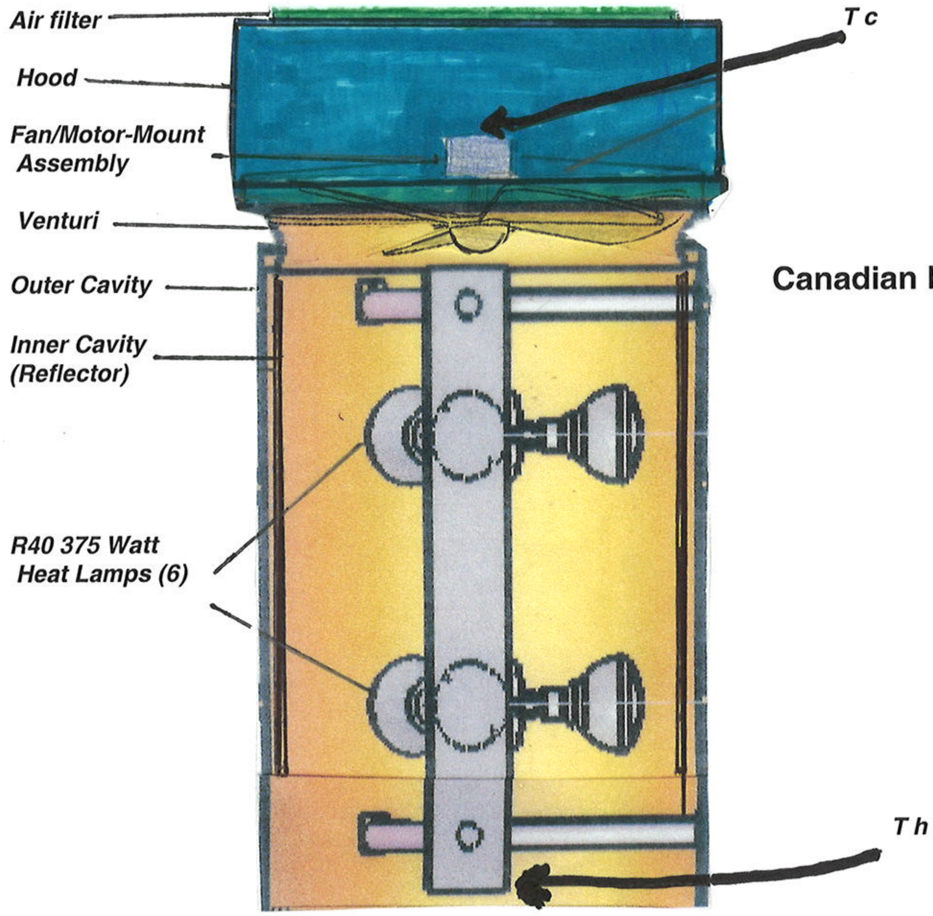
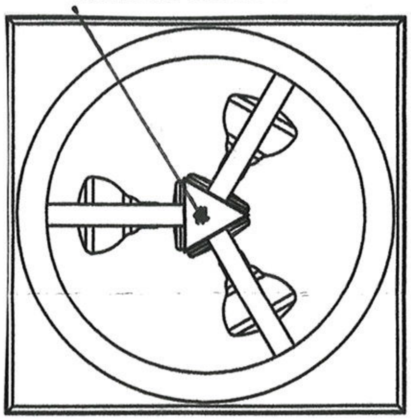
Dual Cavity, Single Pass Heat Exchanger; Electric Air Heater U.S. Patent 7133604B1



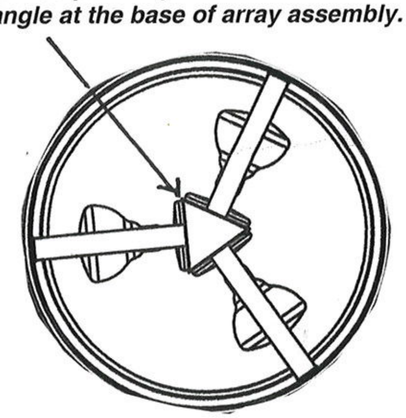
Canadian Patent 2535305

T c—intput temperature—is directly above the fan motor.



Top View (T c)

T h—output temperature--is at a 60° angle at the base of array assembly.



Bottom View (T h)

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HASER / Optical Resonator

A cylinder is an ideal geometric shape conducive to electrical, optical and thermal energy emissions. Electrically, a Faraday Cage is an ideal hollow conductor. Optically, a cylindrical shape is an ideal internal reflector / resonant optical cavity. With the heat lamp at proper focal length, thermal transfer to the reflector is sufficient to create both a real and virtual image over 175° F at the lamp's centerline. Therefore, the ideal focal length creates the ideal heat sink. The filaments never completely heat up, and this is probably why the R-40 incandescent IR heat lamps have lasted over 27,000 hours, 5 X their rating.

