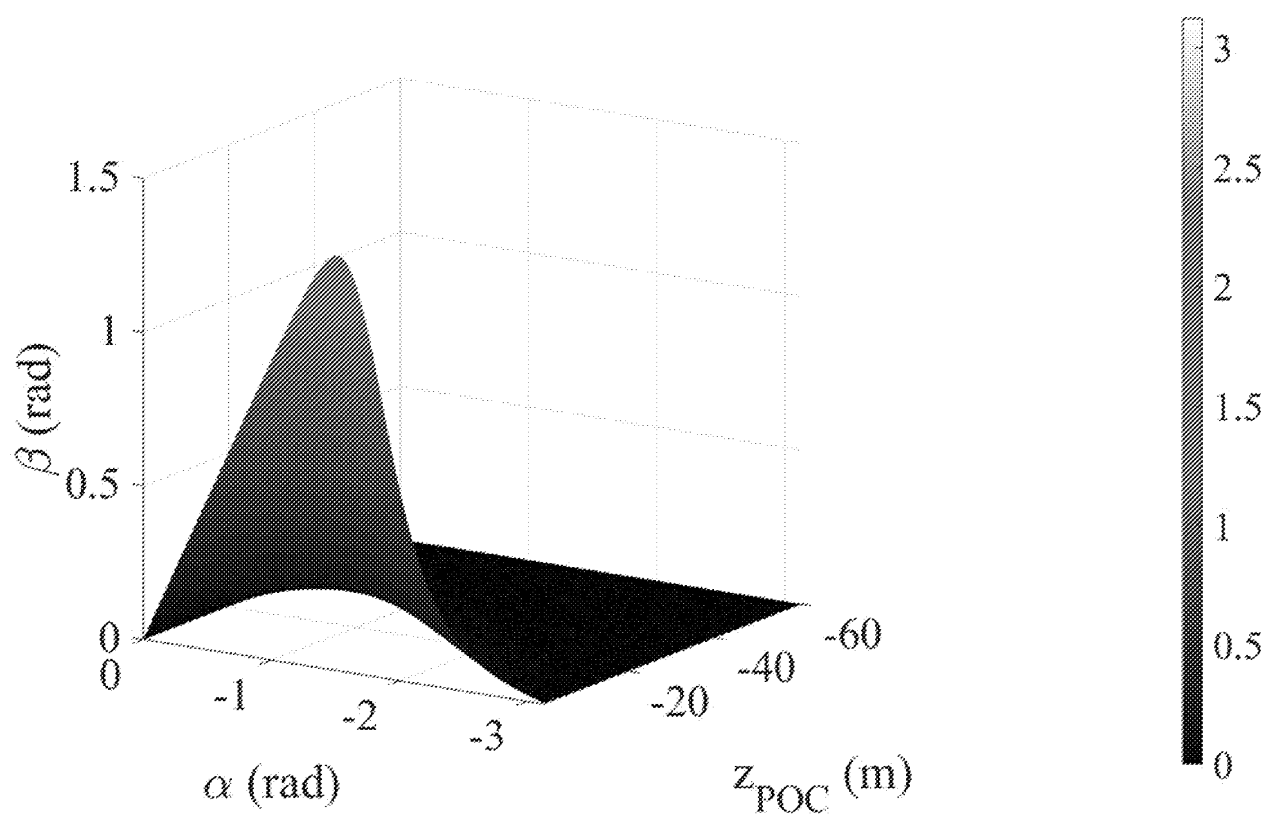


FIG. 12

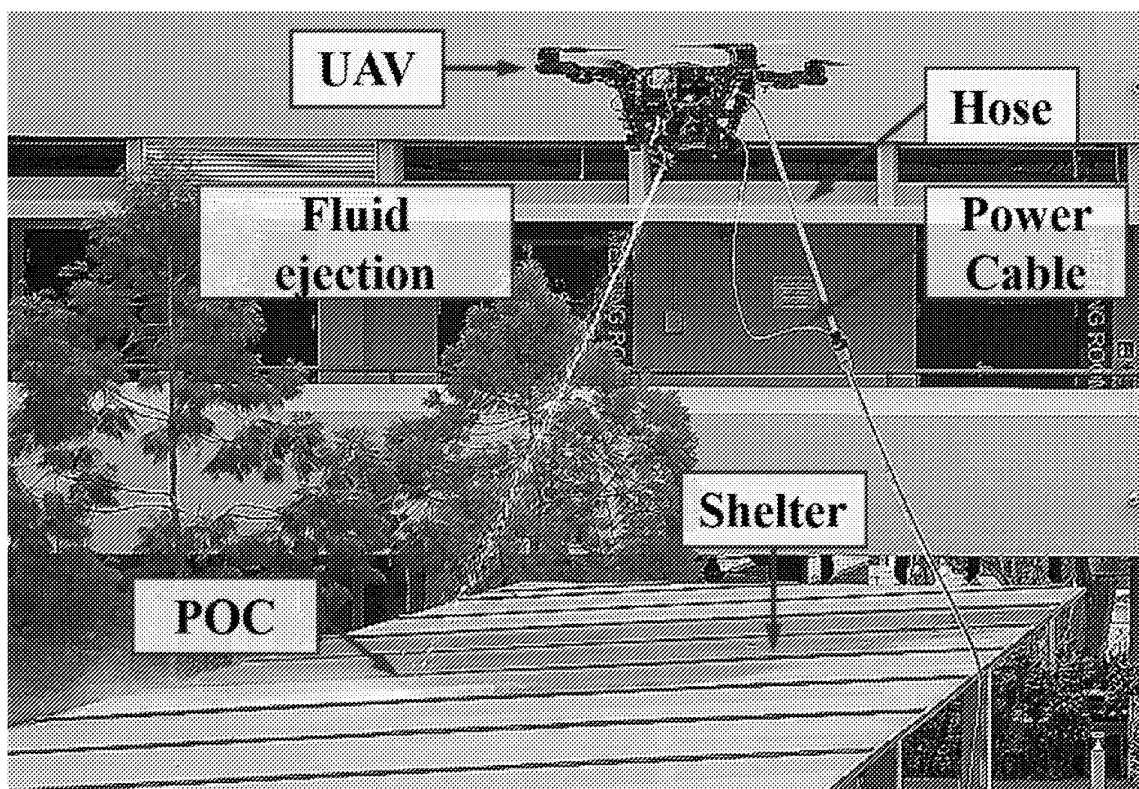


FIG. 13A

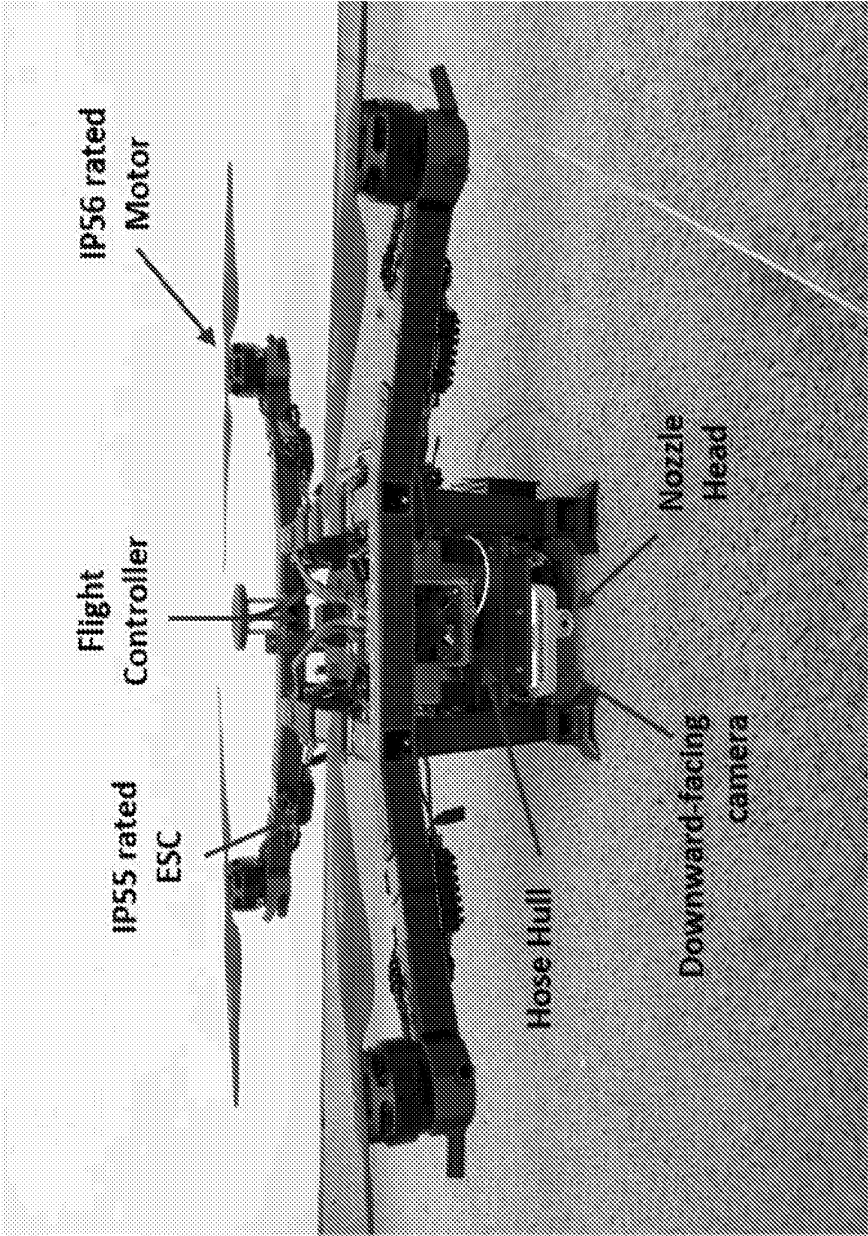


FIG. 13B

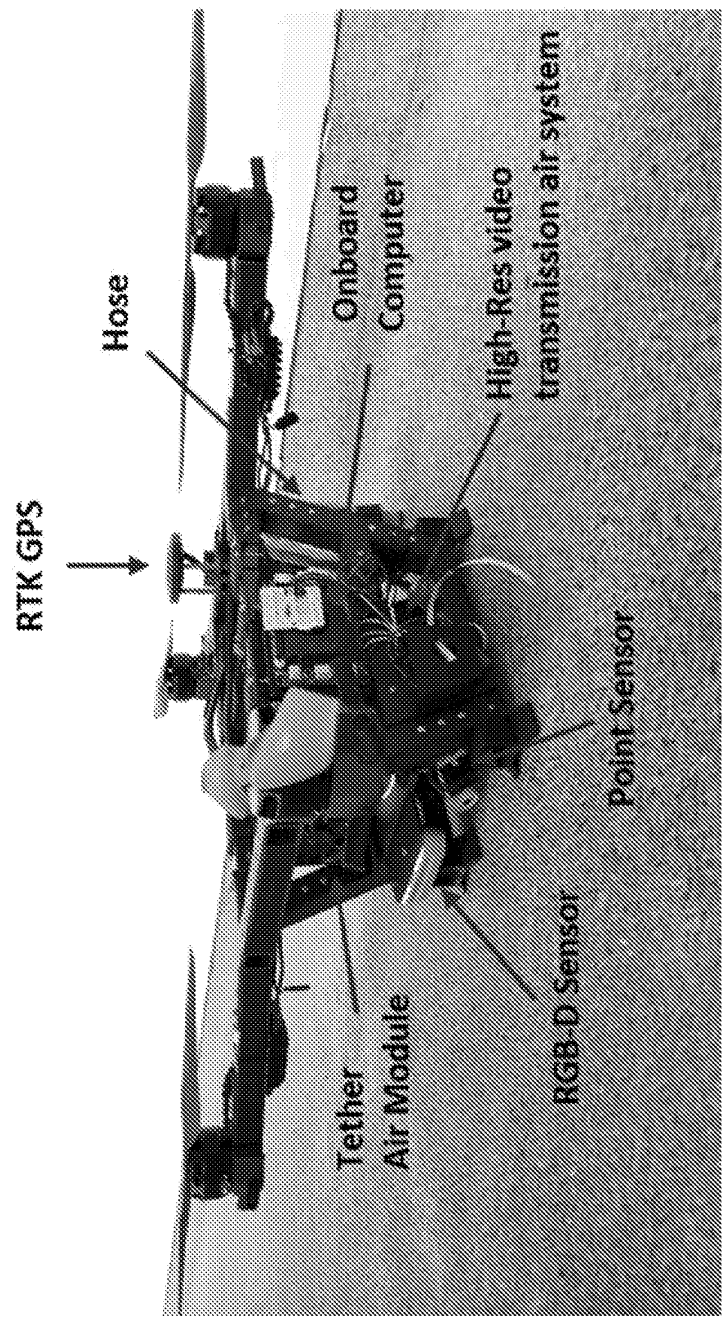


FIG. 13C



FIG. 13D

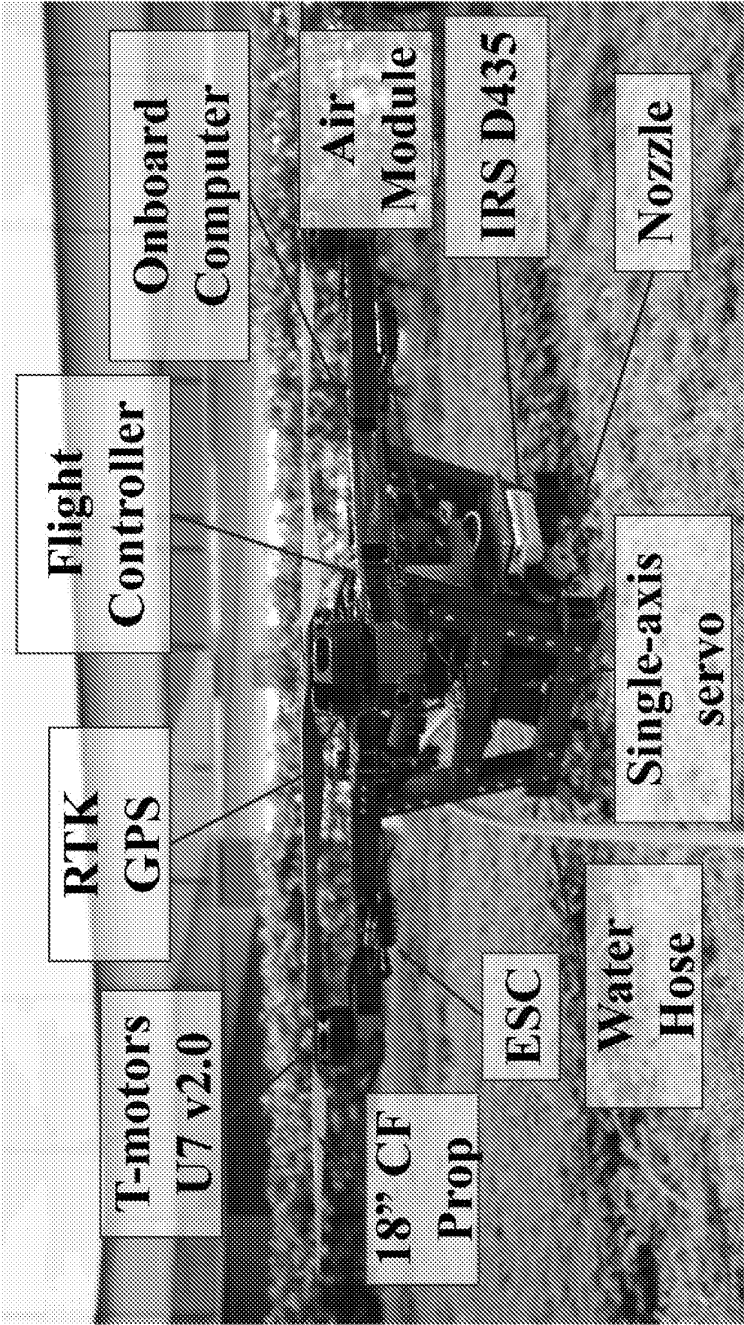


FIG. 13E

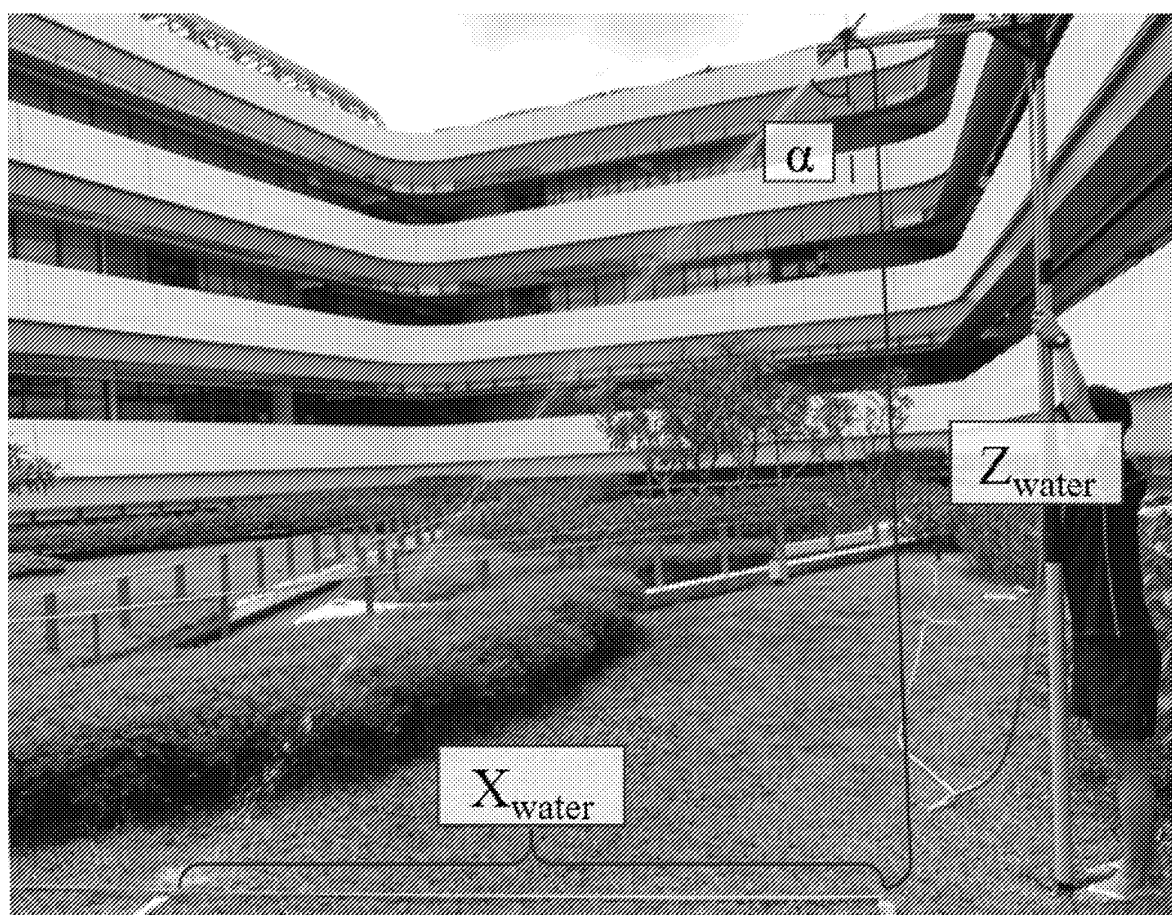


FIG. 14

