

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

GOOGLE LLC

Petitioner

v.

ECOFACITOR, INC.

(record) Patent Owner

Patent No. 8,131,497

DECLARATION OF RAJENDRA SHAH

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I. ENGAGEMENT AND COMPENSATION

1. My name is Rajendra Shah. (Ex. 1003). I have been retained by Google LLC for the purpose of providing my opinion with respect to the unpatentability of U.S. Pat. No. 8,131,497 (“the ’497 patent”). I am being compensated for my time in preparing this declaration at my standard hourly rate, and my compensation is not dependent upon my opinions or the outcome of the proceedings. My curriculum vitae is attached as Ex. 1003.

II. QUALIFICATIONS

2. I am currently the Principal at AnalyzRS LLC, a company providing, among other things, consulting services for the HVAC industry. I have been employed in this position since 2016.

3. I consider myself to have significant knowledge and experience in Heating, Ventilating and Air Conditioning (“HVAC”) systems, with particular knowledge relating to associated technology integration, control algorithms, modeling and simulation, and data analytics. I have significant knowledge and experience relating to the optimization of the operational efficiency of HVAC systems. My current Curriculum Vitae is attached as Exhibit 1003, and summarizes my qualifications.

4. Prior to my work for AnalyzRS LLC, I was employed at United

Technologies Carrier Corporation in Indianapolis, Indiana from 1991 to 2016. During my career at Carrier, my work focused on the design and development of HVAC systems and associated technologies. From 1991 to 2000, I was employed as a Senior Program Manager for Advanced Systems at Carrier. While in that position, I had responsibility for the launch of new product categories, including two stage air conditioners and heat pumps, variable speed fan coils, digital thermostats, multi zone controls, expandable filters and fresh air ventilators.

5. From 2000 to 2008 I was employed as an Engineering Manager for Systems Development. In that role I designed and managed the design of premium air conditioners, heat pumps, indoor fan coils, advanced thermostats, multi-zone controls and indoor air quality products. In particular, my team developed Carrier's Infinity® HVAC system, which was originally launched in 2004, and which went on to be a highly successful product.

6. From 2008 to 2016 I held the title of Engineering Fellow, Systems and Controls. I was one of the first eight Fellows selected to what was Carrier's top engineering position out of thousands of engineers worldwide. While in this position, I worked to develop Carrier's Infinity® Touch Control system with internet connectivity, which was first launched in 2012. This product received the Dealer Design Gold award from industry magazine ACHR News in 2013 and has continued to be a top-selling product for Carrier.

7. Beginning in 1984, I was employed as Project Manager for Electronically Commutated (Brushless DC) Motors at General Electric (GE) Motors. While employed in this role, I developed and launched GE's new line of brushless DC variable speed motors targeted at residential heating and air conditioning applications.

8. Beginning in 1977, I was employed by United Technologies Electronic Controls as a Project Engineer for Control Design. In this position, I designed high volume electronic controls, including electronic circuit design and microprocessor software, for appliances and heating and air conditioning systems.

9. I am a named inventor on at least 50 patents, with applications still pending. My patents primarily relate to the field of HVAC technology.

10. I hold a Bachelor's degree in Electrical Engineering from the Indian Institute of Technology, Bombay, India, which I obtained in 1975. I also obtained a Master's degree in Electrical Engineering, Ohio State University, Columbus, Ohio in 1977 and a Master's degree in Business Administration from the University of St Francis, Fort Wayne, Indiana in 1983.

III. SUMMARY OF OPINIONS

11. In my opinion, at least claims 1, 4, 7, and 10 of the '497 patent are anticipated by the Oswald publication. It is also my opinion that at least claims 1, 3-7, and 9-12 are obvious over Oswald, and the Cler patent. It is also my opinion

that claims 2 and 8 are obvious over the Oswald publication, the Cler publication, and in further view of the Rosen publication.

IV. MATERIALS REVIEWED

12. In forming my opinions, I have relied on my knowledge of the field and my experience, and have specifically reviewed the following exhibits:

Exhibit No.	Description
1001	U.S. Patent No. 8,131,497 (“ the ’497 patent ”).
1004	U.S. Pat. App. Pub. 2005/0171645 (“ Oswald ”).
1005	U.S. Pat. No. 4,897,798 (“ Cler ”).
1007	Joint Claim Construction Chart in <i>Smart HVAC Systems, and Components Thereof</i> , 337-TA-1185 (ITC March 6, 2020).
1008	U.S. Pat. No. 6,216,956 (“ Ehlers ”).
1009	U.S. Pat. No. 5,943,544 (“ Charles ”).
1010	U.S. Pat. No. 6,789,739 (“ Rosen ”).
1011	File History of U.S. App. Ser. No. 12/959,225.
1013	File History of U.S. App. Ser. No. 12/211,733.
1014	U.S. Pat. App. Pub. 2005/0288822 (“ Rayburn ”).
1015	U.S. Pat. No. 4,660,759 (“ Barnard ”).
1016	U.S. Pat. No. 6,029,092 (“ Stein ”).
1017	Horan, T, <i>Control Systems and Applications for HVAC/R</i> , Prentice-Hall, Inc., 1997.
1018	Levenhagen, J, <i>HVAC Control and Systems</i> , McGraw-Hill, Inc., 1993.

V. UNDERSTANDING OF THE RELEVANT LAW

13. I have the following understanding of the applicable law:

A. Anticipation

14. I understand that a claim in an issued patent can be unpatentable if it is anticipated. I understand that “anticipation” means that there is a single prior art reference that discloses every element of the claim, arranged in the way required by the claim.

15. I understand that an anticipating prior art reference must disclose each of the claim elements expressly or inherently. I understand that “inherent” disclosure means that the claim element, although not expressly described by the prior art reference, must necessarily be present based on the disclosure. I understand that a mere probability that the element is present is not sufficient to qualify as “inherent disclosure.”

B. Obviousness

16. I understand that a claim in an issued patent can be unpatentable if it is obvious. Unlike anticipation, obviousness does not require that every element of the claim be in a single prior art reference. Instead, it is possible for claim elements to be described in different prior art references, so long as there is motivation or sufficient reasoning to combine the references, and a reasonable expectation of success in achieving what is set forth in the claims.

17. I understand that a claim is unpatentable for obviousness if the

differences between the claimed subject matter and the prior art are such that the subject matter as a whole would have been obvious at the time the alleged invention was made to a person having ordinary skill in the art to which said subject matter pertains.

18. I understand, therefore, that when evaluating obviousness, one must consider obviousness of the claim “as a whole”. This consideration must be from the perspective of the person of ordinary skill in the relevant art, and that such perspective must be considered as of the “time the invention was made.”

19. The level of ordinary skill in the art is discussed in ¶¶26-27 below.

20. The relevant time frame for obviousness, the “time the invention was made”, is discussed in ¶¶28-29, below.

21. I understand that in considering the obviousness of a claim, one must consider four things. These include the scope and content of the prior art, the level of ordinary skill in the art at the relevant time, the differences between the prior art and the claim, and any “secondary considerations.”

22. I understand that “secondary considerations” include real-world evidence that can tend to make a conclusion of obviousness either more probable or less probable. For example, the commercial success of a product embodying a claim of the patent could provide evidence tending to show that the claimed invention is not obvious. In order to understand the strength of the evidence, one would want to

know whether the commercial success is traceable to a certain aspect of the claim not disclosed in a single prior art reference (*i.e.*, whether there is a causal “nexus” to the claim language). One would also want to know how the market reacted to disclosure of the invention, and whether commercial success might be traceable to things other than innovation, for example the market power of the seller, an advertising campaign, or the existence of a complex system having many features beyond the claims that might be desirable to a consumer. One would also want to know how the product compared to similar products not embodying the claim. I understand that commercial success evidence should be reasonably commensurate with the scope of the claim, but that it is not necessary for a commercial product to embody the full scope of the claim.