Heat Amplification by the Stimulated Emission of Radiation

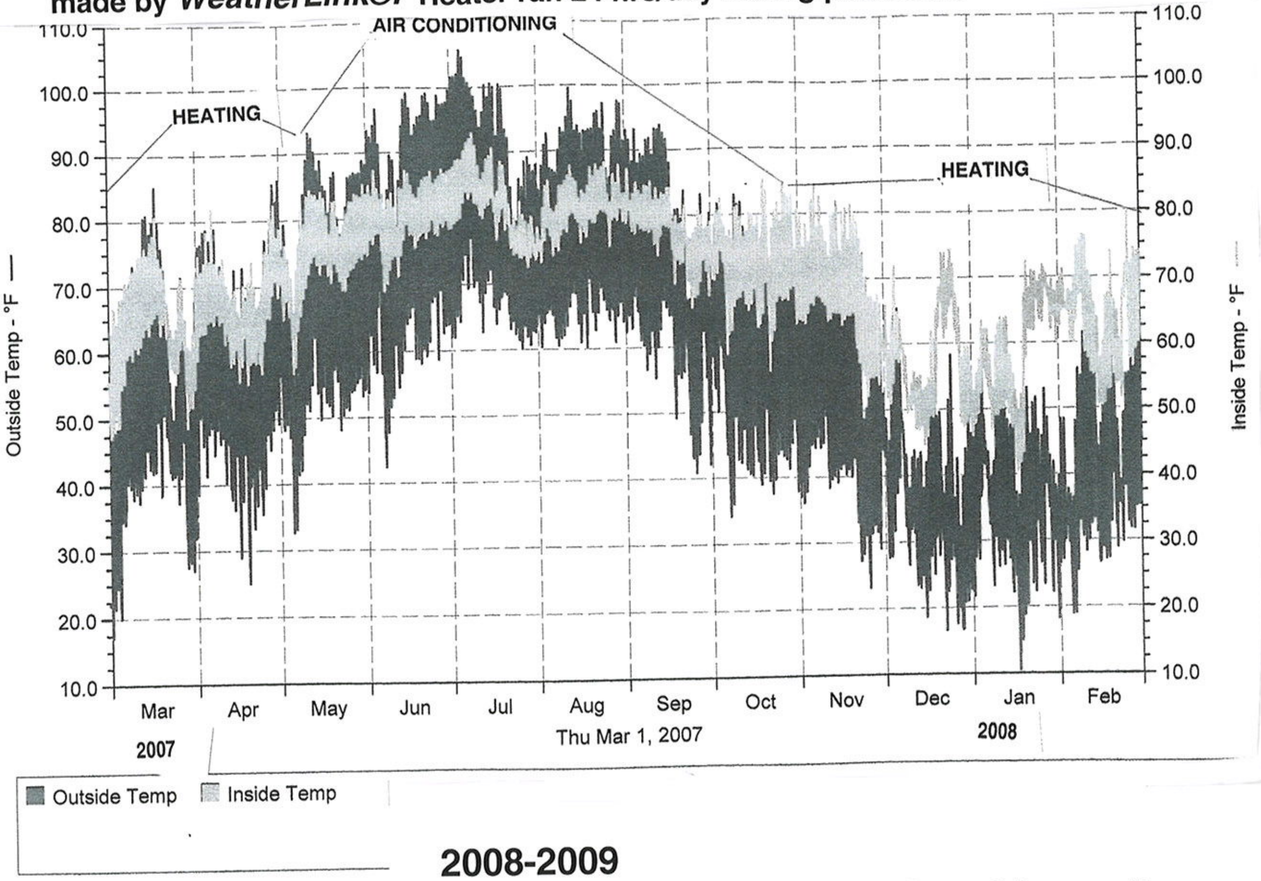
Highly efficient transfer of energy from wall outlet to R-40 lamps due in part to 10 ga. high heat wire. The basic electricity analogy of SWR—Standing Wave Ratio—is in radio. The cable between a transmitter and it's antenna (radiator) must be balanced in order to carry as much of the transmitter's power to the radiator. In radio, an ideal SWR is 1:1. The heat lamps radiate IR and light energy creating multiple wave-fronts. The resultant wave-fronts have an ideal SWR of approximately 1:1.5. The 1.5 portion is the magnified reflection of the R-40 heat lamp, the holographic image, both real and virtual. The holograph is the result of an ideal cylindrical reflector—optical resonator—containing a wave-front, generating standing waves. The standing-waves are reverse EM wave modes (M vertical E horizontal, as opposed to; typical E vertical M horizontal modes)

Conservation of angular momentum is greatly reduced in that the actual heat-energy source (the filaments) are adiabatically insulated from the external environment. This contravenes the ASHRAE correction factor for humidity content of air contacting a radiant heat source (Carnot Cycle) causing friction to airflow. Additionally, the ASHRAE correction factor does not apply to environmental conditions below 20% RH.

Heating a 21,000 ft.^{3} Building 2007-2009

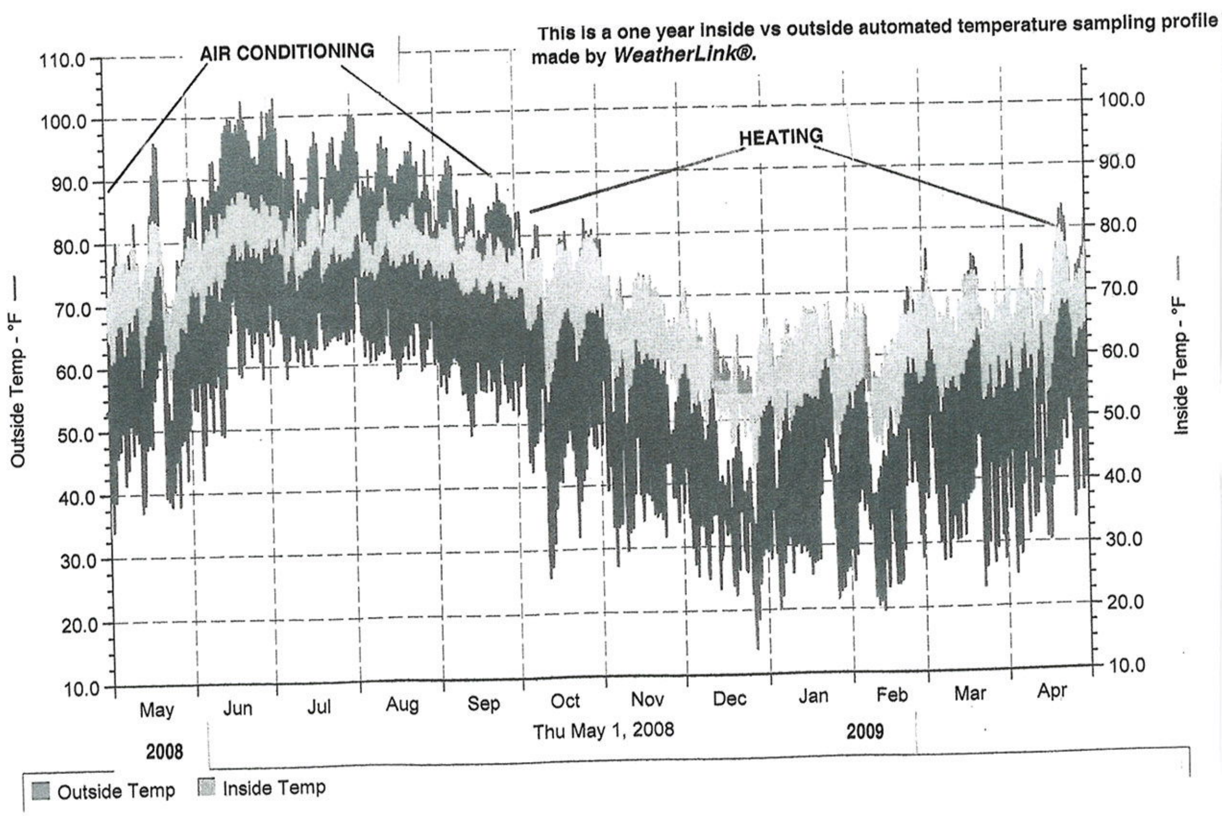
2007-2008

This is a one year inside vs outside automated temperature sampling profile made by *WeatherLink®*. Heater ran 24 hrs/day during peak cold.