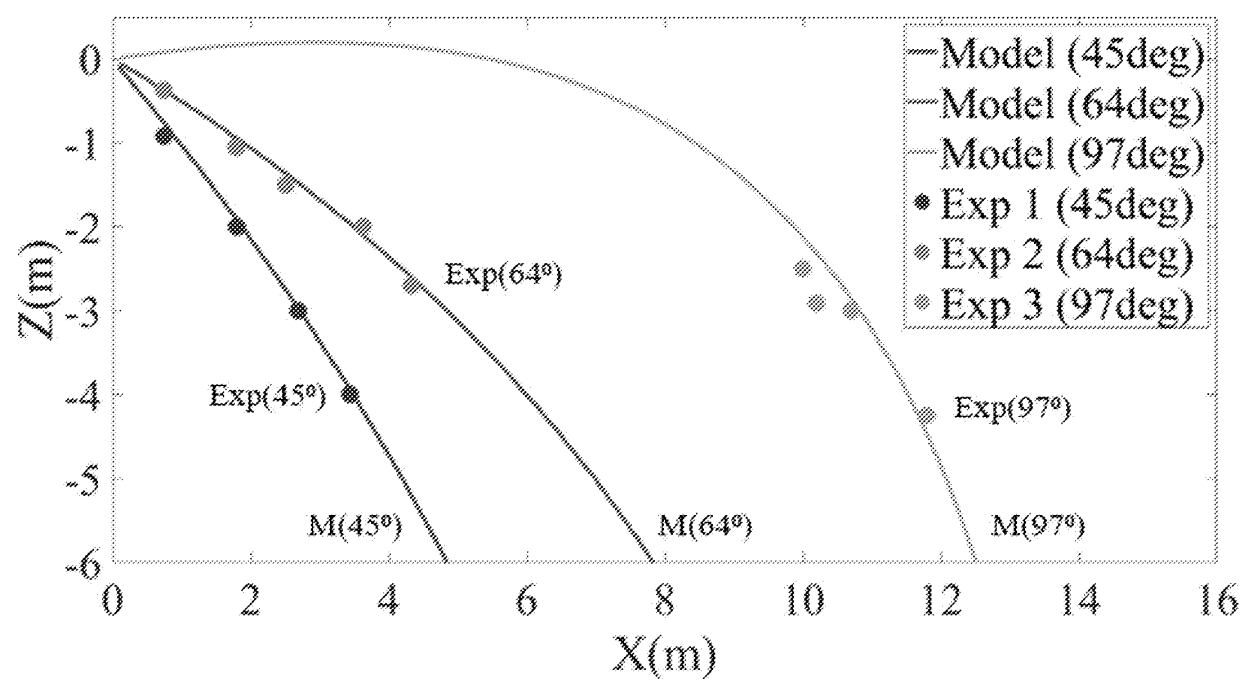


FIG. 15

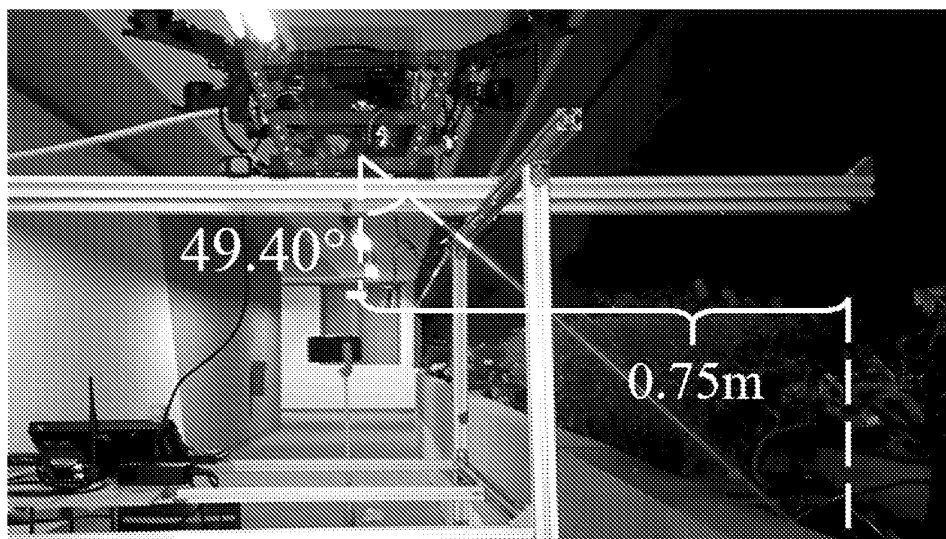


FIG. 16A

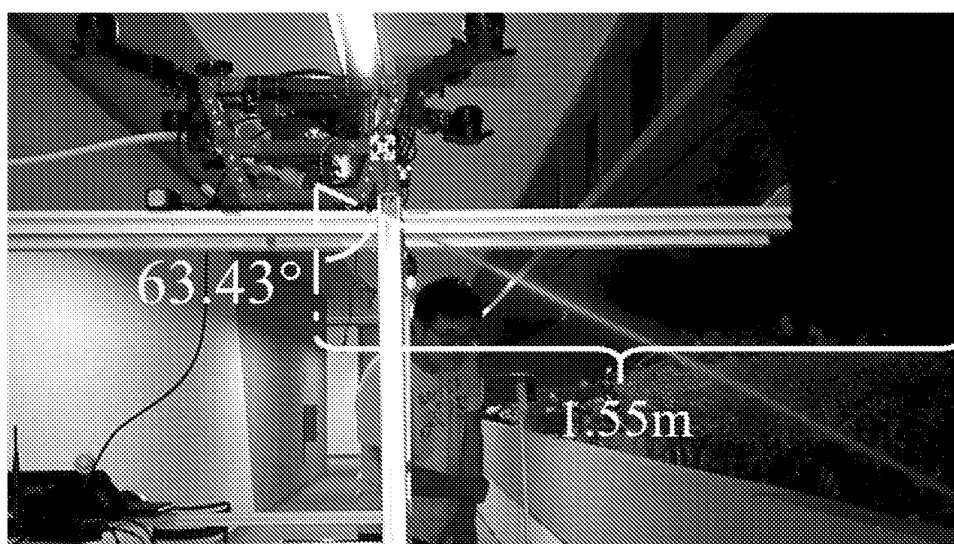


FIG. 16B

Yolov3 Tiny Architecture

Image Size	640x480 pixels
Classes	1
Batch	24
Subdivisions	8
Layers	24
Kernel Size	3x3
Filters (127, 171)	(classes + 5)*3
Data Augmentation	Scale/Flip/Crop/Hue/Saturation/Exposure