23. Other kinds of secondary considerations are possible. For example, evidence that the relevant field had a long-established, unsolved problem or need that was later provided by the claimed invention could be indicative of non-obviousness. Evidence that others had tried, but failed to make an aspect of the claim might indicate that the art lacked the requisite skill to do so. Evidence of copying of the patent owner’s products before the patent was published might also indicate that its approach to solving a particular problem was not obvious. Evidence that the art recognized the value of products embodying a claim, for example, by praising the named inventors’ work, might tend to show that the claim was non-

obvious.

24. I further understand that prior art references can be combined where there is an express or implied rationale to do so. Such a rationale might include an expected advantage to be obtained, or might be implied under the circumstances. For example, a claim is likely obvious if design needs or market pressures existing in the prior art make it natural for one or more known components to be combined, where each component continues to function in the expected manner when combined (i.e., when there are no unpredictable results). A claim is also likely unpatentable where it is the combination of a known base system with a known technique that can be applied to the base system without an unpredictable result. In these cases, the combination must be within the capabilities of a person of ordinary skill in the art.

25. I understand that when considering obviousness, one must not refer to teachings in the specification of the patent itself. One can, however, refer to portions of the specification admitted to being prior art, including the “BACKGROUND” section. Furthermore, a lack of discussion in the patent specification concerning how to implement a disclosed technique can support an inference that the ability to implement the technique was within the ordinary skill in the prior art.

VI. LEVEL OF ORDINARY SKILL IN THE ART

26. In my opinion, the relevant art was that of heating, ventilation, and air conditioning (“HVAC”) control and building automation. I note that the ’497 patent

teaches that “[t]his invention relates to the use of thermostatic HVAC controls that are connected to a computer network.” (Ex. 1001, 1:17-18). In my opinion, the level of ordinary skill encompassed a person with at least a (1) Bachelor’s degree in engineering, computer science, or a comparable field of study, and (2) at least five years of (i) professional experience in building energy management and controls, or (ii) relevant industry experience. In my opinion, additional relevant industry experience may compensate for lack of formal education or vice versa.

27. I believe I would meet this definition, and would have met this definition in the relevant timeframe. My testimony is offered from this perspective, even if it does not specifically refer to the perspective of a person of ordinary skill in the art in every instance.

VII. RELEVANT TIMEFRAME FOR DETERMINING OBVIOUSNESS

28. I understand that obviousness must be evaluated “at the time of the invention.” From the cover pages of the ’497 patent, I can see that the first provisional application for a patent was filed in the United States on September 17, 2007.

29. For the purpose of this declaration, I will analyze obviousness in the time frame immediately prior to this date, although my testimony is usually applicable to a longer period of time before September 17, 2007. My testimony is directed to this timeframe, even if I do not always use a past tense.

VIII. TECHNICAL INTRODUCTION

A. The '497 Patent Disclosure

30. The '497 patent at-issue relates generally to heating or cooling systems ("HVAC systems"). (Ex. 1001, Abstract, 1:17-18). Such HVAC systems have, for decades prior to the relevant timeframe, been controlled by thermostats. (Ex. 1001, 1:24-42)("Climate control systems such as heating and cooling systems for buildings (heating, ventilation and cooling, or HVAC systems) have been controlled for decades by thermostats."). A thermostat is a device which senses the temperature of a system and performs actions so that the system's temperature is maintained near a desired setpoint.

31. Thermostats are typically wall-mounted units that have an internal temperature sensor which measures the actual temperature. (Ex. 1001, 1:31-48). In general, thermostats read temperature from the sensor located within the thermostat. (Ex. 1001, 2:21-23)("In general, thermostats read temperature from the sensor located within the 'four corners' of the thermostat.").

32. Thermostats also allow a user to set a target or "desired" temperature, which is sometimes referred to as a "setpoint." (Ex. 1001, 1:31-48)(Ex. 1005, 1:12-14). The target temperature, or "set point," is compared against the actual temperature, and the HVAC system is switched on or off in an attempt to achieve the set point temperature. (Ex. 1001, 1:31-42)(Ex. 1010, 1:21-27)("In the well

known manner, a simple thermostat can be adjusted to establish a temperature set point such that, when the temperature in the conditioned space reaches the set point, the thermostat interacts with the heating and/or/cooling equipment to take suitable action to heat or cool the conditioned space as may be appropriate for the season.”).

33. As the '497 patent accurately summarizes, “[a]t the most basic level, a thermostat includes a means to allow a user to set a desired temperature, a means to sense actual temperature, and a means to signal the heating and/or cooling devices to turn on or off in order to try to change the actual temperature to equal the desired temperature.” (Ex. 1001, 1:26-31).

34. Programmable thermostats were well known in the art during the relevant time. (*See, e.g.*, Ex. 1010, 1:29-49)(“Modern thermostat systems . . . have many features which provide more precise supervision of the heating and/or cooling equipment to achieve more economical and more comfortable management of the temperature of a conditioned space. . . . Many modern thermostat systems are programmable by a user.”)(Ex. 1001, 1:35-42)(“More recently, electronic digital thermostats have become prevalent. These thermostats use solid-state devices such as thermistors or thermal diodes to measure temperature, and microprocessor based circuitry to control the switch and to store and operate based upon user-determined protocols for temperature vs. time.”).

35. The '497 patent reports that there may be opportunities to improve

typical thermostat function. (Ex. 1001, 1:53-62). This is because, for example, according to the '497 patent, programmable thermostats are either not programmed or programmed sub-optimally, and programmable thermostats having only two inputs (the actual temperature and the desired temperature) can be limited in functionality. (Ex. 1001, 1:53-2:2).

36. As the '497 patent notes, the rate at which an HVAC system can heat or cool a building depends on the temperature outside and the thermal properties of the building. (Ex. 1001, 2:52-67). For example, older houses may have little or no insulation, be poorly sealed, and have simple single-glazed windows. As a result, such houses will do a very poor job of retaining internal heat in the winter and rejecting external heat in the summer. Absent the use of heating or cooling, the inside temperature in such houses will trend to track outside temperatures very closely. (*Id.*) The '497 patent states that such houses may be said to have low “thermal mass.”¹ By contrast, asserts the '497 patent, a newer house built using contemporary techniques for energy efficiency such as high levels of insulation, double glazed windows and other techniques, will, absent the use of heating or cooling, tend to absorb external heat and release internal heat more slowly. The

¹ The '497 patent here conflates the concepts of “thermal mass” and “thermal conductance”.

newer house can be thought of as having higher “thermal mass” than the older house.
(*Id.*)

37. The '497 patent explains that the thermal properties of a building and the weather outside, including the temperature outside, can be used in calculations relating to HVAC systems. (Ex. 1001, 11:10-19). For example, the '497 patent discusses having a server that uses measurements of inside temperature, outside temperature, and other factors to predict the building's thermal characteristics and the performance of the HVAC system. (Ex. 1001, 8:63-9:9). The '497 patent explains that “effective thermal mass for [a] structure” “is the speed with the temperature inside a given building will change in response to changes in outside temperature and differences between inside and outside temperatures.” (Ex. 1001, 8:67-9:5).

38. The exact nature of the calculations used in '497 patent to calculate the operational efficiency of a HVAC system, however, is not disclosed. Instead the '497 patent states only generally that inside temperature, outside temperature, and other factors are taken into account, and that the server can calculate the “thermal mass index” of a house “by applying a basic algorithm that weighs each of these external variables as well as variables for various characteristics of the home itself (such as size, level of insulation, method of construction, etc.) and data from other houses and environments.” (Ex. 1001, 11:8-19).

B. Claims of the '497 Patent

39. The '497 patent has two independent claims. Independent claim 1, which is directed to a “system,” reads as follows:

“1. A system for calculating a value for the operational efficiency of a heating, ventilation, and air conditioning (HVAC) system comprising:

at least one HVAC control system that receives temperature measurements from at least a first location conditioned by at least one HVAC system;

one or more databases that store at least said temperatures measured at said first location over time; and

one or more processors that receive outside temperature measurements from at least one source other than said HVAC system,

wherein said one or more processors are configured to calculate one or more rates of change in temperature at said first location for periods during which the status of the HVAC system is ‘on’ and

wherein said one or more processors are further configured to calculate one or more rates of change in temperature at said first location for periods during which the status of the HVAC system is ‘off’, and

to relate said calculated rates of change to said outside temperature measurements.”