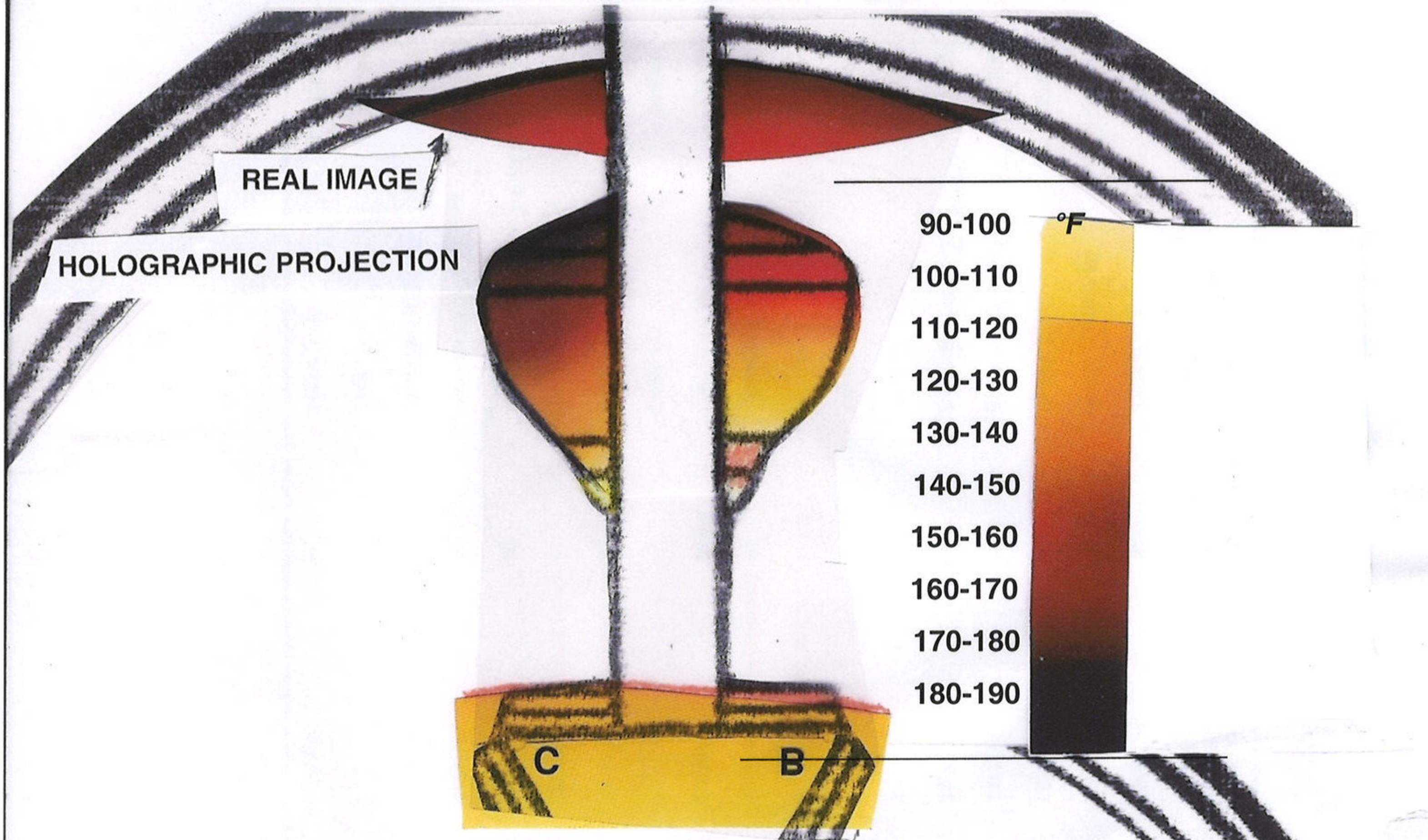


2008-2009

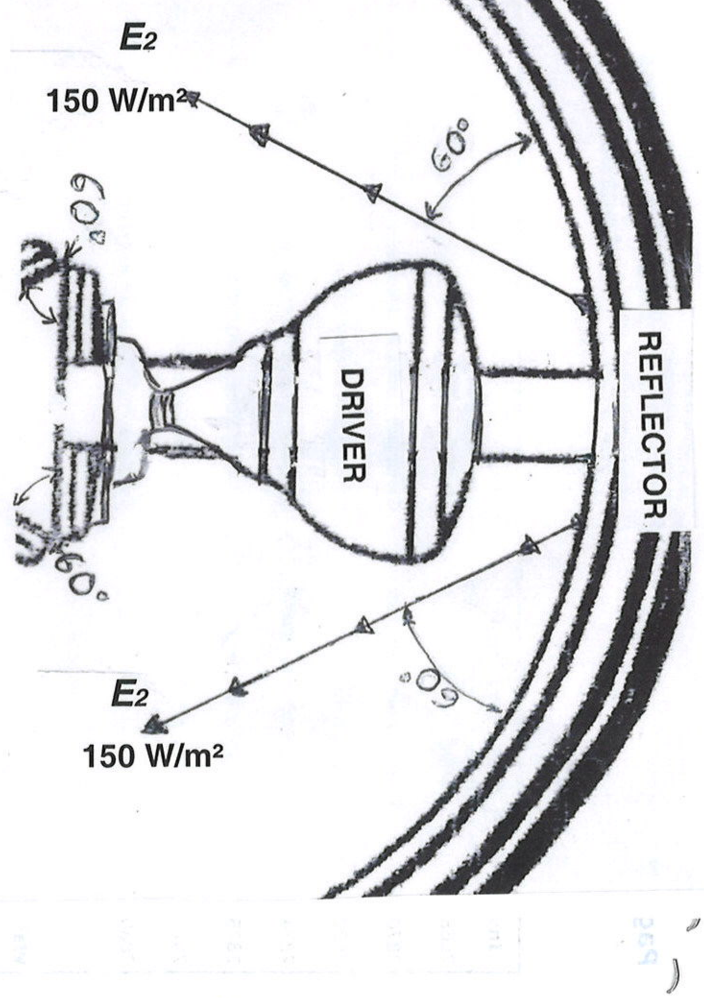
The building was heated daily from a cold start-up for about 8 hours. It took 4-5 hours to warm the building for work purposes