FIG. 17A

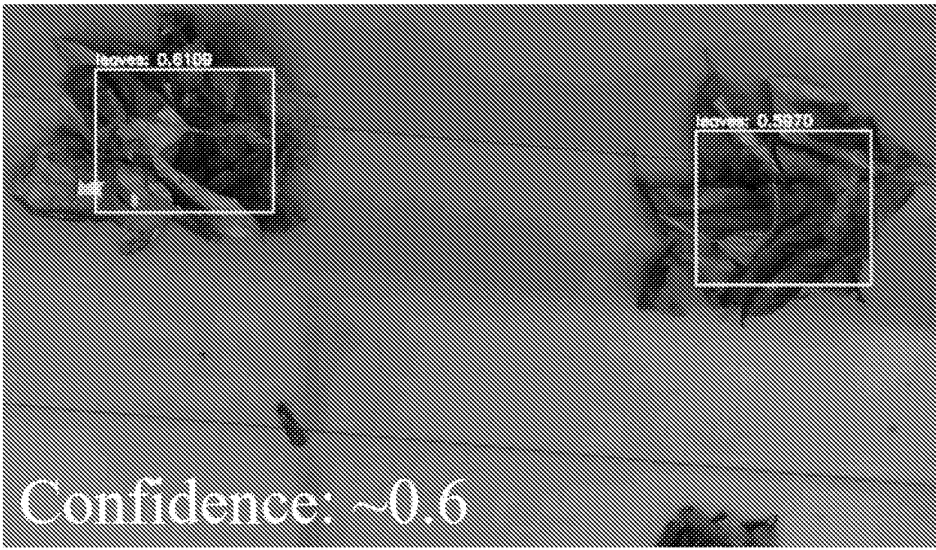


FIG. 17B

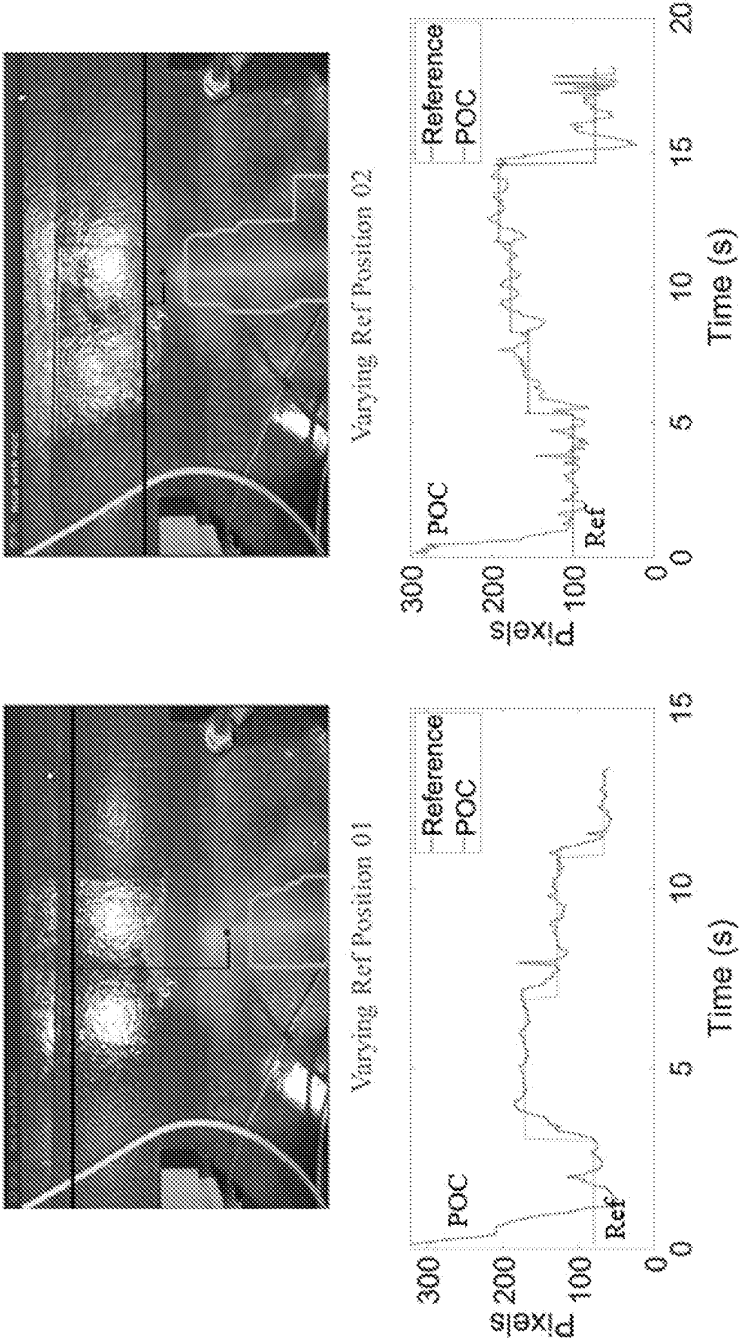


FIG. 18B

FIG. 18A

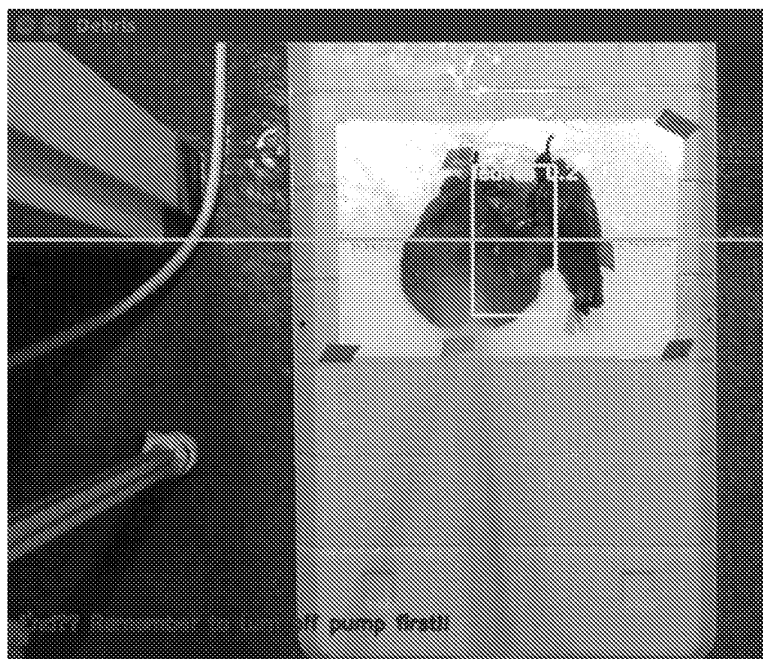


FIG. 19A

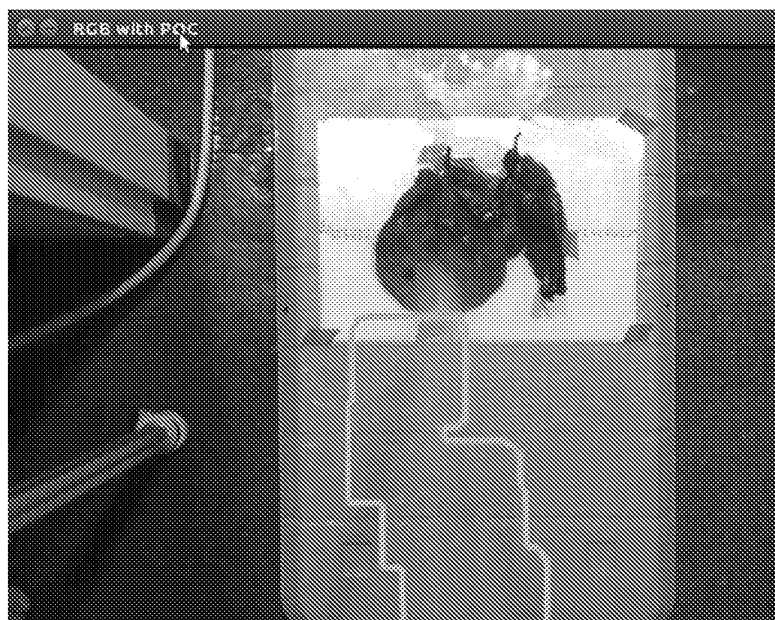


FIG. 19B

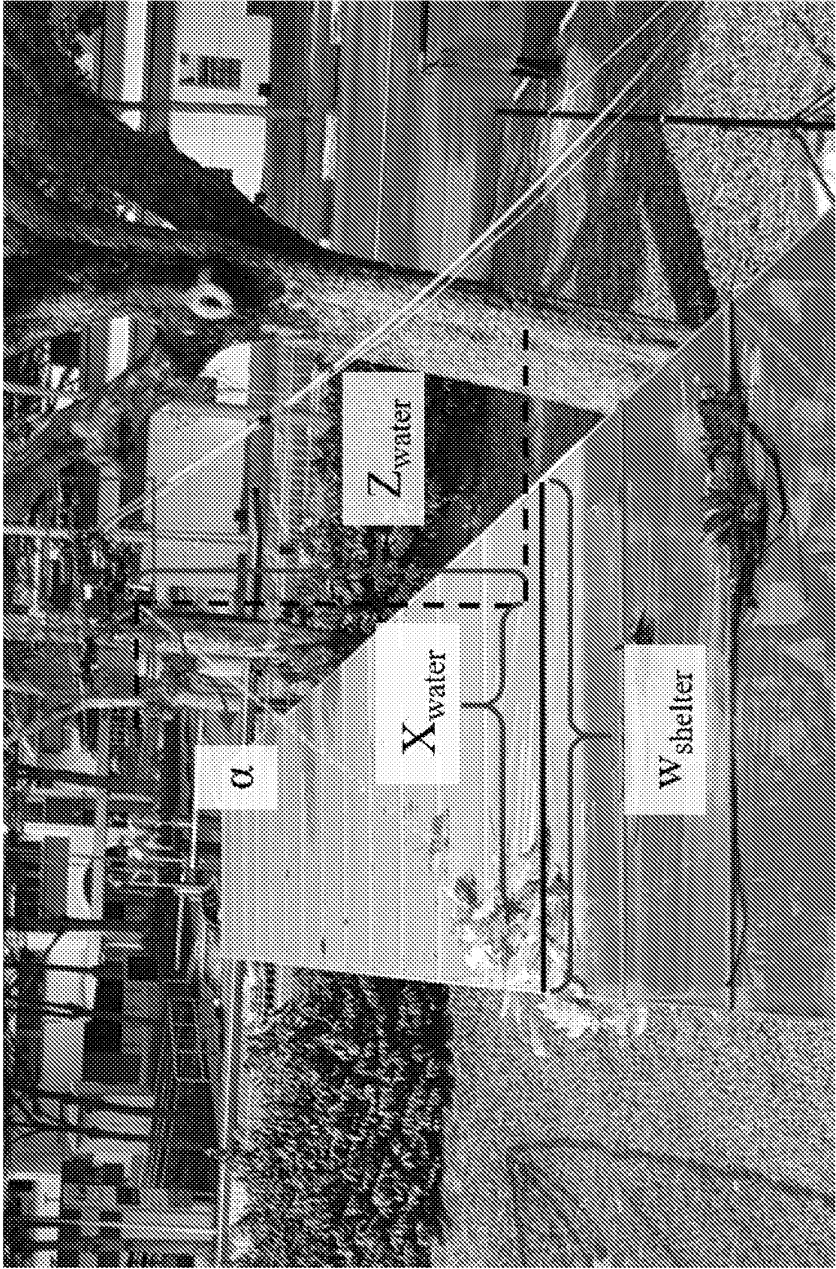


FIG. 20

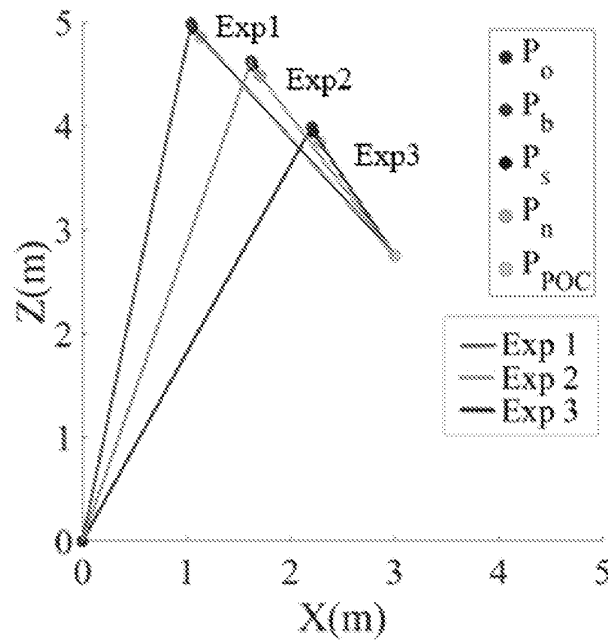


FIG. 21

Hybrid Kinematics Results

Parameters	Exp ₁	Exp ₂	Exp ₃
$W_{shelter}$ (m)	2	2	2
X_{poc} (m)	3	3	3
Z_{poc} (m)	2.75	2.75	2.75
X_{water} (m)	1.86	1.29	0.71
Z_{water} (m)	2.10	1.73	1.09
α (°)	43.55	38.08	33.96
Q	0.80	1.00	1.00
R	0.26	0.10	0.17
S	1.00	0.11	0.15

FIG. 22



FIG. 23A

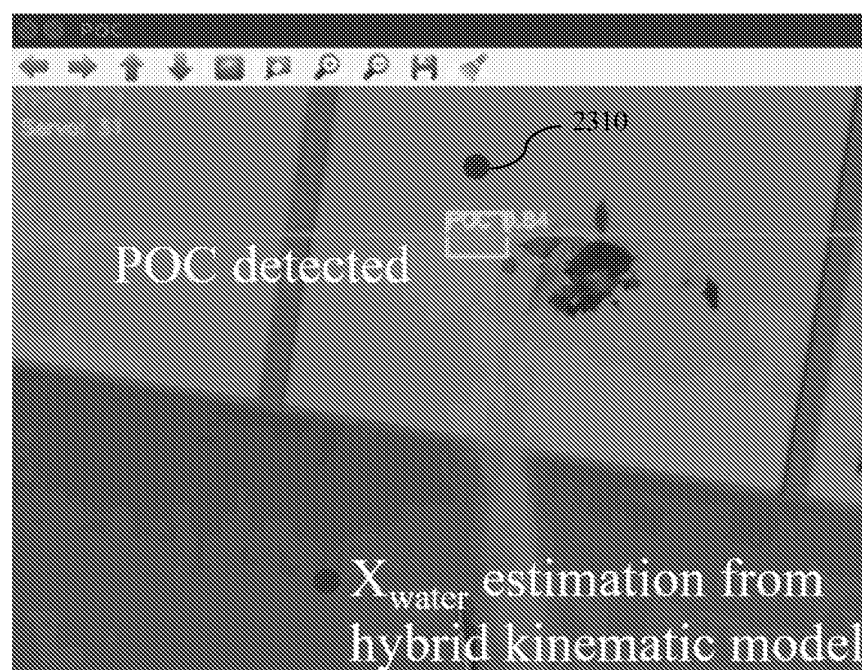


FIG. 23B

Hybrid Kinematics Results

Parameters	Exp4
$W_{shelter}$ (m)	2.00
X_{poc} (m)	2.00
Z_{poc} (m)	2.75
X_{water} (m)	0.50
Z_{water} (m)	0.90
$\alpha(^{\circ})$	29.36
Q	0.900
R	0.162
S	0.132