40. Thus, claim 1 is directed overall to a system for calculating operational efficiency. The claimed system must be able to calculate the rates of change of

inside temperature at a first location being “conditioned” by the HVAC system (in other words, the “**inside** temperature”) when an HVAC system is ‘on’ and when it is ‘off.’ The system must also be able to “relate” these rates of change to the **outside** temperature. The claim does not require any specific method of “relat[ing]” the calculated rates of changes to the outside temperature measurements.

41. As I note above, the ’497 patent does not describe any particular calculations that it uses to determine operational efficiency of the HVAC system. Nor does the ’497 patent describe any specific calculations for the rates of change when the HVAC system is ‘on’ or ‘off,’ or how those might relate to operational efficiency, if at all.

42. However, the relationship between the rate of change in inside temperature and the outside temperature was well-known in the art. Specifically, it was well known that, everything else being equal, the rate at which heat flows from a point on the interior of a building through an external wall to the exterior is generally proportional to the difference in temperature between the two points. For example, on a hot summer afternoon, a building will gain heat (incur a rise in temperature) faster than on a cool day. This places a greater demand on the air conditioning system on a hot day. Similarly, on a cold winter day, the building will lose heat more quickly, placing greater demand on the heating system. Thus, the

apparent ability of the HVAC system to change the temperature of the building depended strongly on the external temperature. (See, e.g., Ex. 1012, 1:39-41)(recognizing “the fact that the time required to raise or lower the temperature of a condition space varies as a function of outdoor air temperature”).

43. This relationship was both common sense and textbook knowledge in the relevant timeframe. (Ex. 1017, p. 200)(“The quantity of heat migrating through the wall is *directly proportional* to the temperature difference and *inversely proportional* to the resistance of the insulation, wall materials and film of air that forms on the wall’s surfaces.”)(Ex. 1018, p. 281). As described above, it was well-understood that the rate of heat transfer into or out of a building (without the application of an HVAC system) was based on the heat flow across exterior walls, which was proportional to the difference between exterior and interior temperature. Thus, the larger the difference between the inside and outside temperature, the faster a building would heat up or cool down.

44. This effect was taken into account by numerous prior art systems which, like the ’497 patent, sought to more efficiently manage HVAC systems. One common prior art application that used the concepts of claim 1 of the ’497 patent (calculating rates of change with the HVAC system ‘on’ and ‘off’ and the outside temperature) related to the use of a so-called “**setback**” schedule.

45. A setback schedule is simply a schedule to change the setpoint of a

thermostat at different times of day, in order to save energy. (*See, e.g.*, Ex. 1012, 4:14-16)(“Thermostat setback 80 takes place to conserve energy at times when occupancy comfort 39 is not scheduled.”)(Ex. 1018, p. 128, 135). A simple setback schedule can be illustrated through the following example. Some structures, such as a typical workplace, are only generally occupied during the daytime. Thus, they may not need to be either heated (or cooled) to the same degree at night when they are expected to be unoccupied. A user might program a workplace thermostat during the winter to have a daytime (8 AM to 5 PM) setpoint of 70 F, but an evening setpoint of 50 F, when it is generally expected that the building will be unoccupied.

46. To achieve these two different setpoints, the thermostat would turn the HVAC system ‘off’ at 5 PM, but turn it back on sometime before 8 AM, to make sure the workplace was warm enough by 8 AM. Setting the setpoint down to 50 F (e.g.) was called “setback”, while heating the building back up to 70 F in the morning was called sometimes “recovery.” (*See, e.g.*, Ex. 1015, 1:20-39)(“For example, the setpoint temperature within the building can be set up during summer months and set back during winter months when the building is not occupied in order to reduce the cost of running the temperature control systems during times of non-occupancy.”)(Ex. 1008, 19:27-20:3)(Ex. 1012, 7:19-23)(Ex. 1005, 1:12-30).

47. A further refinement of the setback and recovery concept was known as “**optimum start / stop.**” The point of optimum start / stop was to calculate the

optimum time to stop the HVAC system prior to setback, as well as the optimum time to start the HVAC system again to begin recovery. (*See, e.g.*, Ex. 1015, 1:7-39)(“Together with the set up and set back function, the systems can perform an optimum start function in which the air conditioning system is reenergized for an amount of time calculated to bring the space temperature within the comfort range for the building by the start of occupancy. In addition, typical systems will also provide an optimum stop function in which the air conditioning system is shut off for a period of time prior to end of occupancy, this period of time designed to allow the space temperature to drift within the comfort range but not drift beyond the comfort range before the end of occupancy.”).

48. It was understood decades before the '497 patent that HVAC systems could be turned off somewhat prior to their scheduled setback time, and then allowed to drift to the setback temperature (in the present example, drifting from 70 F to 50 F), without causing the building to become uncomfortable. This could save energy by turning off the HVAC system somewhat early—perhaps at 4 pm instead of at 5 pm, in the present example. (*See, e.g.*, Ex. 1015, 1:33-39). Similarly, to perform recovery from a setback temperature, the HVAC system would be turned on at the latest possible time to reach the daytime temperature in time for occupancy. In the present example, any energy used to maintain the building at 70 F before employees began to show up at 8 am would in effect be wasted energy. Thus, it would be most

efficient to turn on the system at the latest possible time to achieve an acceptable temperature at the time occupancy starts.

49. To determine the optimum HVAC system stopping and starting times, one needed to know how fast the HVAC system itself could heat or cool a structure, and how fast the structure would naturally heat or cool when the HVAC system was ‘off’. (Ex. 1015, 1:60-2:13). Knowing these rates permits one to calculate the best times to turn the HVAC system ‘on’ and ‘off’. (*Id.*).

50. Both of these rates were, of course, affected by the outside temperature. (*See, e.g.*, Ex. 1015, 1:40-59). As I explain above, for example, it is harder to heat a building on a cool day, and harder to cool a building on a warm day. The textbook “Control Systems and Applications for HVAC/R” explains as follows:

*“Optimum Start and Optimum Stop are strategies that further reduce electrical consumption in comparison to time of day scheduling. They vary the scheduled start and stop times of the equipment based upon current environmental conditions. The time of day program confines equipment to a fixed operating schedule. **On extreme weather days, the zone may take 60 minutes to reach comfort levels while during milder weather it may only take 20 minutes.** The time of day program schedule must reflect the earliest start time to be sure the zone is at comfort set point before the occupants arrive. Any additional time the equipment operates at the occupied period set point, before the occupied period begins, wastes energy.”*

(Ex. 1017, p. 261)(Emphasis added).

51. Optimum start / stop calculations which took into account the outside temperature conditions were common in the prior art. For example, Levenhagen's 1993 textbook entitled "HVAC Controls and Systems", published 14 years prior to the first application leading to the '497 patent, states:

"Optimum start and stop is one of the most commonly used standard EMS programs. Here, the outdoor air temperature and inside space temperatures are used to calculate the lead time necessary to condition a space to achieve comfort conditions by the time of occupancy."

(Ex. 1018, p. 281).

52. Given applications like optimum start / stop, the principal claimed elements of the '497 patent (rates of change with the HVAC System 'on' and 'off', as related to outside temperature) were already in widespread use in numerous prior art systems. These systems, like the '497 patent, sought to more efficiently manage HVAC systems to reduce energy consumption. One such system is described by U.S. Pat. Pub. 2005/0171645 to Oswald (Ex. 1004), which I discuss in detail below.

IX. CLAIM INTERPRETATION

53. I understand that it is sometimes necessary or useful for claim terms in a patent to be further explained or interpreted ("construed"). I understand that in the present proceeding, the Board applies the same claim construction standard used by District Courts in actions involving the validity or infringement of a patent. This

involves construing claim terms in accordance with the ordinary and customary meaning of such terms, as understood by one of ordinary skill in the art, in light of the claim language, the technical disclosure of the patent (i.e. the specification) and the prosecution history or “file history” of correspondence with the United States Patent and Trademark Office (USPTO) pertaining to the patent.