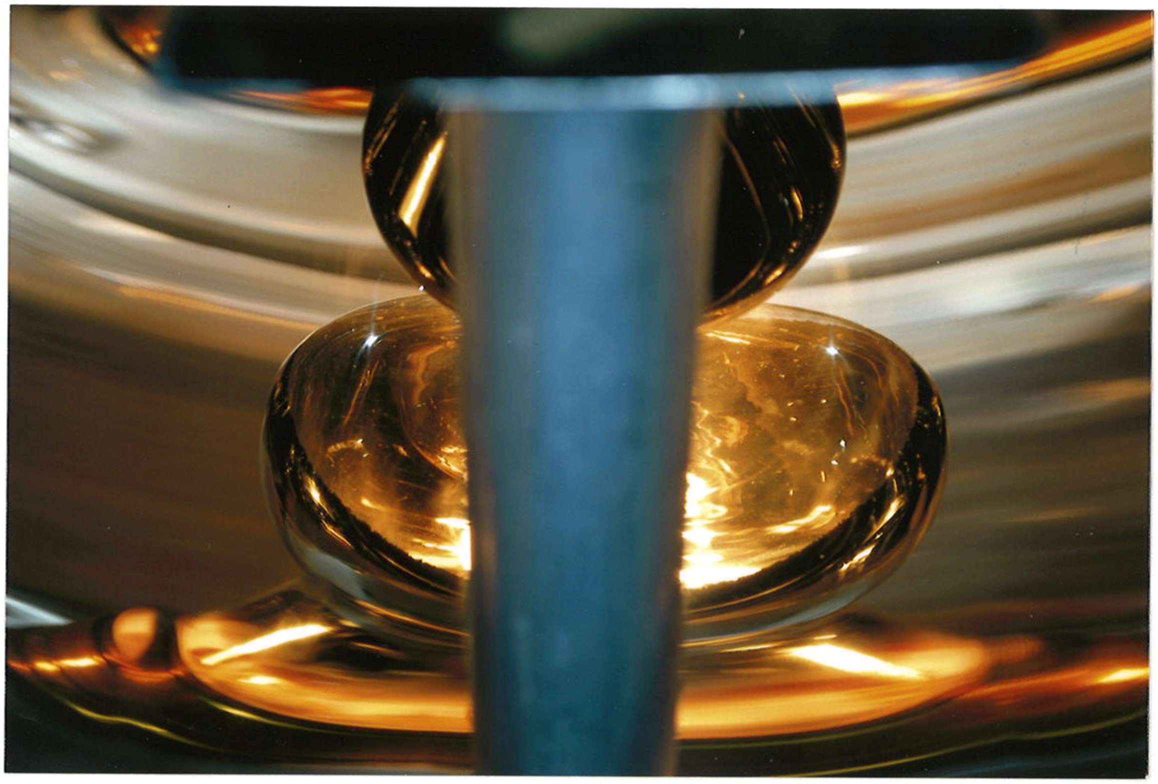
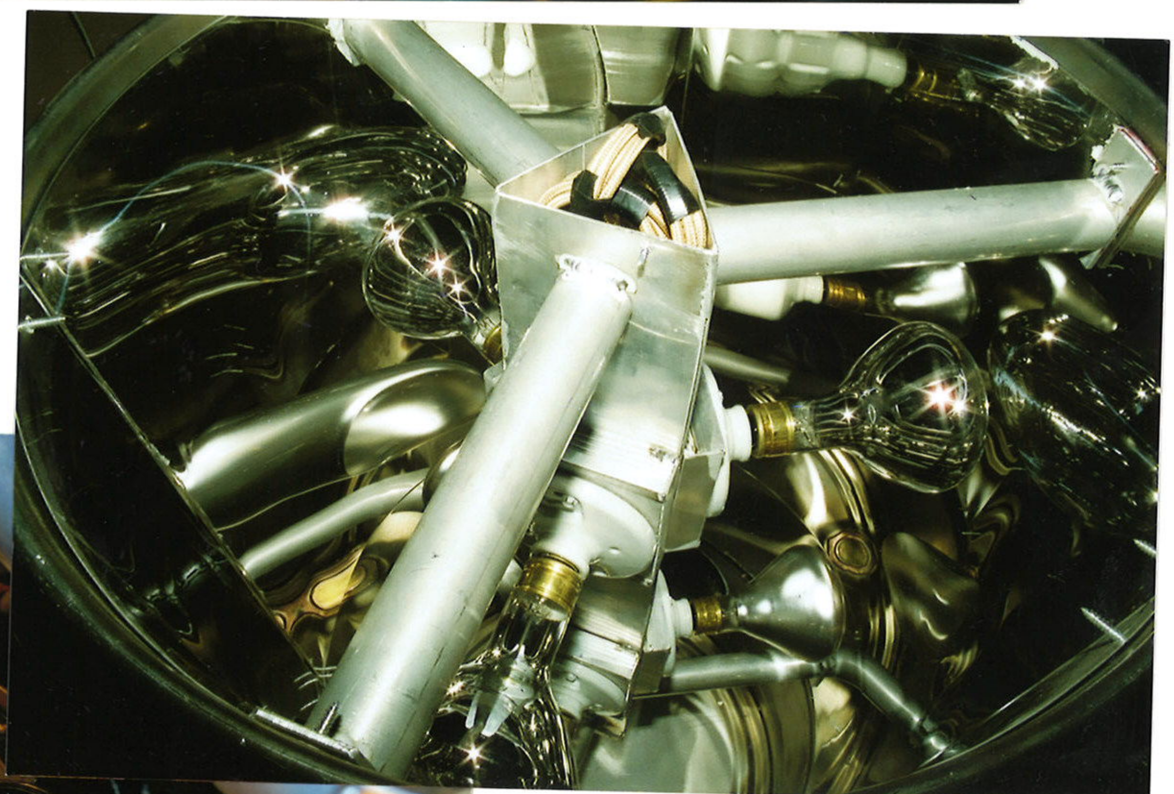
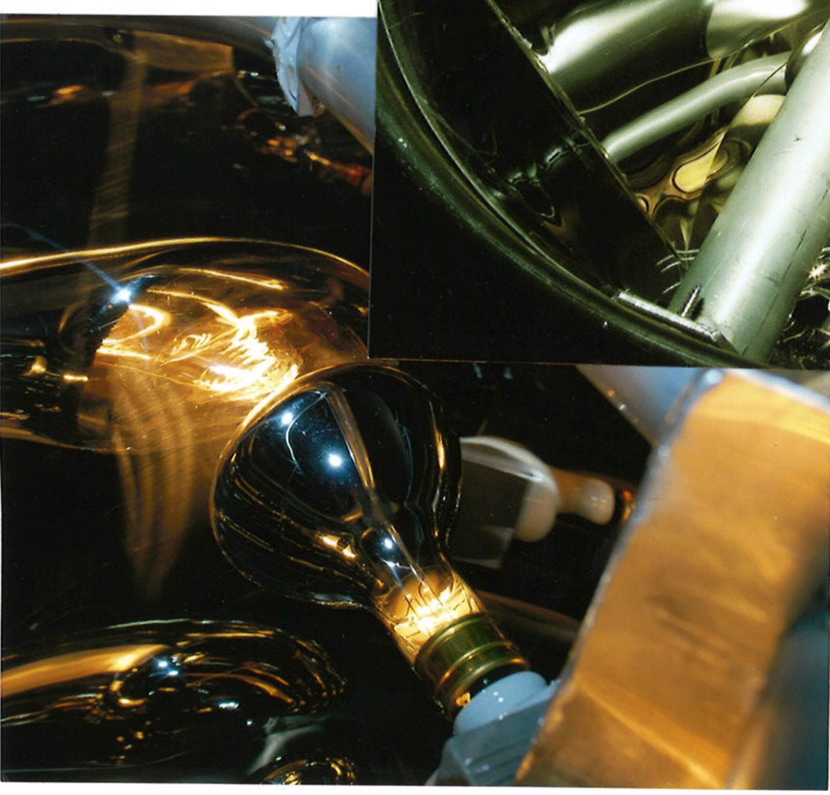
CROSS-SECTION OF HEATER;
Thermal Distribution between driver array and reflector.