FIG. 24

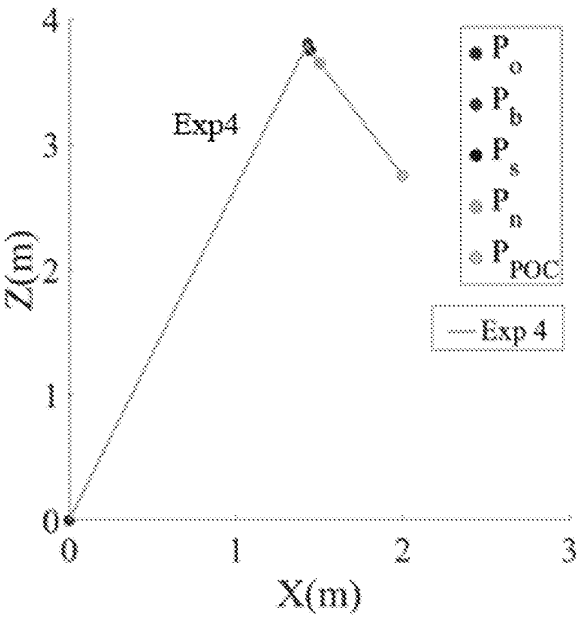


FIG. 25

2600

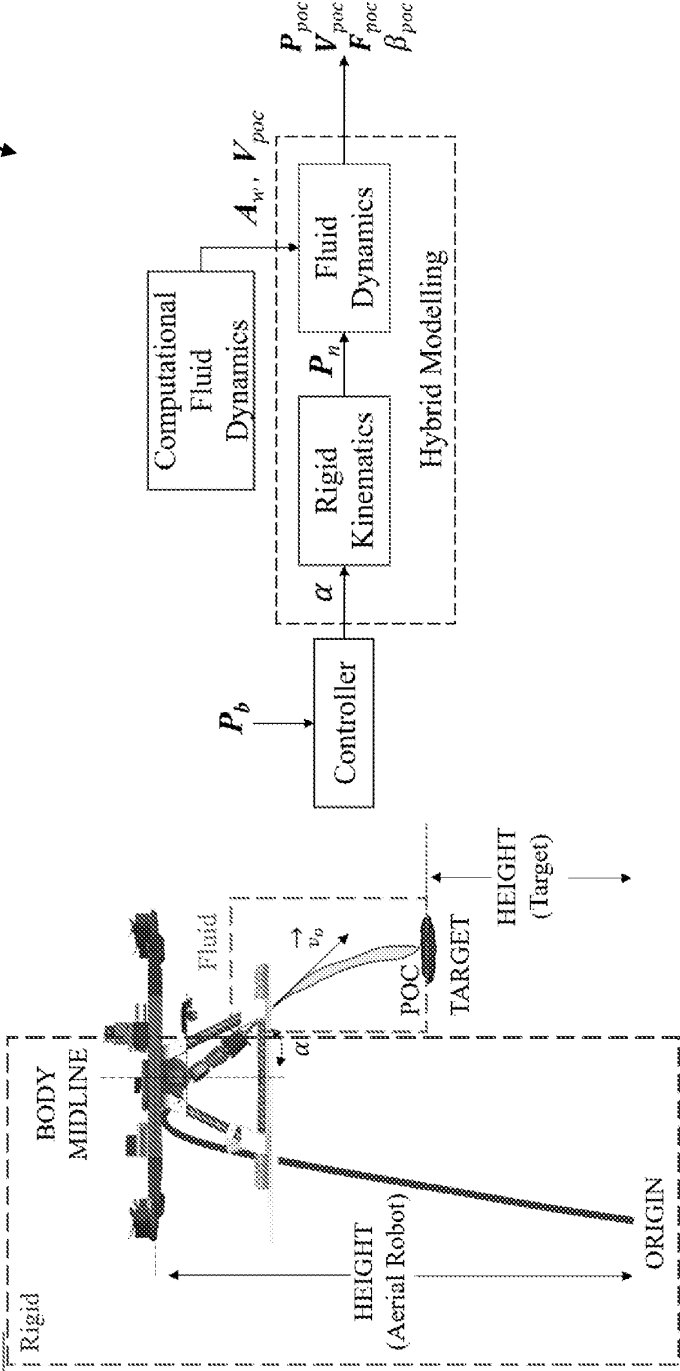


FIG. 26

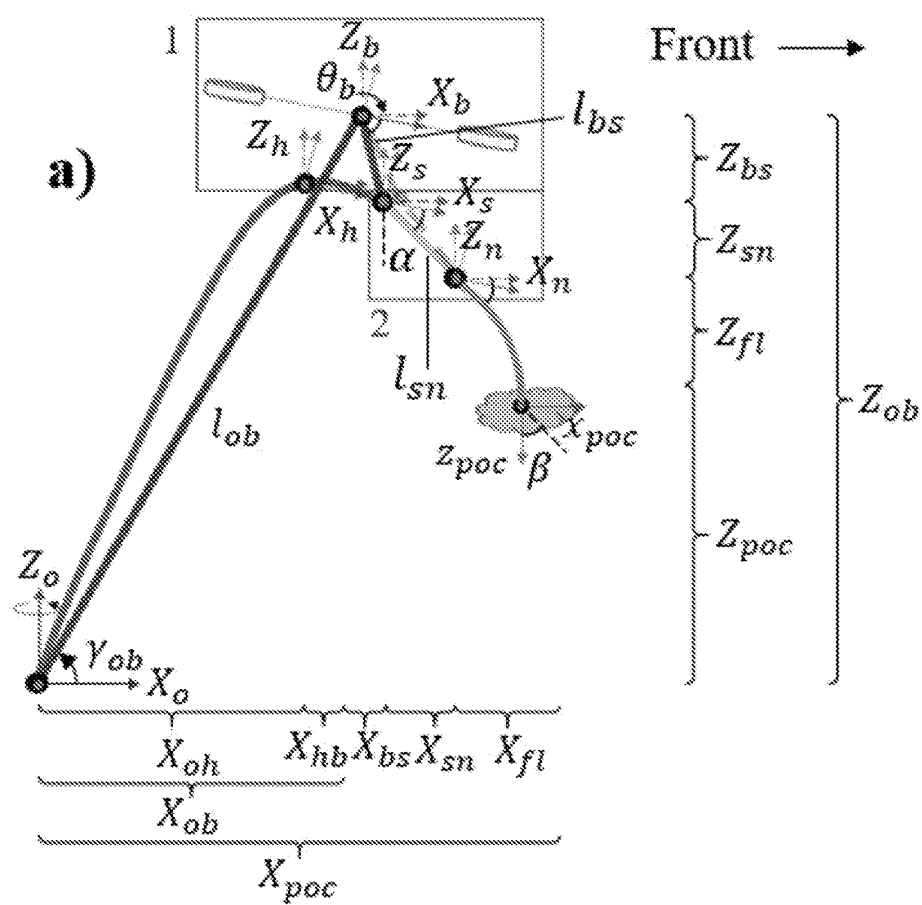


FIG. 27A

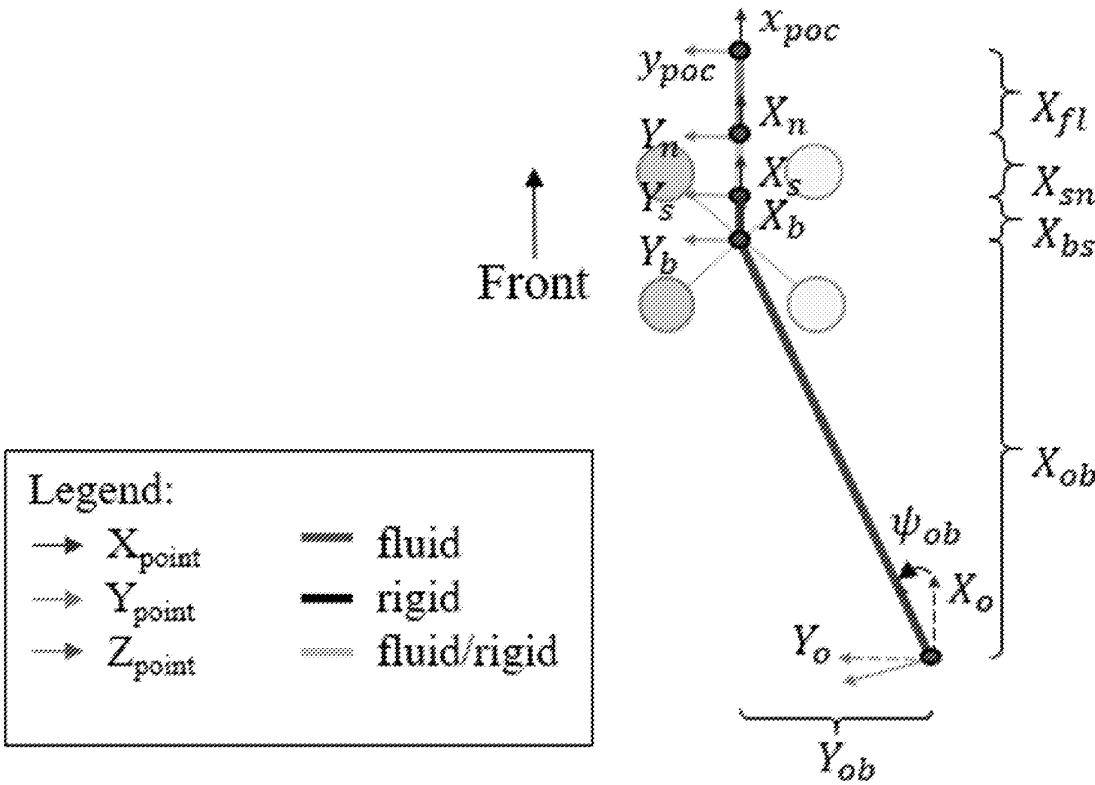


FIG. 27B

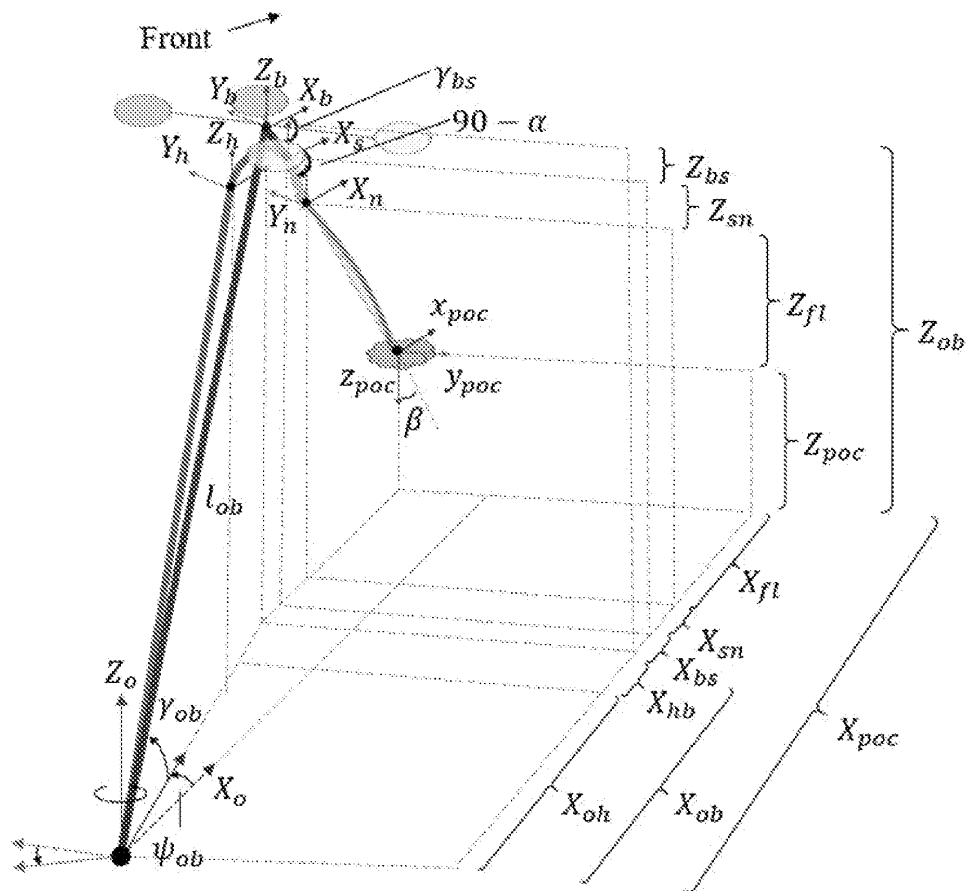


FIG. 27C

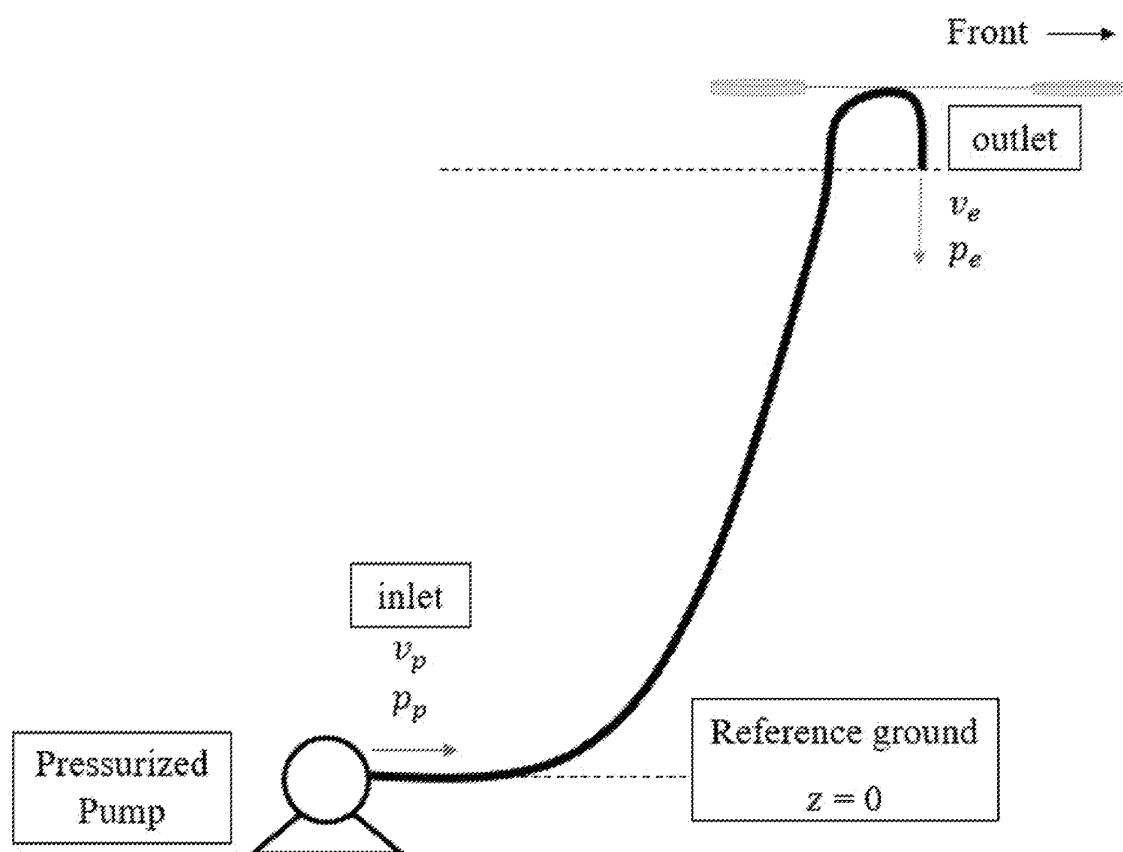


FIG. 28

Model	Type	Parameters
Turbulence	k- ω Shear Stress Transport	Default model constants (see [24])
Drag	Schiller Naumann	Drag coeff = 0.44 (for Re > 1000)
Multiphase	Eulerian-Eulerian Implicit Discretization	Discrete phase - Water Continuous phase - Air Surface Tension coeff - 0.072 N/m
Computational Algorithm	Phase coupled SIMPLE	Spatial Discretization: Pressure - 2nd Order Momentum/Volume fraction /TKE/TDR - 1st Order (Upwind)