54. I further understand that the file history of a parent patent application can be relevant to the claim construction of claim terms appearing in patents that have descended from that parent application.

55. I understand that certain “extrinsic” evidence, such as dictionaries or other prior art, can sometimes be useful to understand the meaning of a claim term. However I understand that where there is a conflict between any such extrinsic evidence and the patent and patent’s prosecution history, the latter control.

56. I am informed that in the co-pending International Trade Commission (“ITC”) investigation captioned *Smart HVAC Systems, and Components Thereof* 337-TA-1185 (ITC), various parties have taken claim construction positions. (Ex. 1007).

A. Claims 1-2, 4-5, 7-9, and 11—“HVAC system” or “heating, ventilation, and air conditioning (HVAC) system”

57. I note that independent claim 1 uses the phrase “heating, ventilation, and air conditioning (HVAC) system”, while claims 1-2, 4-5, 7-9 and 11 use the phrase “HVAC system”.

58. In my opinion, the '497 patent uses the term "HVAC system" to refer to devices for heating and/or cooling in a general sense. For example, the '497 patent states:

"HVAC units may be conventional air conditioners, heat pumps, or other devices for transferring heat into or out of a building."

(Ex. 1001, 7:19-21)(Emphasis added). In my opinion, the '497 patent's use of the word "or" indicates to one of ordinary skill in the art that the '497 patent is identifying conventional air conditioners and heat pumps as devices that can transfer heat into or out of a building as HVAC units and also that other devices for transferring heat into or out of a building are also understood to be HVAC units.

59. I note that the corresponding petition for inter partes review states that the Board should construe the phrases "heating, ventilation, and air conditioning (HVAC) system" and "HVAC system" to mean "devices for transferring heat into or out of a building." I have reviewed the claim interpretation set forth in the corresponding petition for inter partes review, and I am of the opinion that this claim interpretation would have been reasonable to a person of ordinary skill in the art in the relevant timeframe in the context of the '497 patent. My testimony applies this interpretation.

X. GROUND 1: CLAIMS 1, 4, 7, AND 10 ARE ANTICIPATED BY OSWALD

60. In my opinion, claims 1, 4, 7, and 10 are anticipated by U.S. Pat. App.

Pub. 2005/0171645 (“Oswald”) (Ex. 1004).

61. I note that Oswald was not of record during the prosecution of any application leading to the ’497 patent.

62. I can see from the face of Oswald that it was published on August 4, 2005. I am informed that it is therefore prior art to the ’497 patent.

A. Overview of My Anticipation Opinion

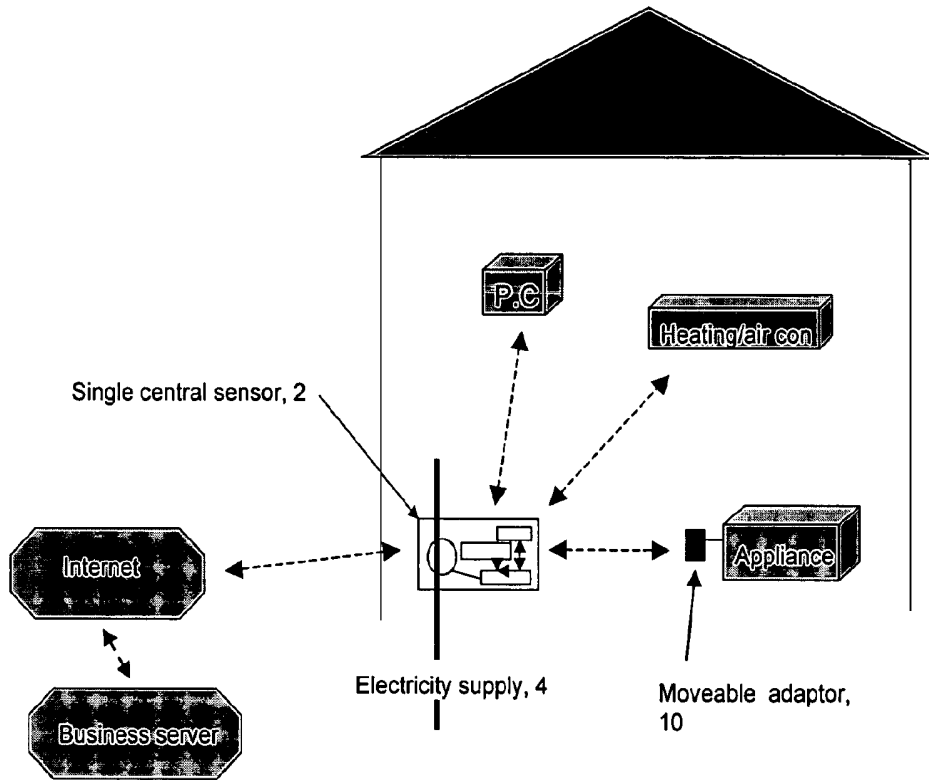
63. In my opinion Oswald anticipates the challenged claims. I provide below a brief overview of Oswald’s teachings.

64. Oswald describes a household energy management system. Oswald teaches that its system:

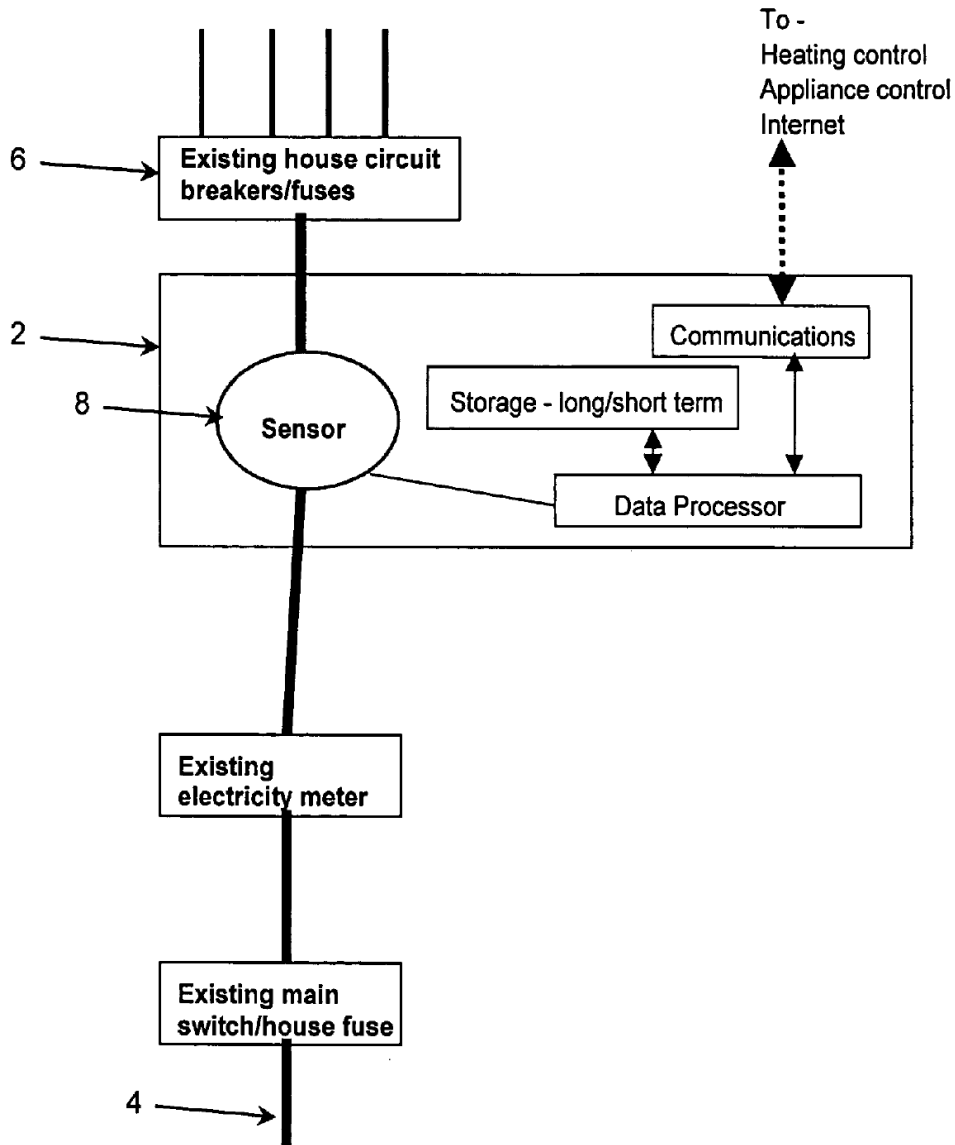
“uses measurements of the household electricity supply 4 to identify and to determine the energy consumption of individual household appliances. From these measurements, models can be built of the behaviour of the occupants of the house, the thermal properties of the house and the efficiency of the appliances.”