Specular Reflection of Radiant Energy Inside a Cylindrical Reflector



W/m² irradiance measurements obtained with an Eppley PSP pyranometer. Readings were taken 23" from *E*2, so *E*2 would be even greater at it's source. (inverse square law) The optical magnification of the heat lamp translates into heat amplification with high thermoelectric gain.

SUMMARY OF HEATER USAGE 2007-2013

	Total # of Hours	Total kWh	Total $$	Cost $$ per-hour
2007-08	1521	3287	387.67	0.27
2008-09	4426	10504	1101.96	0.25
2009-10	4801.5	10502	1096.12	0.25
2010-11	4520.25	8221	883.89	0.2
2011-12	4552.5	7645	867.02	0.17
2012-2013	4556.25	7080	826.47	0.17
2013-2014	5022.75	8828	1175.97	0.21
2014-2015	4330.25	83.9	1196.06	0.27
Total	33730.5	56150.9	7535.16	1.79

$0.22 per hr 8 year average

#3 install	3000
plus	
Total	
	36730.5

SUMMARY 2007-2009; Running times, kWh and Cost $$

	# of Hours	kWh	$$	Cost $$ per-hour	2008-2009 # of Hours	kWh	$$	Cost $$ per-Hour
November	140	240	29.75	0.21	304.5	634	71.88	0.24
December	179	443	54.34	0.3	799	1632	166.47	0.21
January	233	627	69.79	0.3	905	2375	246.7	0.27
February	566	1265	140.01	0.25	884	2384	252.89	0.29
March	260	579	73.81	0.29	703.5	1697	184.32	0.26
April	143	133	19.97	0.25	710	1641	179.7	0.25
Total	1521	3287	387.67	$0.27	4306	10363	1101.96	$0.25

SUMMARY 2009-2010; Running times, kWh and Cost $$

2009-2010	# of Hours	kWh	$$	Cost $$ per-hour	2010-2011 # of Hours	kWh	$$	Cost $$ per-hour
November	443.25	855	104.67	0.24	547	835	93.92	0.17
December	851.5	2083	224.36	0.26	684.75	1626	153.79	0.22
January	888.25	2236	236.81	0.27	819.75	1906	200	0.24
February	832.25	1966	211.7	0.25	778	1751	190.2	0.24
March	719	2001	190.15	0.26	722.5	1280	151.54	0.21
April	575.25	1361	124.43	0.22	622.5	823	94.44	0.15
Total	4309.5	10502	1096.12	$0.25	4174.5	8221	883.89	$0.20

SUMMARY 2011-2012 Running times, kWh and Cost$$ 2012-2013

2011-2012	# of Hours	kWh	$$	Cost $$ per-hour	2012-2013 # of Hours	kWh	$$	Cost $$ per-hour
November	361	100	27.89	0.08	508.25	532	60.22	0.12
December	948.25	2261	243.89	0.22	794.5	1570	173.59	0.22
January	771	1770	189.33	0.24	805.25	1878	147.73	0.18
February	792.25	1476	198	0.25	828	1917	229.98	0.28
March	757.5	1083	93.75	0.12	643.75	361	88.46	0.14
April	797	955	114.16	0.14	606.25	539	80.54	0.13
May	125.5	42	16	0.13	370.25	283	45.95	0.12
	4552.5	7687	$883.02	$0.17	4556.25	7080	826.47	$0.17

SUMMARY 2013-2014 Running times, kWh and Cost$$

2013-2014	# of Hours	kWh	$$	Cost $$ per-hour	2014-2015 # of Hours	kWh	$$	Cost$$ per-hour
November	292.75	136	29.83	0.1	390.25	394	73.42	0.19
December	724.25	866	123.79	0.17	660	1761	227.71	0.34
January	792	1942	243.19	0.31	847	2359	281.69	0.33
February	803	1948	244.3	0.3	705.5	1423	194.41	0.27
March	802.75	1729	223.77	0.28	651	1302	181.22	0.28
April	707.25	1252	166.68	0.23	621.25	548	88.81	0.14
May	566.5	674	98.41	0.17	455.25	603	148.8	0.33
June	334.25	281	46	0.14	0	0	0	1.88
	5022.75	8828	1175.97	0.21	4330.25	8390	1196.06	$0.27

Specifications

Patented Infrared Air Heater
(Prototype III, design #1)*

Capacity: 7.6 ft^3 or 13,100 in^3
= 215,000 cm^3 *Reflective cavity portion only.*

Heat Sources: 6-375 Watt R40 incandescent heat lamps (3+3)

Total 2.75X6 ft. or 16 ft^2 (14,864 cm^2)
reflective surface (mirror finish chrome steel)

Total Array Input: HIGH: 2250 Watts for lamps + 200 Watts for fan
LOW: 3 lamps @1125 Watts + 150 Watts for fan

Energy Output: 74,000- BTU/hr (mean high)
37,000-BTU/hr (mean low)
BTU=1600-2000 CFM X ΔT.
($\Delta T = T_H - T_C$*, measured with matched thermistors*)