CFD simulation setup: where Re is the Reynold's number, SIMPLE is Semi-Implicit Method for Pressure Linked Equations, TKE is Turbulence Kinetic Energy and TDR is Turbulent Dissipation Rate

FIG. 29

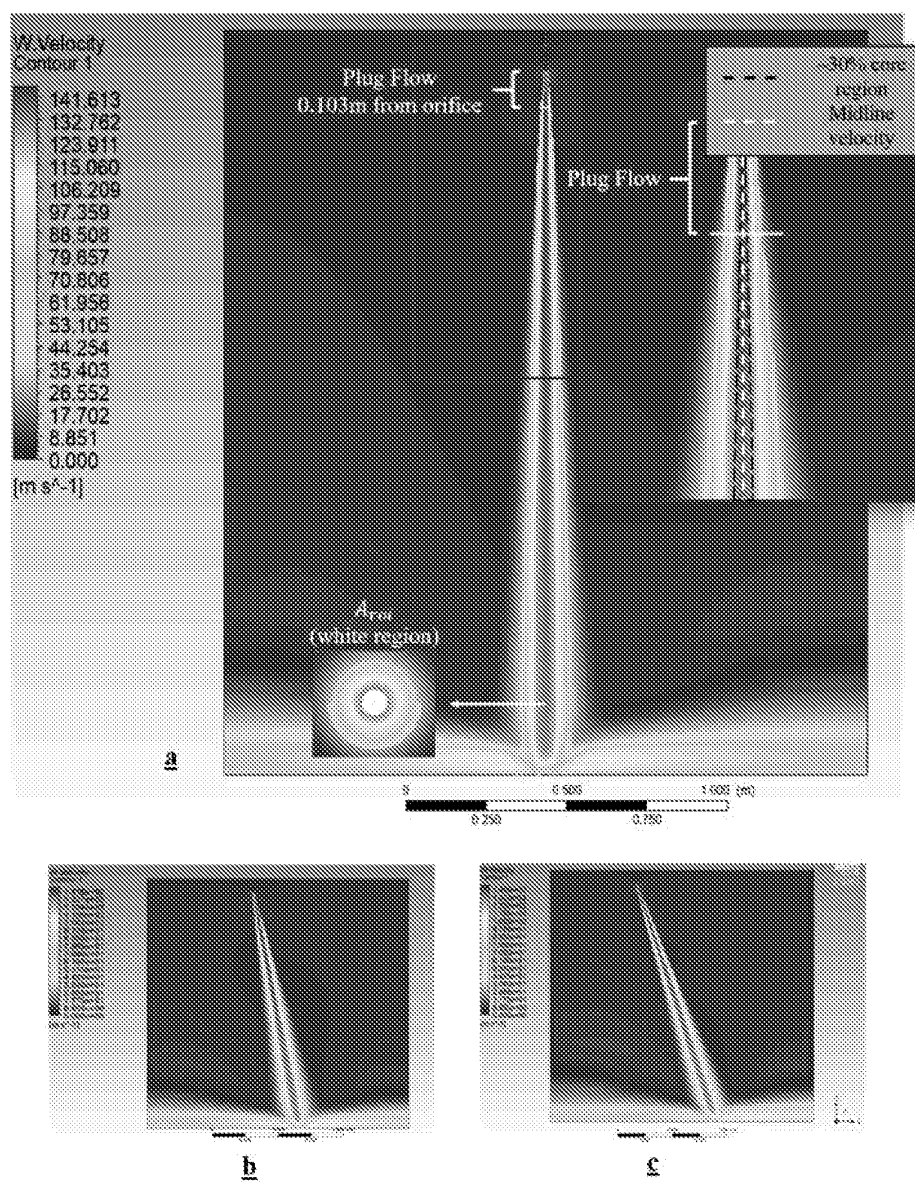
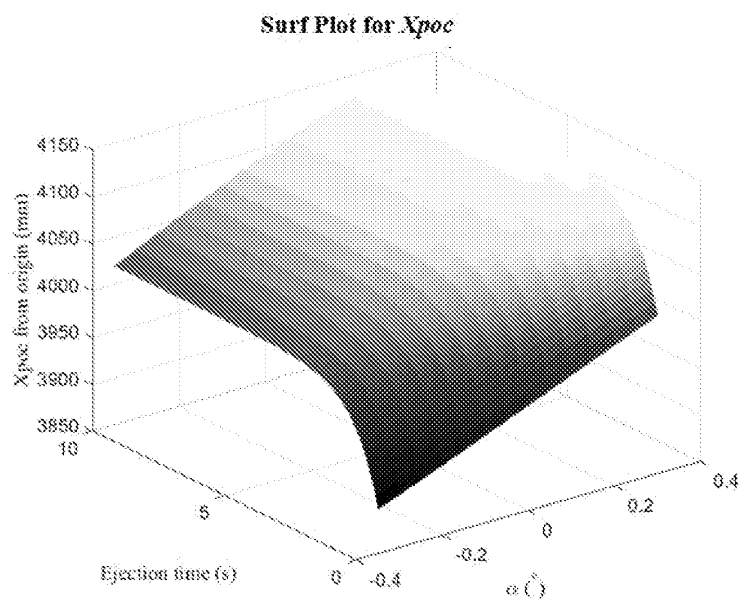
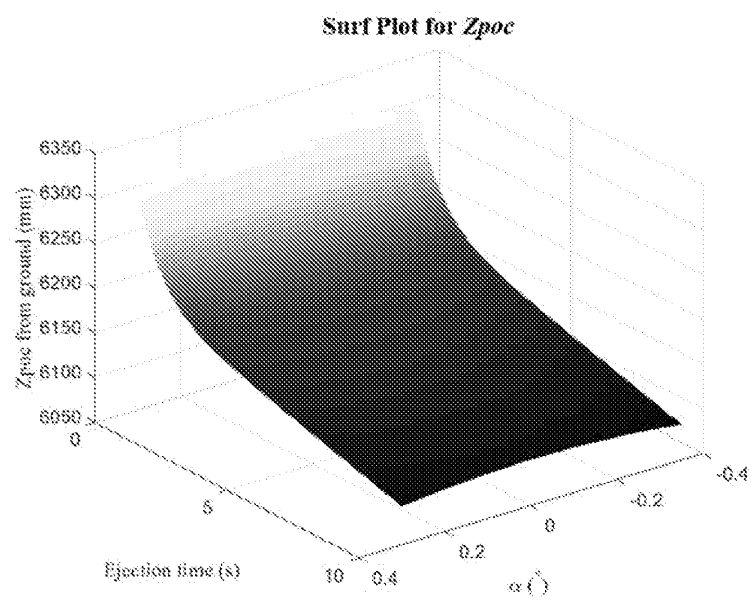


FIG. 30

**FIG. 31A****FIG. 31B**

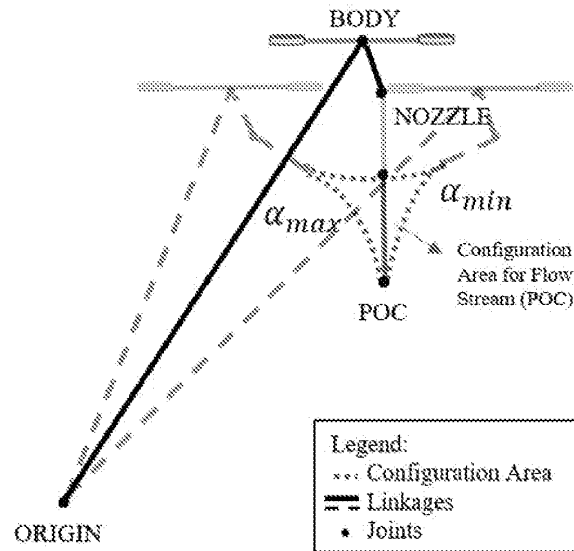


FIG. 31C

Parameters	FK _a	IK _a	FK _b	IK _b	FK _c	IK _c
tgt_x (m)	2.0	2.0	3.0	3.0	4.0	4.0
tgt_y (m)	-1.5	-1.5	2.5	2.5	0.0	0.0
tgt_z (m)	2.75	2.75	2.75	2.75	2.75	2.75
alt_{robot} (m)	4.0	4.0	5.0	5.0	6.0	6.0
X_{water} (m)	2.25	1.92	3.06	2.93	4.03	3.97
Y_{water} (m)	-1.63	-1.50	2.46	2.50	0.0	0.0
Z_{water} (m)	2.60	2.67	2.49	2.72	2.58	2.55
α (°)	5.0	1.0	5.0	1.0	5.0	1.0
γ_{ob} (°)	57.0	58.82	50.0	52.56	50.0	56.98
ψ_{ob} (°)	-36.87	-38.29	39.81	40.76	0.0	0.0
l_{ob}	5.0	4.67	6.0	6.30	7.0	7.16