(Ex. 1004, Abstract).

65. An overview of Oswald’s system is depicted in Fig. 3, which is reproduced below:



66. As can be seen above in Fig. 3, Oswald's system has a processor ("P.C.") and an HVAC System ("Heating/air con"). These components communicate with a "Single central sensor, 2." A more detailed diagram of Oswald's Single central sensor is provided in Fig. 1, reproduced here:



67. Oswald explains that this “single central sensor 2 monitors the electrical power feeding into the house (e.g. current, voltage and power factor), stores appropriate data and analyses the data to determine what is happening with the house’s appliances and with the occupants.” (Ex. 1004, ¶¶0055).

68. Oswald teaches creating a transient thermal model to model thermal properties and system efficiency. (Ex. 1004, ¶¶0024-0025, claims 27-28). Oswald specifically teaches that “[a] transient thermal model of the house heating is a

mathematical model of the house heating characteristics including terms for the steady state heat loss and also terms for its transient thermal performance.” (Ex. 1004, ¶0127). Oswald’s transient thermal model receives inside and outside temperature measurements. (Ex. 1004, ¶¶0024-0025, claims 27-28). Using these measurements, the transient thermal model calculates both the efficiency of the HVAC system and the rates of heating and cooling when the HVAC system is ‘on’ and ‘off’. (Ex. 1004, ¶¶0036, 0141, 0146-0148).

69. Oswald explains the use of his model as follows:

“The household energy management system according to the second aspect of the invention may further comprise one or more temperature sensors for measuring the temperature inside the house; a source of information about the temperature outside the house; a modelling means, which uses the inside and outside temperature measurements to derive **a transient thermal model of the house, which can predict changes in the inside temperature on the basis of the information about the outside temperature** and on the basis of the operation of heating and/or cooling electrical appliances identified as connected to the supply....”

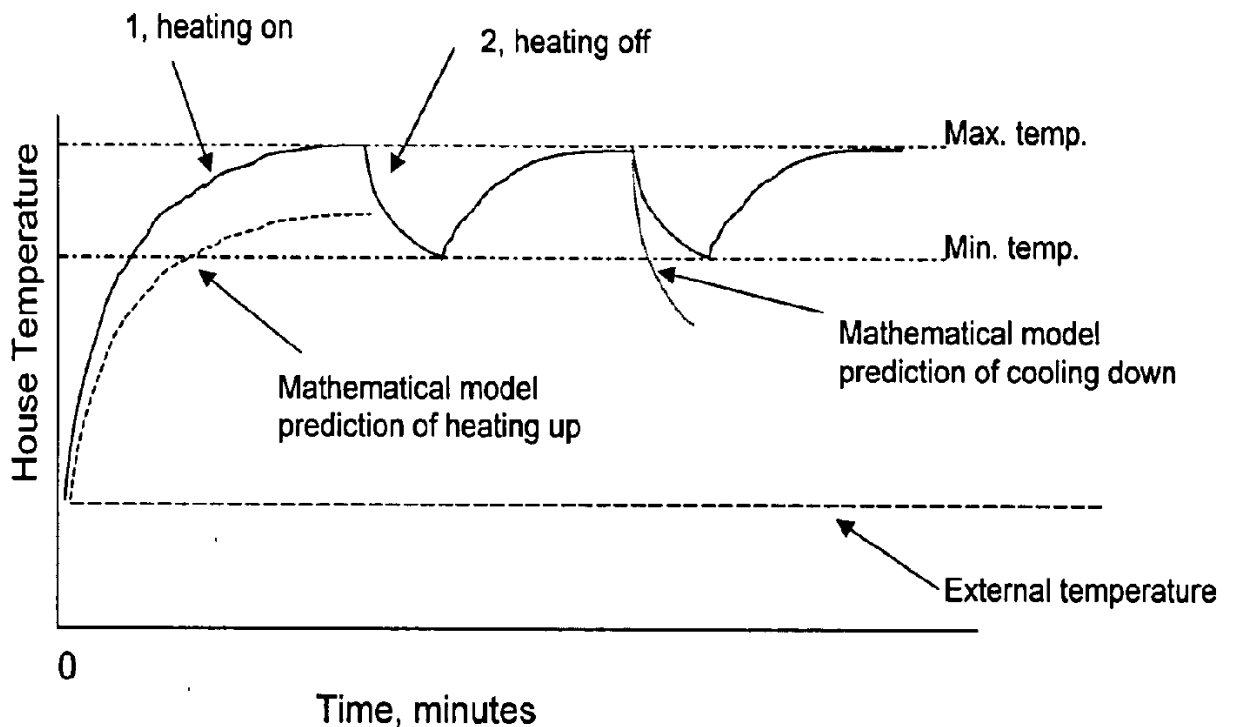
(Ex. 1004, ¶0024)(Emphasis added). Oswald continues:

“In such a system, **the derived transient thermal model may be periodically updated** and the reference transient thermal model may be a derived transient thermal model from an earlier period, whereby the **warning means are for warning the user** of the system of

deteriorating thermal properties of the house or of **deteriorating efficiency of the connected heating and/or cooling electrical appliances.**”

(Ex. 1004, ¶0025)(Emphasis added).

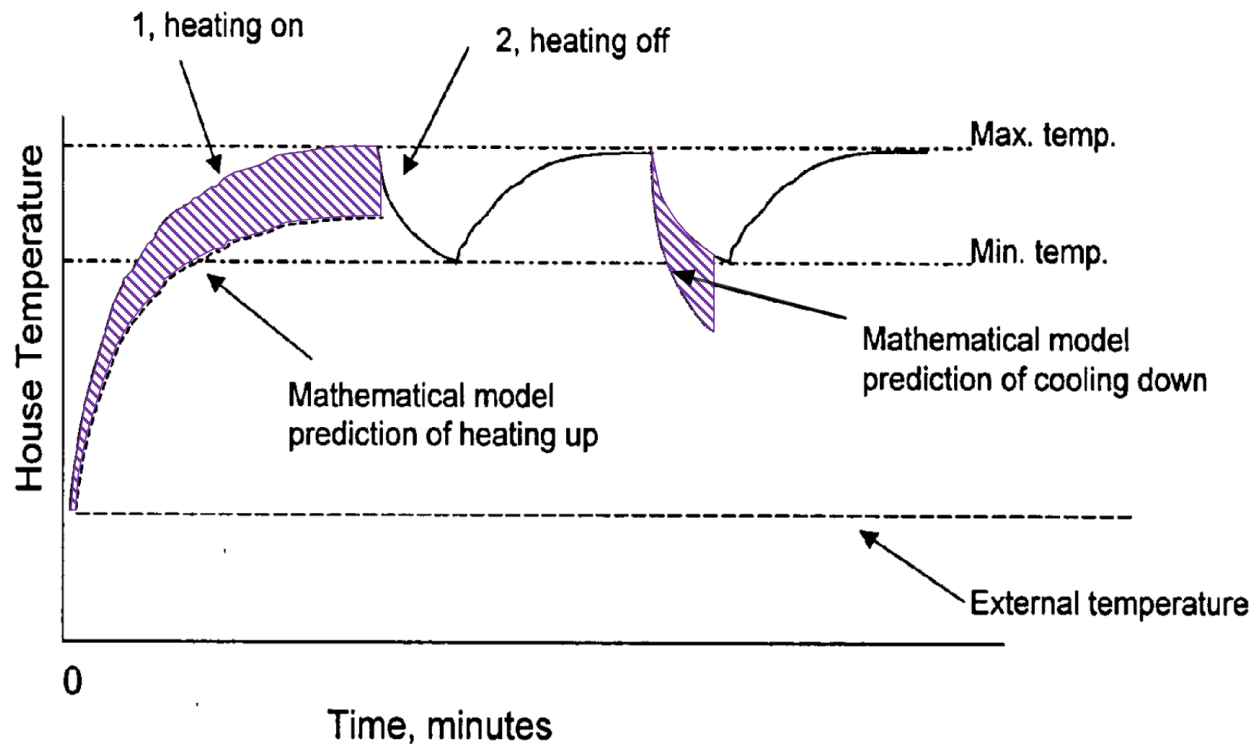
70. Once created, the transient thermal model can be used to make predictions about how the HVAC system will be able to heat and cool the house, as shown, for example, in Oswald’s Fig. 8, reproduced here:



(Ex. 1004, Fig. 8, ¶¶0135-0136).