EE to ME ratio: 10 : 1 (Radiant Energy / Mechanical Energy)

Irradiance =500 Watts/M^2

Energy to
Weight Ratio: @74,000 BTU = 740 BTU/lb. (HIGH)
<u>@37,000</u> BTU = 370 BTU/lb. (LOW)

Preheat: NONE (crash-start)

Effectiveness: 6 hrs to increase temperature of 21,000 ft^3
(566 m^3) building by 7° F (13.8° C) **

Fan: 18" quadrafoil, metal

Controls: on/off arrays 'A, A+B,' variable fan speed, fan on/off

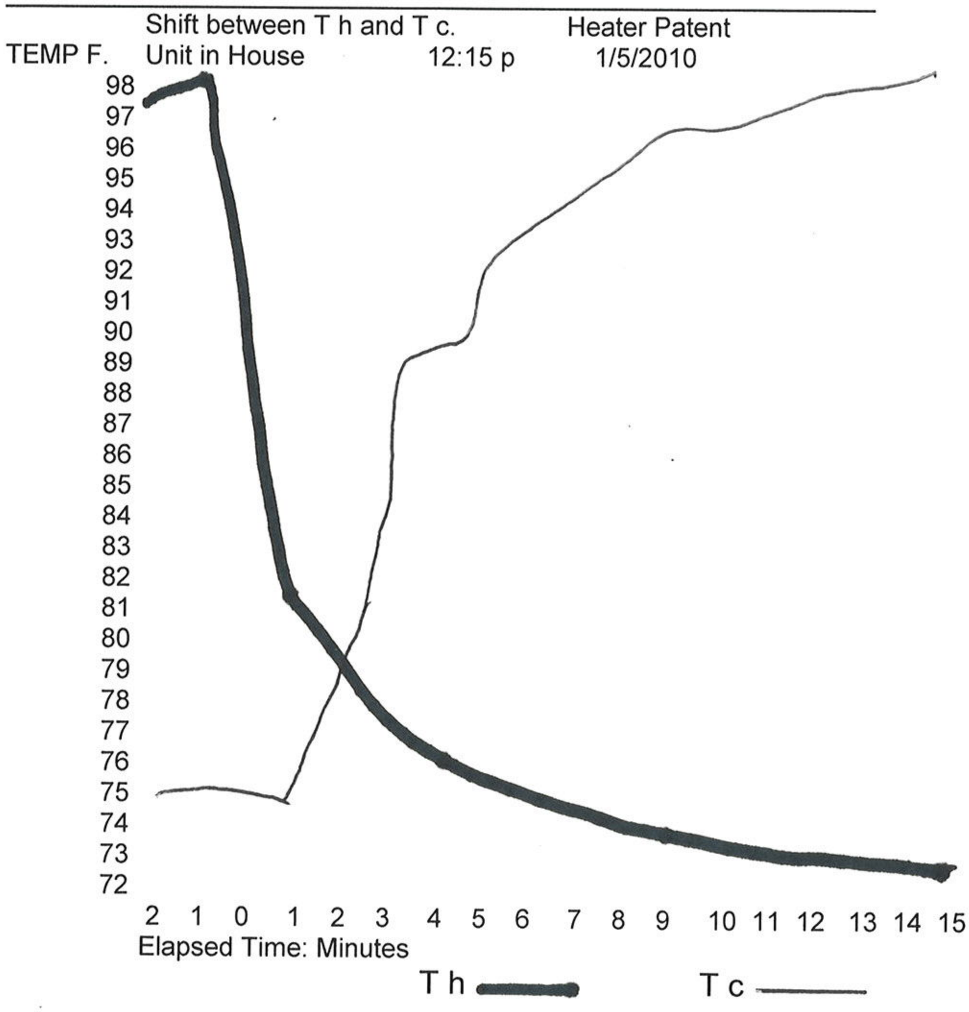
Dimensions: 23" D. X 50" H. (58 cm D. X 147 cm H.)

Weight: approximately 100 lbs. (45 kg.)

*** U.S. Patent 7133604 B1** **Canadian Patent 2535305** .

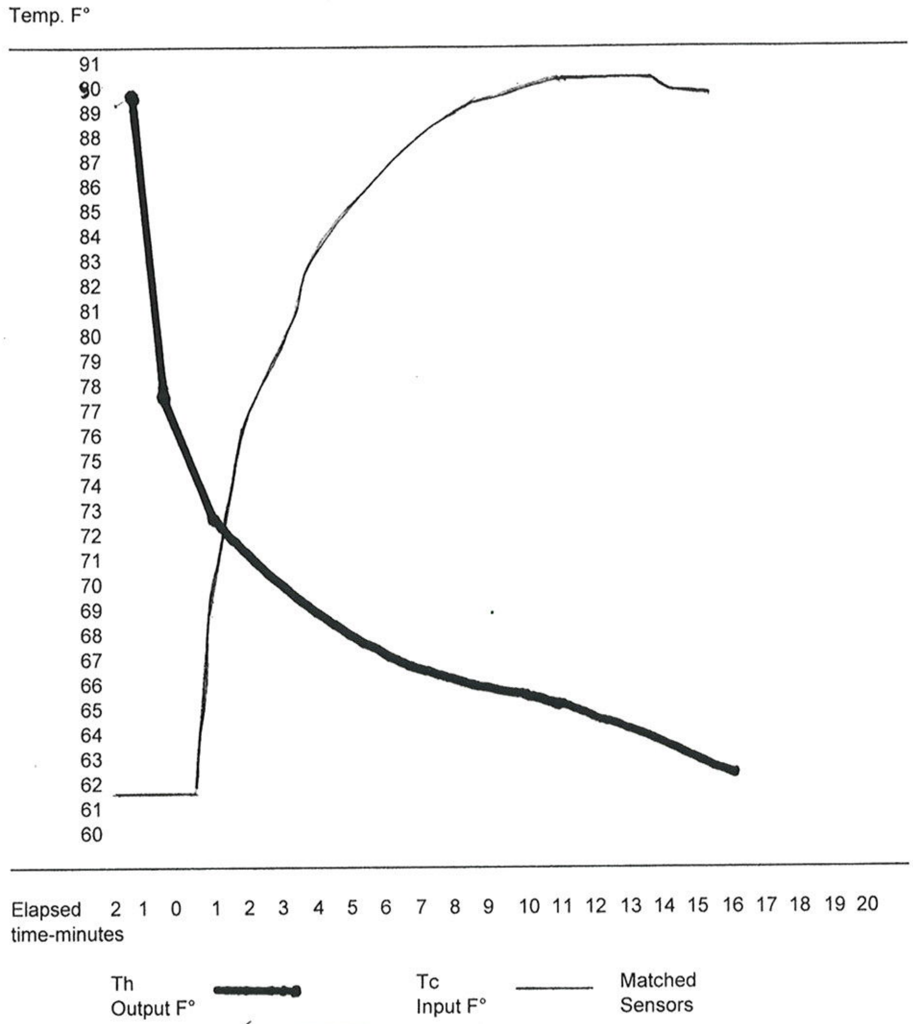
HYSTERESIS OF ELECTRIC HEATER IN HOUSE 1/5/2010
12:15