Hybrid Kinematics Simulation Results

FIG. 32

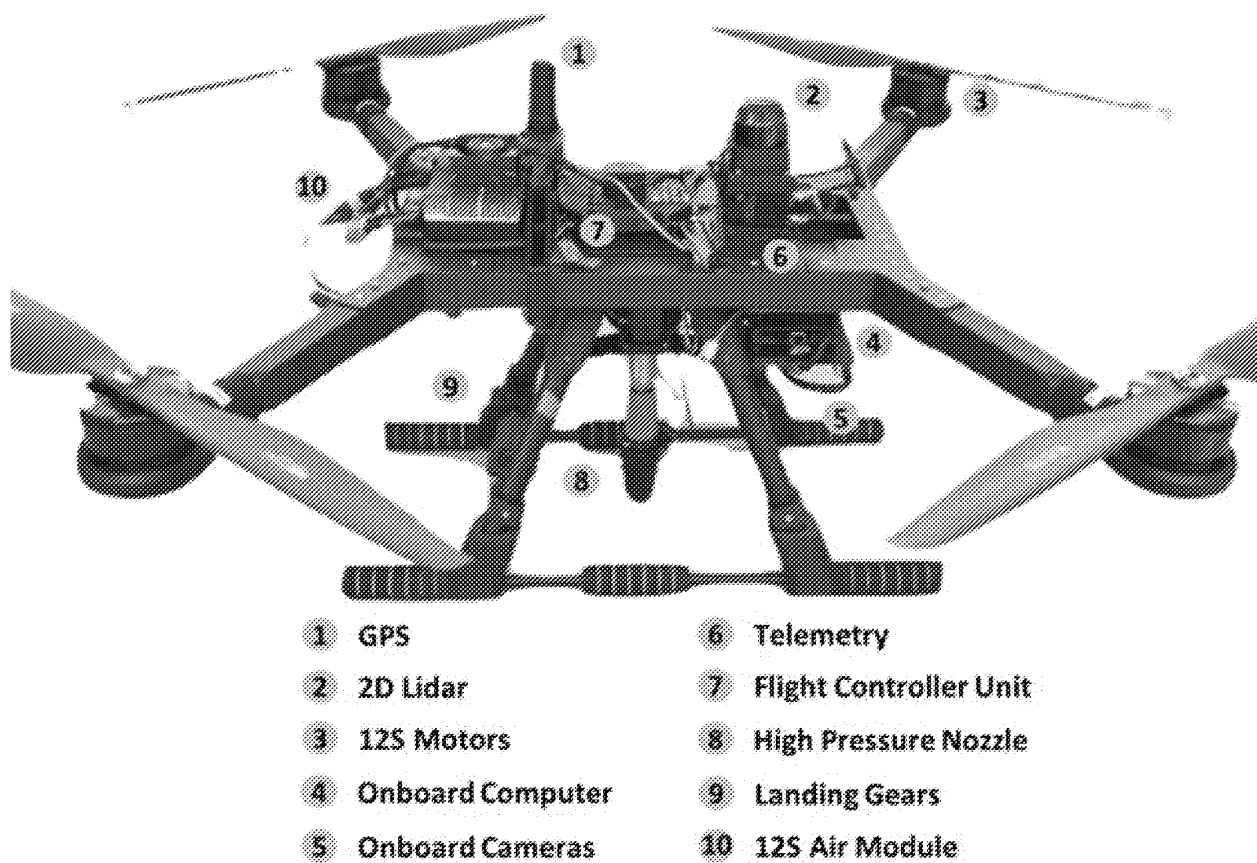


FIG. 33A

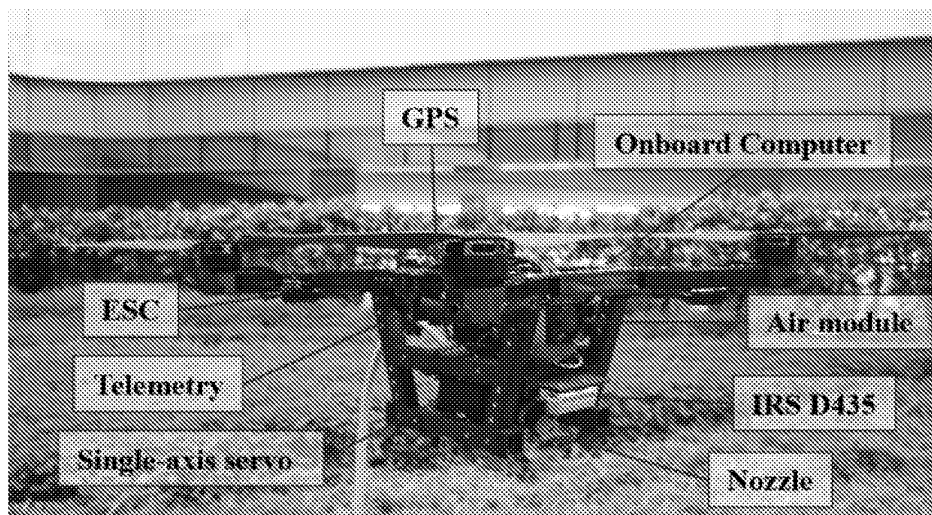


FIG. 33B



FIG. 33C

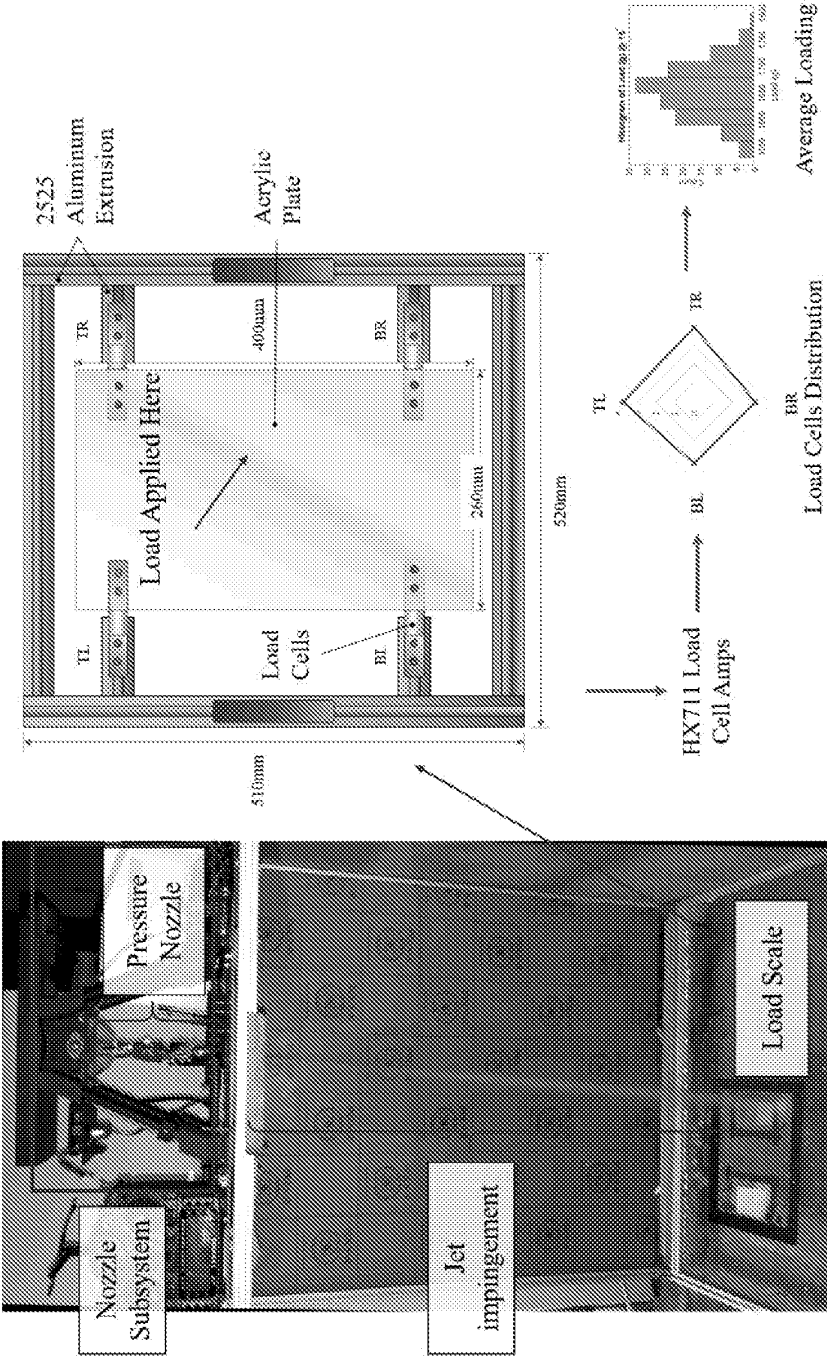


FIG. 34

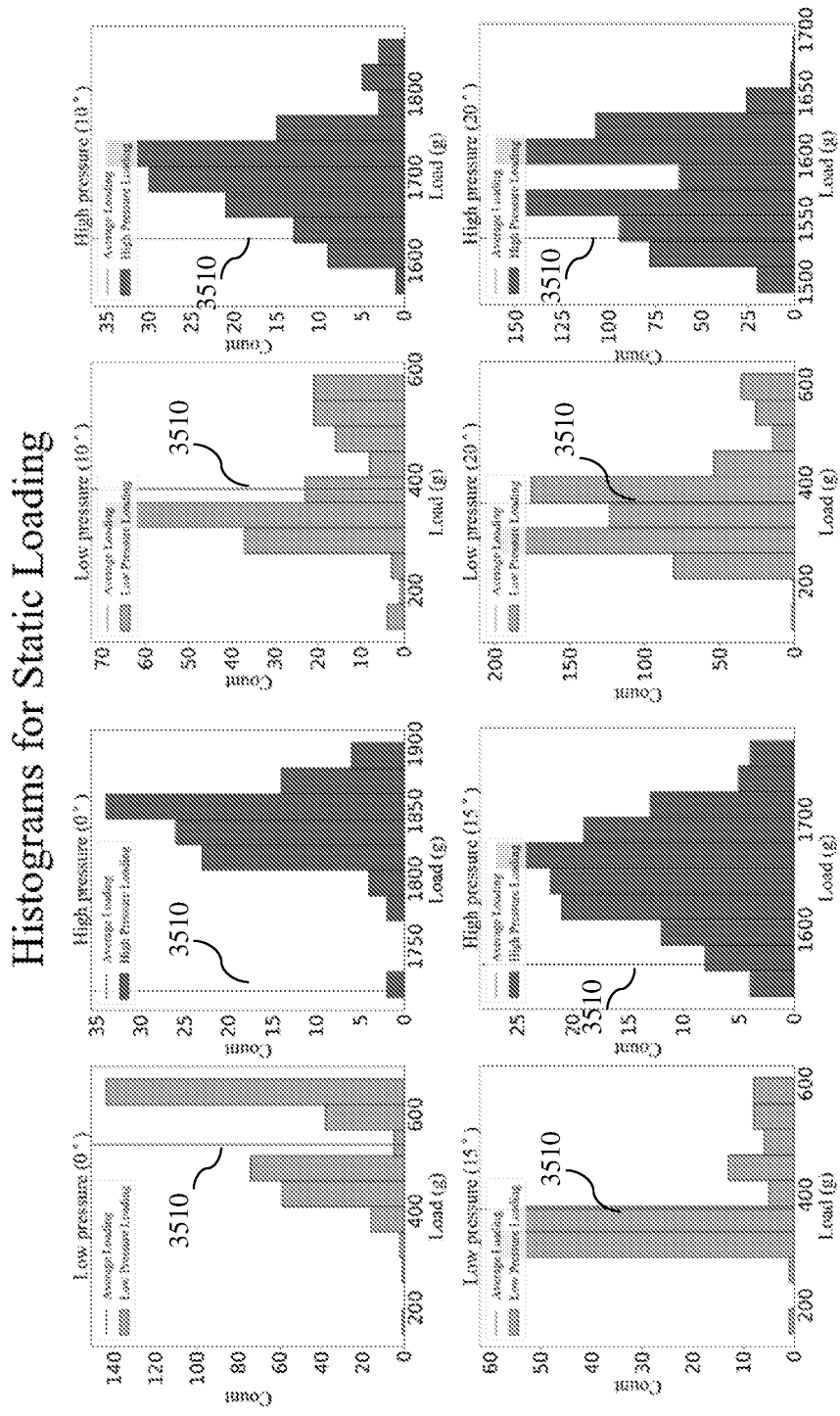


FIG. 35

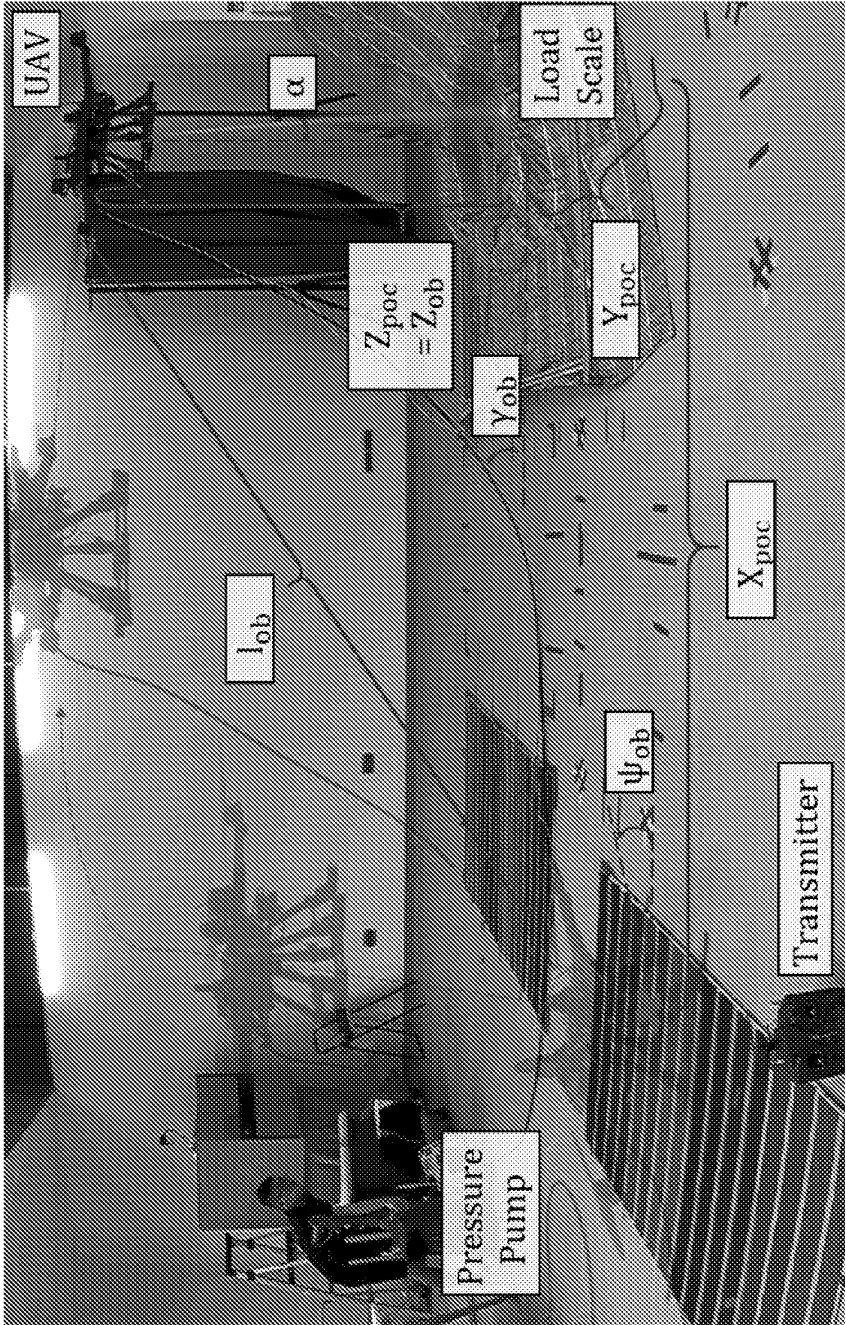


FIG. 36

Exp	α (°)	Predicted Force (kgf)	Measured Force (kgf)	Predicted Position (m)	Measured Position (m)	Position Error(m)	Force Error (%)
1	5	0.79	0.93	3.54, 1.1, 1.88	3.45, 1.05, 1.80	0.13	-15.05
2	0	1.44	1.43	3.44, 0.1, 1.67	3.36, 0.15, 1.50	0.19	+0.69
3	5	1.15	1.24	3.44, 1.8, 1.77	3.46, 1.89, 1.65	0.15	-7.49

Experimentation Data: Position Flight

FIG. 37

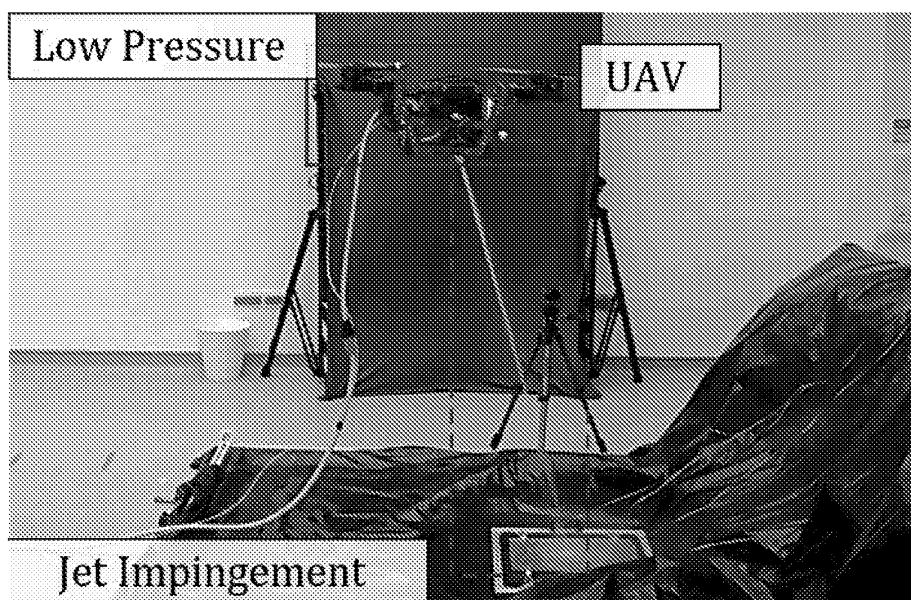


FIG. 38A

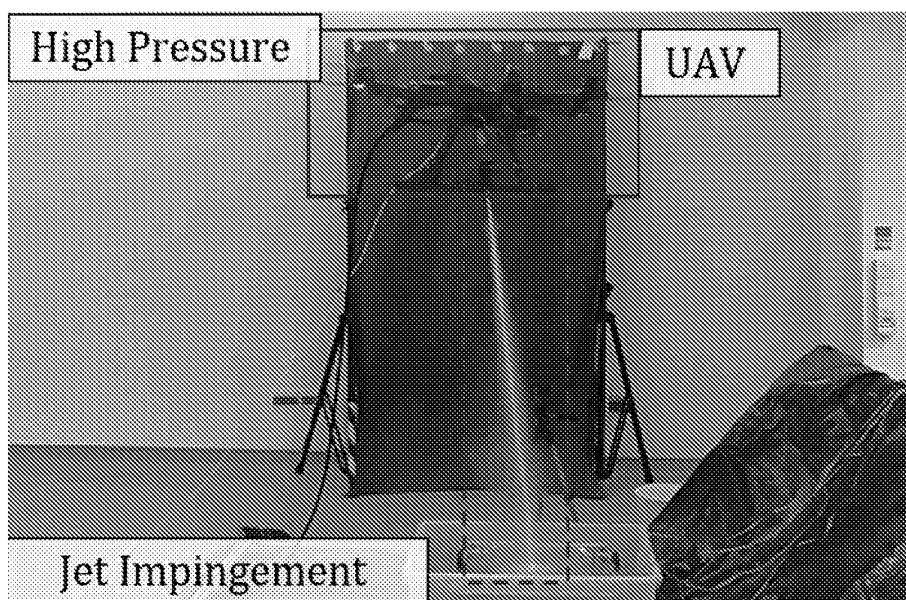


FIG. 38B

Parameters:		Low Pressure: 45bar				High Pressure: 120bar			
Alt (m)	α (°)	F_{pred} (kgf)	F_{meas} (kgf)	Force Error (%)	β (°)	F_{pred} (kgf)	F_{meas} (kgf)	Force Error (%)	β (°)
1.5	0	0.430	0.427	0.603	0.0	1.408	1.458	-3.393	0.0
	5	0.394	0.396	-0.664	4.922	1.327	1.338	-0.845	4.994