71. As depicted above in Fig. 8, Oswald determines a predicted temperature as a function of time, including the rates at which the house heats up and cools down with the HVAC system ‘on’ and ‘off’ (see Fig. 8 above, labels near the top “1.

heating on” and “2. heating off”). These values were calculated taking into account the outside temperature (the “External temperature”), and are thus “related” to outside temperature measurements. Oswald teaches that “[f]rom then on the model will measure the actual response of the house to varying thermal conditions and adapt the mathematical model until a good fit is obtained between actual response and mathematically modelled response.” (Ex. 1004, ¶0135). From this, a person having ordinary skill in the art (“POSA”) would understand that Oswald’s model outputs (among other things) an inside temperature value of the house, and that Oswald obtains a “good fit”, by adjusting parameters of the model until the function of inside temperature with respect to time, matches the measured values of inside temperature over time. Oswald teaches “the software changes the coefficient terms in the model until the best fit with all known data is achieved.” (Ex. 1004, ¶0136). For example, in Fig. 8, Oswald would adjust the parameters of the model until the space between the model house temperature curve and the actual house temperature curve (shown below with purple hatching) is minimized:



To do this, Oswald's system would use require the measurements of inside temperature over time (to compare to the model output, which is inside temperature over time), as well as the outside (external) temperature over time, which will affect the rate of heating and cooling. Oswald teaches that "the software changes the coefficient terms in the model until the best fit with all known data is achieved." (Ex. 1004, ¶0136).

72. In my opinion, Oswald teaches every element of claims 1, 4, 7, and 10, as discussed in the Claim Mapping portion of my declaration.

B. Claim Mapping

73. In the paragraphs below, I map the elements of Oswald in a way that would meet the claim language of the '497 patent, rendering claims 1, 4, 7, and 10

anticipated by Oswald. The claim language appears in bold-italics. At times, I have added numbering in square brackets (e.g., [1b], [1c]) to facilitate discussion.

INDEPENDENT CLAIM 1

“1[a]. A system for calculating a value for the operational efficiency of a heating, ventilation, and air conditioning (HVAC) system comprising:”

74. In my opinion, Oswald teaches a **system for calculating a value for the operational efficiency of a heating, ventilation, and air conditioning (HVAC) system.**

75. As I discuss above, Oswald teaches an Energy Management System (“EMS”). (Ex. 1004, Title, Abstract, ¶¶0002, 0012). Oswald describes:

“[a] household energy management system [which] uses measurements of the household electricity supply 4 to identify and to determine the energy consumption of individual household appliances. From these measurements, **models can be built of** the behaviour of the occupants of the house, the thermal properties of the house and **the efficiency of the appliances.**”

(Ex. 1004, Abstract)(Emphasis added).

76. Among its “appliances,” Oswald’s EMS includes **HVAC** systems. Oswald’s Abstract states:

“Using the models, the **household appliances**—in particular **heating and cooling appliances**—**can be controlled** to optimize energy efficiency....”

(Ex. 1004, Abstract (Emphasis added), ¶¶0122-0148, claims 8, 27-28). As I discuss above, Oswald’s “heating and cooling appliances” are HVAC systems because they are “devices for transferring heat into or out of a building.” (*See also, e.g.,* Ex. 1004, ¶0141 (teaching the use of a “gas boiler”) and ¶0095 (teaching the use of “air conditioning”)).

77. Oswald goes on to disclose that its EMS **calculates a value for the operational efficiency of an HVAC system**. (Ex. 1004, ¶¶0033-0036, 0122-0148, claims 27-28). As I discuss above, Oswald teaches that its EMS can construct and continuously update a “transient thermal model” of a house. (Ex. 1004, ¶¶0122-0126). Oswald then uses this transient thermal model to evaluate the operational efficiency of the heating and cooling appliances (HVAC system) over time. (Ex. 1004, Abstract, claims 27-28, ¶¶0036, 0146-0148, 0024-0025).

78. For example, Oswald states that “models can be built of the behaviour of the occupants of the house, the thermal properties of the house and the **efficiency** of the appliances.” (Ex. 1004, Abstract)(Emphasis added). Oswald further states that its system provides the benefit of “[r]ecommending energy saving measures to the householder **based on actual measurements of** the householder’s behaviour, the thermal efficiency of the house and the **operational efficiency of household appliances**.” (Ex. 1004, ¶¶0033-0036)(Emphasis added). Oswald’s references to “efficiency” are references to operational efficiency, because the HVAC system only

has an efficiency when it is operating. Oswald specifically refers to efficiency as “operational efficiency” in ¶0036. (Ex. 1004, ¶0036).

79. Oswald repeatedly updates its thermal model and estimates of operational efficiency over time, and warns a user when the operational efficiency deteriorates:

“In such a system, **the derived transient thermal model may be periodically updated** and the reference transient thermal model may be a derived transient thermal model from an earlier period, **whereby the warning means are for warning the user of the system of deteriorating thermal properties of the house or of deteriorating efficiency of the connected heating and/or cooling electrical appliances.**”

(Ex. 1004, ¶¶0025)(Emphasis added)(see also ¶0146) Thus, Oswald is calculating operational efficiency over time.

80. Thus, Oswald teaches a system for calculating a value for the operational efficiency of a heating, ventilation, and air conditioning (HVAC) system.

“[1b] at least one HVAC control system that receives temperature measurements from at least a first location conditioned by at least one HVAC system;”

81. In my opinion, Oswald teaches **at least one HVAC control system that receives temperature measurements from at least a first location**

conditioned by at least one HVAC system.

82. First, Oswald teaches that its Energy Management System (“EMS”) has components in **a first location conditioned by at least one HVAC system**, such as a house. The components are used to manage appliances at that location. (Ex. 1004, Abstract (“A household energy management system uses measurements of the household electricity supply 4 to identify and to determine the energy consumption of individual household appliances. . . . Using the models, the household appliances—in particular heating and cooling appliances—can be controlled to optimize energy efficiency. . . .”), claim 1, ¶¶0012-0018, 0123-0127, 0135-0148).

83. In my opinion, an **HVAC control system** in Oswald is Oswald’s “single central sensor 2” (Ex. 1004, ¶¶0054-0057, 0148, 0119, 0086-0089). The sensor 2 helps control the HVAC system. (Ex. 1004, ¶¶0101, 0139, 0148). For example, Oswald states:

“The single central sensor system can alter the control temperature of the house if the householder is obviously active or has gone out.”