Minutes	T h		T c	milliGauss
2	97.7		74.6	400 max
1	97.9		75	
0	0	Cool Down	0	
1	80.6		73.4	
2	79.2		77.4	
3	77.2		83.8	
4	75.9		88.7	
5	75.2		91	
6	75.2		92.7	
7	74.5		94.3	
8	73.9		95.7	
9	73.8		95.9	
10	73.8		96.4	
11	73.4		96.8	
12	73.2		97.2	
13	73		97.3	
14	73		97.7	
15	73		97.3	



HYSTERESIS OF HEATER pre-through post shutdown heater in shop 02/09/2014

Th vs Tc; Tc placement 1 inch above fan motor shaft



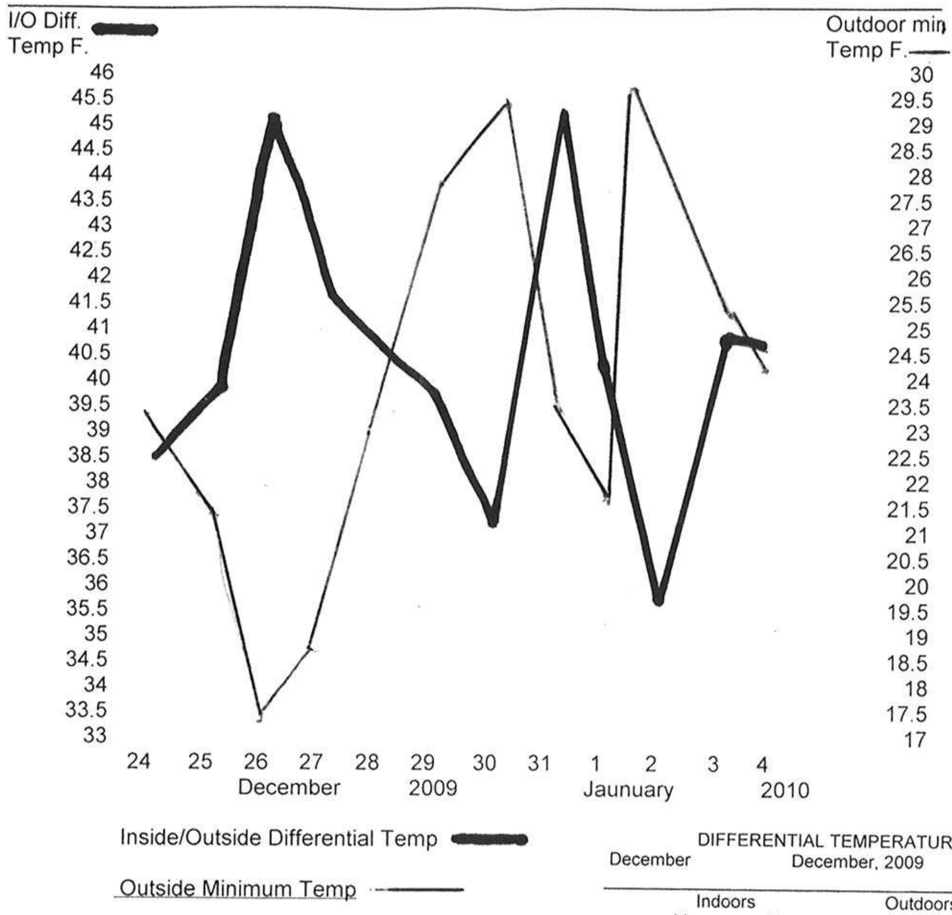
HYSTERESIS OF HEATER IN SHOP 9-Feb-14 Fahrenheit

Minutes	Th	Tc
2	89.2	61.5
1	89.4	61.5
0	77	61.5
1	72.2	68.9
2	70.7	76.5
3	69.1	81
4	68.5	83.1
5	67.5	85.1
6	66.9	86.5
7	66.4	87.8
8	66	88.9
9	65.8	89.4
10	68.5	89.8
11	65.3	90
12	64.8	90.1
13	64.4	90.1
14	64	90.1
15	63.9	89.8
16	63.7	89.6
	1323.3	1561.2
Max F°	89.4	90.1
Min F°	63.7	61.5
Δ	25.7	28.6

HYSTERESIS CURVES BETWEEN ΔT AND OUTSIDE MINIMUM DIURNAL TEMPERATURES

Prescott, Arizona elevation 5040 ft. December 2009-January 2010

INSIDE-OUTSIDE TEMPERATURE DIFFERENTIAL vs Outdoor Temperature
2009-10 Electric Heater Performance at Minimum Diurnal Temperatures



This graph compares warmth of the house to low outdoor temperatures. These are also diurnal, minimum temperatures. Interestingly, official U.S minimum temperatures for Prescott were lower, creating even greater hysteresis curves (and validation of heater's effectiveness).

DIFFERENTIAL TEMPERATURE BETWEEN INDOORS & OUTDOORS
December, 2009 Prescott, AZ el. 5040 ft

December	Indoors	Outdoors	Differential Temp
11	62	22.1	39.9
12	67	34.6	32.7
13	68.2	39.6	28.6
14	65.4	27.1	38.3
15	63.8	24.5	39.7
16	66.1	29	37.1
17	65.1	27.7	37.4
18	65.9	30.2	35.7
19	65.4	28.3	37.1
20	64.7	24.6	40.1
21	66.2	30.6	35.6
22	68.3	33.2	35.1
23	64.2	29.1	35.1
24	61.5	23.1	38.4
25	60.9	21.3	39.6
26	62.3	17.1	45.2
27	60.2	18.6	41.6
28	62.8	23	39.8
29	65.1	28	37.1
30	65.3	29.4	35.9
31	68.8	23.3	45.9
Total	1359.5	564.4	795.9
21 day mean F	64.7	26.8	37.9

January 2010	Indoors	Outdoors	Differential Temp
1	62	21.6	40.4
2	65.9	30.2	35.7
3	65.1	24.6	40.5
4	64.4	24	40.4