	10	0.357	0.320	3.411	9.823	1.273	1.273	0.197	9.989
	15	0.316	0.320	-1.030	14.736	1.213	1.264	-4.058	14.983
	20	0.321	0.315	1.936	19.643	1.118	1.140	-1.971	19.977
2.0	0	0.310	0.297	4.362	0.0	1.332	1.389	-4.074	0.0
	5	0.295	0.292	1.069	4.887	1.262	1.313	-3.884	4.992
	10	0.299	0.286	4.638	9.772	1.227	1.240	-1.091	9.983
	15	0.295	0.278	5.992	14.629	1.174	1.220	-3.786	14.974
	20	0.259	0.264	-1.820	19.502	1.163	1.174	-0.960	19.965
2.5	0	0.278	0.267	3.929	0.0	1.337	1.354	-1.275	0.0
	5	0.259	0.234	10.838	4.846	1.216	1.284	-5.324	4.988
	10	0.271	0.232	16.871	9.667	1.126	1.230	-8.479	9.975
	15	0.262	0.230	13.694	14.496	1.181	1.211	-2.470	14.950
	20	0.268	0.225	18.842	19.290	1.187	1.149	3.413	19.939
3.0	0	0.251	0.239	5.341	0.0	1.234	1.281	-3.687	0.0
	5	0.239	0.236	1.262	4.793	1.220	1.269	-2.191	4.972
	10	0.218	0.219	-0.642	9.584	1.193	1.220	-2.226	9.948
	15	0.233	0.210	11.027	14.339	1.028	1.089	-5.568	14.886
	20	0.170	0.169	0.999	19.004	0.864	0.899	-3.869	19.802

Experimentation Data: Low Pressure vs High Pressure

FIG. 39

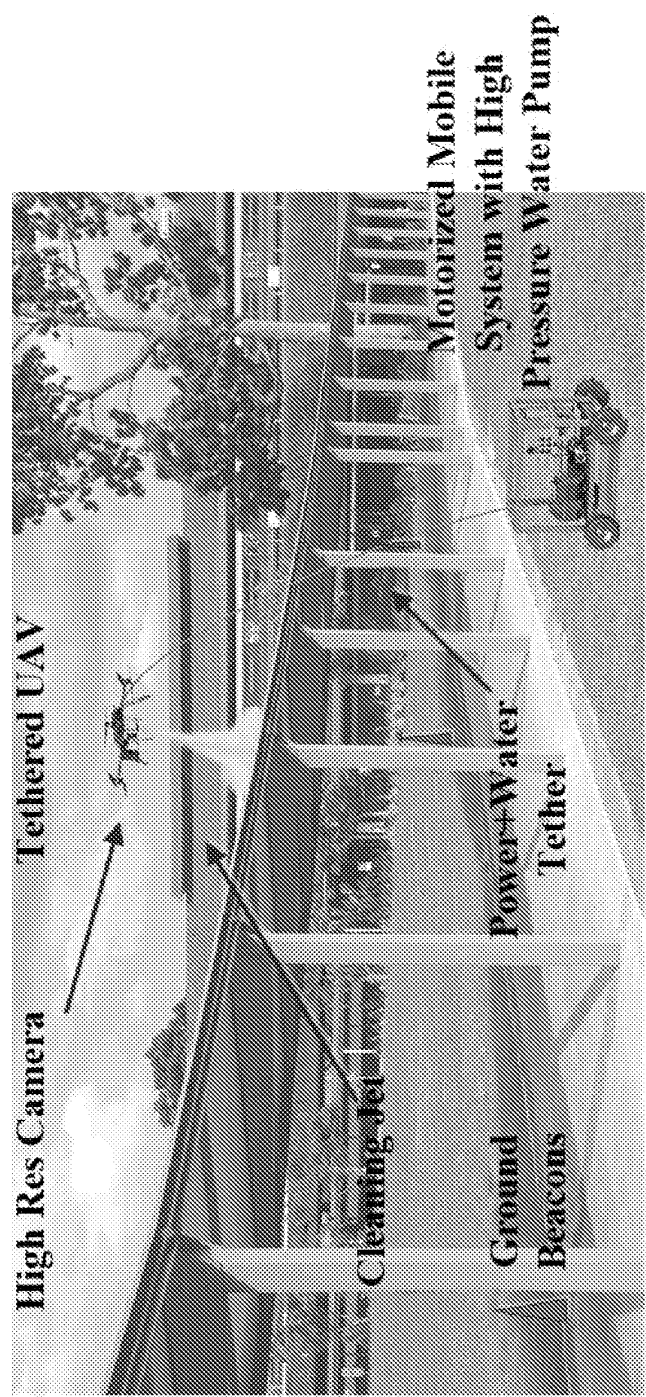


FIG. 40