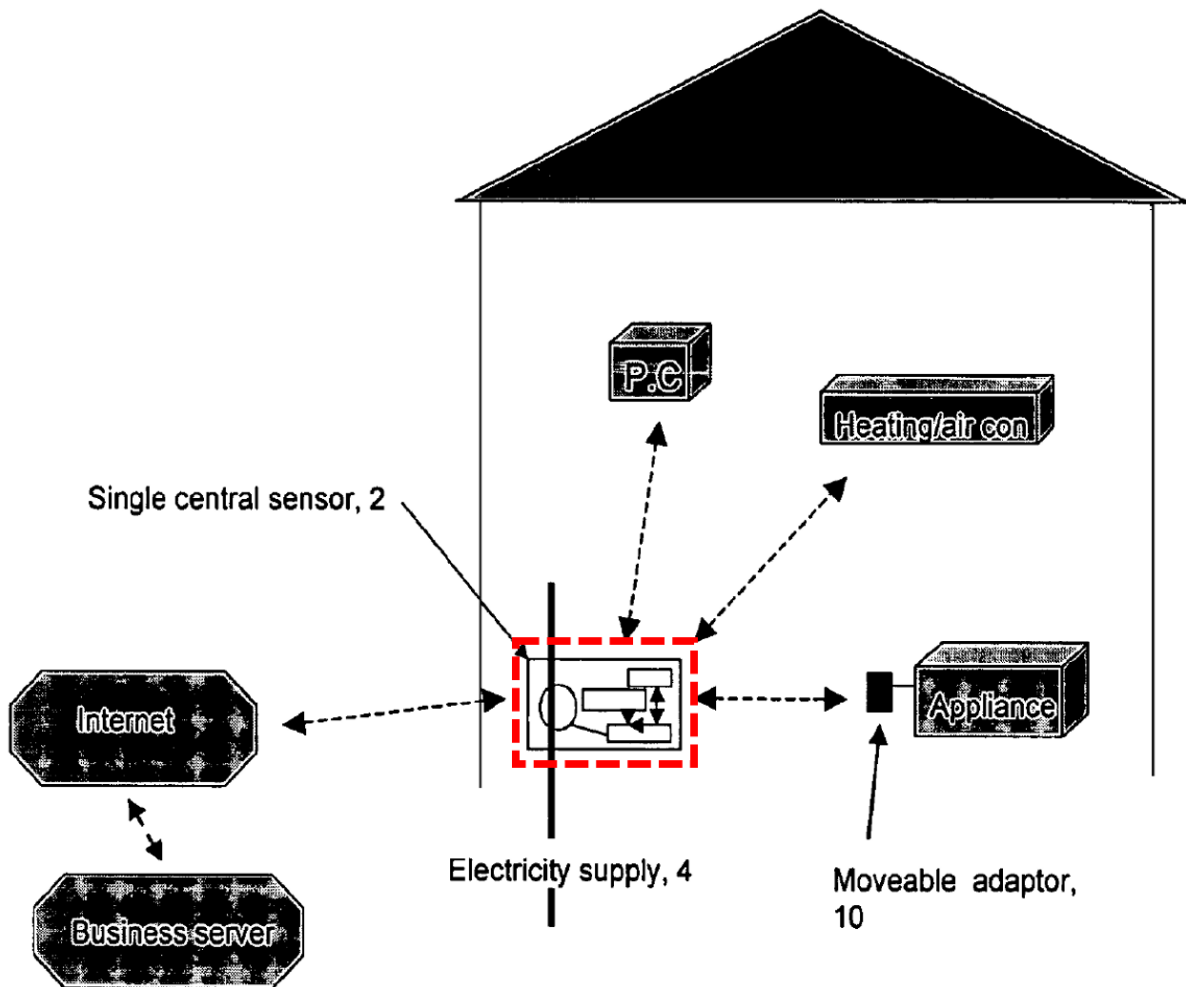
(Ex. 1004, ¶0101)(Emphasis added). Oswald also states that the sensor 2 performs an optimum start / stop function:

“In traditional systems the householder uses a time controller to define when the heating (or air conditioning) should turn on and off. **With the use of the transient thermal model, the householder can**

now define when the house is to reach the controlled temperature schedule rather than when to start heating. This allows the single central sensor system to calculate the optimum time to turn on. For example, say the householder returns home at 17:30 in the evening and wants the house at the desired temperature at 17:30. The system can use the transient model to calculate the time it will take to reach the desired temperature: on a cold windy day this might be 1 hour and on a mild day it might be 30 minutes. In this way the heating system is turned on for the minimum time and the house consumes the minimum heat energy.”

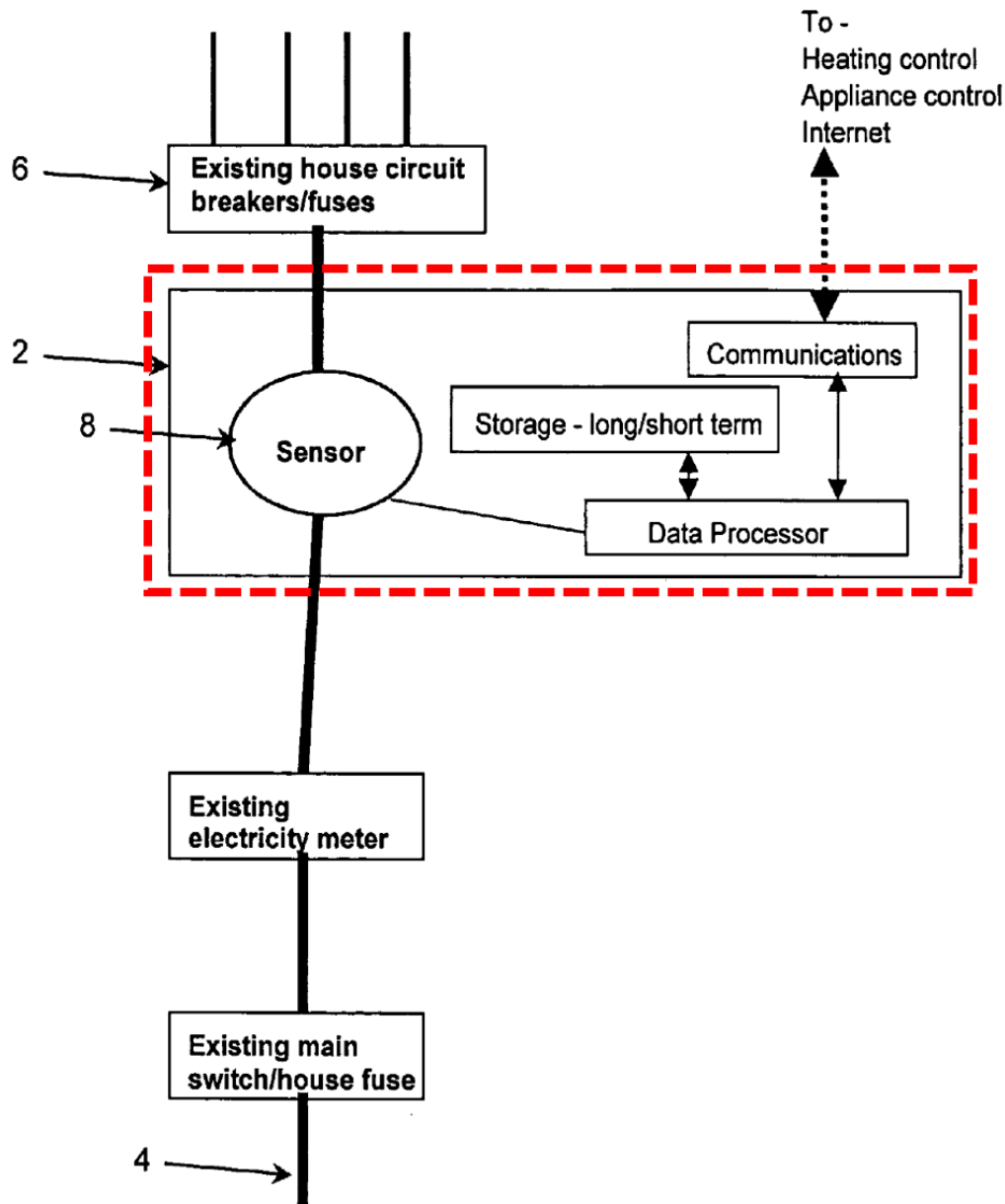
(Ex. 1004, ¶0139)(Emphasis added).

84. The sensor 2 is shown in part in Oswald’s Fig. 3, which is reproduced below with added red-dashed outline around the HVAC control system:



85. The dashed outline added to the figure above is drawn around the Single central sensor, 2, or just “sensor 2” for short. (Ex. 1004, ¶0057).