LED Research for 2^{nd} (Solid State) Design of Heater

2010

1/12 Tests using completed boards of 100 Infrared LEDs

#1 6798-OP 940 nm 5 vf DC max @ 20 ma (1.2 W DC)

Input: 1.4 V @ 1.29 A (1.81 W)

Output: 58 W/M^2 nominal; 134 W/M^2 max (average 96 W/M^2)

-Using 20 amp DC power supply: 1.4 V @ 1.5 A (2 W) obtained

102 W/M^2 nominal; 115 W/M^2 max (average 108 W/M^2)

-An additional test used 2.25 W input with 227 W/M^2 max

#2 OP-290A 890 nm 4 vf @ 1.5 amp (6 W DC)

Input: 1.6 V @ 1.4 A (2.24 W DC)

Output: 134 W/M^2 nom; 151 W/M^2 max

IR Emissions / Irradiance measured with Eppley Precision Spectral Pyranometers. The PSP has a linear response ranging from Near UV to 2800 nm

U.S. Patent Nov. 7, 2006 Sheet 5 of 8 US 7,133,604 B1

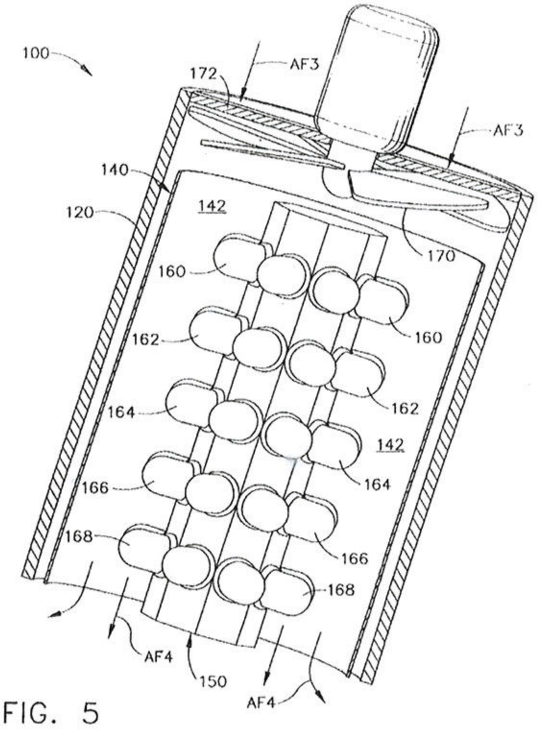
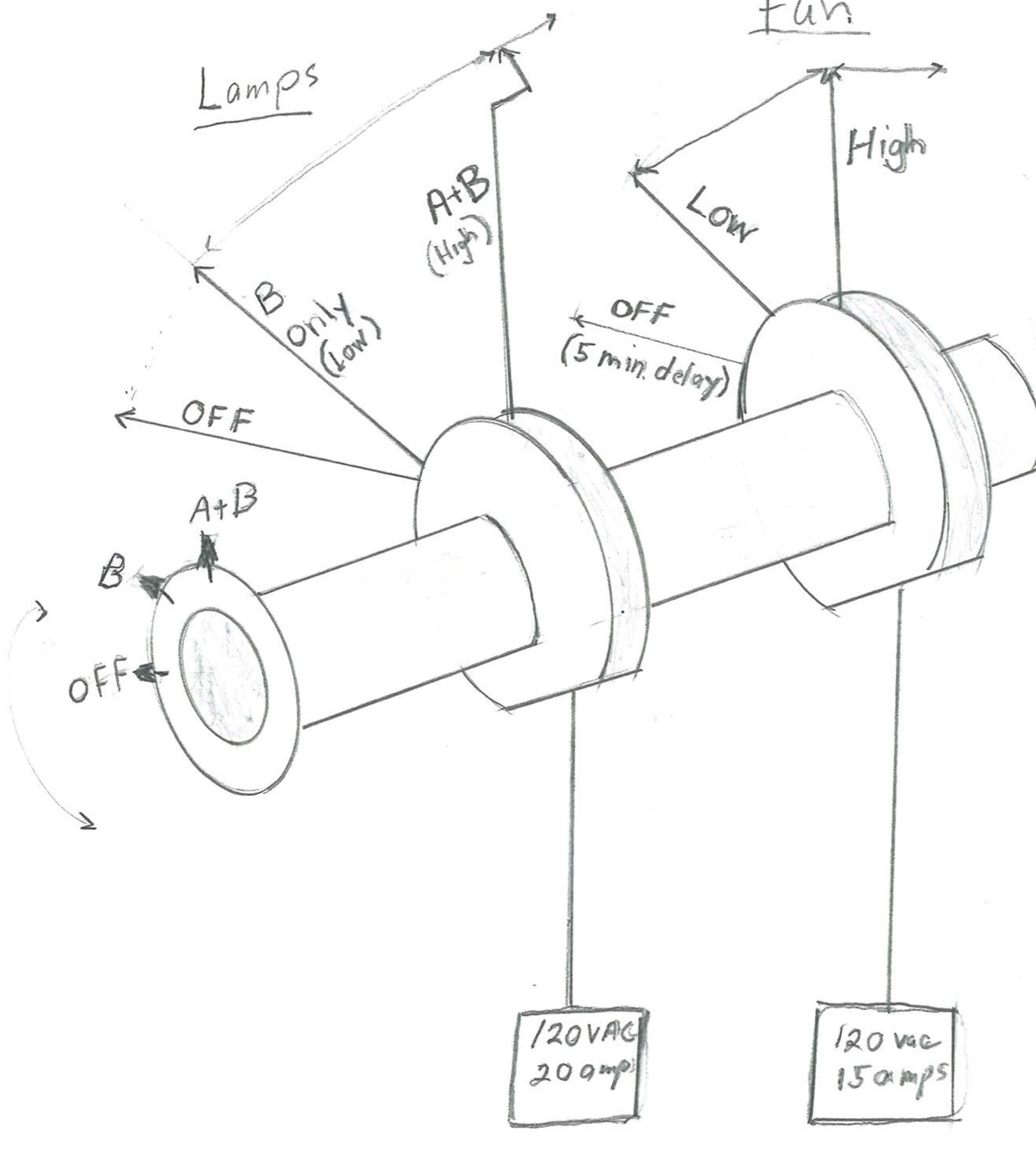


FIG. 5

The solid-state design utilizes LEDs Contained within about 12"D x 12"L (30 cm D x 30 cm L) housing.



Manual
DPDT
Switch
for
Heater