86. The box labeled “single central sensor, 2” in Fig. 3, above, is shown in more detail in Oswald’s Fig. 1, which is reproduced below. The sensor 2 (HVAC control system) is shown with an added, red-dashed outline:



87. Oswald's HVAC control system clearly **receives temperature measurements from a structure** (the house). Oswald teaches that its EMS includes one or more temperature sensors inside the house. Oswald states:

“The household energy management system according to the second aspect of the invention may further comprise one or more temperature sensors for measuring the temperature inside the

house; a source of information about the temperature outside the house; a modelling means, which uses the inside and outside temperature measurements to derive a transient thermal model of the house....”

(Ex. 1004, ¶0024)(*see also* Ex. 1004, claim 27)(Emphasis added).

88. Usually, such temperature sensors would be located in one or more thermostats, and that is the case with Oswald. Oswald in fact teaches a thermostat that has a temperature sensor which passes the temperature to the HVAC control system. As shown in the Fig. 2 above, there is a “heating control appliance control” (upper right) in Oswald’s EMS. Oswald makes clear that the heating control comprises a thermostat. (Ex. 1004, ¶¶0136, 0140-0141, 0148). The thermostat has a temperature sensor, and this sensor passes temperature measurements to the sensor 2 (HVAC control system) (Ex. 1004, ¶0148). For example, Oswald states:

“[A] special house thermostat that communicates with the single central sensor 2 can be used. This thermostat acts as a normal house thermostat—switching open and closed as the temperature rises and falls through set limits. However, **it communicates this to the single central sensor 2 so that the system can still determine when temperature limits are reached and the transient thermal model can still be aligned with the real thermal response.**”

(Ex. 1004, ¶0148)(Emphasis added). From the paragraph above, a POSA would have understood that the sensor 2 receives information that the thermostat has

“switch[ed] open [or] closed as the temperature [rose] and [fell] through set limits”, and that Oswald uses such information to “determine when temperature limits are reached” and align the transient thermal model with “real thermal response”. This latter activity means adjusting the parameters of the transient thermal model to match the inside temperature prediction from the model, as function of time, with actual measurements of temperature over time, as I explain above in ¶71. Oswald’s sensor 2 could not “determine when temperature limits are reached”, nor update the transient thermal model to be “aligned with the real thermal response” (*i.e.* the inside temperature) without having access to the inside temperature measurements over time as measured by the thermostat. (Ex. 1004, ¶0148).

89. Thus, in my opinion, Oswald teaches at least one HVAC control system that receives temperature measurements from at least a first location conditioned by at least one HVAC system.

“[1c] one or more databases that store at least said temperatures measured at said first location over time; and”

90. In my opinion, Oswald teaches **one or more databases that store at least said temperatures measured at said first location over time**. I note that the claim phrase “said temperatures measured at said first location” refers to Oswald’s inside temperature measurements, as discussed above under claim limitation [1b].

91. Oswald teaches that “acquired data” will be stored in a database:

“Stored data [0059] **The data acquired will be stored on a database.** This will include data of appliance characteristics, times appliances are on and off and derived data. It can be stored either within the house in some form of small computer, perhaps as part of the single central sensor 2, or on a more powerful server on the Internet-based network of computers.”

(Ex. 1004, ¶¶0058-0059)(Emphasis added).

92. Inside temperature measurements are acquired from sensors and are thus “acquired data.” In my opinion, a person of ordinary skill in the art would have understood temperature measurements to be stored in Oswald’s database.

93. While this statement in Oswald applies to all temperature data (*i.e.* data acquired **over time**), Oswald also teaches that inside temperature data acquired “over time” is stored in the database. There are two reasons for this. First, as I discuss above in ¶71, Oswald teaches that his transient thermal model outputs inside temperature as a function of time (see Oswald’s Fig. 8 and ¶¶0135-0136), and that the transient thermal model is aligned to the real thermal response (*i.e.* inside temperature), and achieves “the best fit with all known data”. (Ex. 1004, ¶¶0148, 0136). Oswald could not do this without access to stored inside and outside temperature data over time. Second, and separately, Oswald teaches that inside temperature data acquired “over time” is stored in the database because Oswald’s EMS compares different versions of the transient thermal model from different times

(which must be stored) to evaluate HVAC efficiency. (Ex. 1004, ¶¶0024-0025, claims 27-28). For example, Oswald teaches that the EMS has:

“means for comparing the derived transient thermal model with a reference transient thermal model; and means for warning a user of the system of poor thermal properties of the house or of poor efficiency of the connected heating and/or cooling electrical appliances when the derived model differs from the reference model by more than a predetermined limit. [¶][0025] In such a system, the derived transient thermal model may be periodically updated and the reference transient thermal model may be a derived transient thermal model from an earlier period. . . .”

(Ex. 1004, ¶¶0024-0025)(Emphasis added). In this way, inside temperature data acquired “over time” is stored in the database.

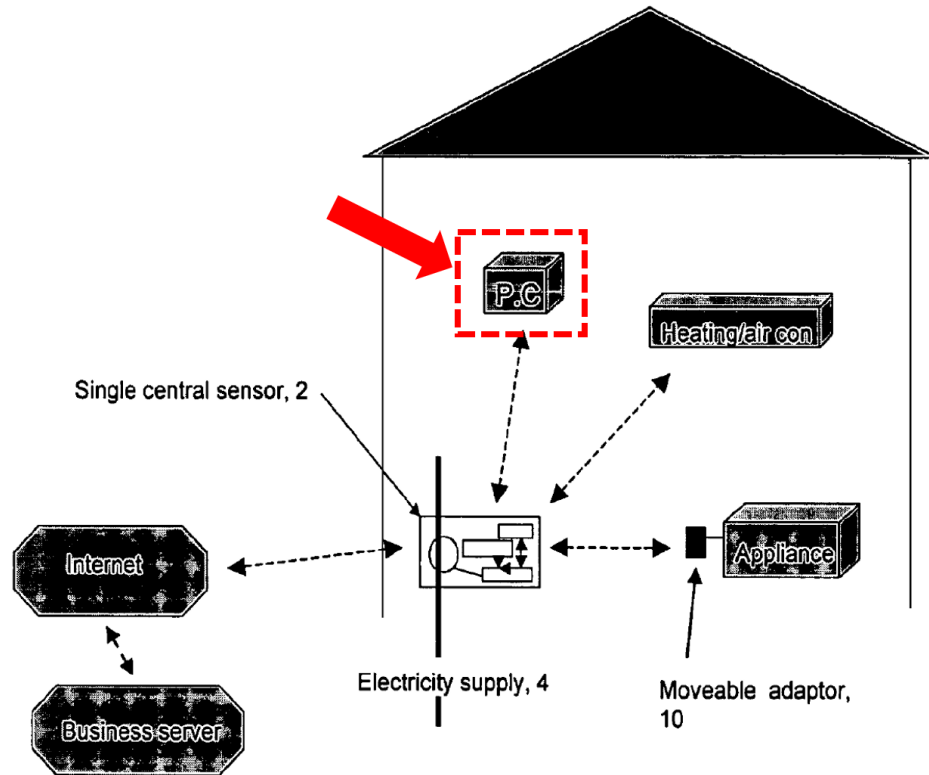
94. Thus, in my opinion, Oswald teaches one or more databases that store at least said temperatures measured at said first location over time.

“[1d] one or more processors that receive outside temperature measurements from at least one source other than said HVAC system,”

95. In my opinion, Oswald teaches (1) **one or more processors** that (2) **receive outside temperature measurements from at least one source other than said HVAC system.**

96. Oswald teaches the use of a **processor**, such as a PC, with his system. (Ex. 1004, ¶¶0052, 0057). One example of a processor is shown in the annotated

version of Fig. 3 of Oswald, reproduced below with an added red-dashed box around and an arrow indicating the PC (Personal Computer) within a house:



97. Oswald teaches that processor can perform the analyses done for the EMS:

“The analysis is performed on computers either local to the house or on the Internet. Communications between the various system items use standard known communication systems i.e. phone, radio, Internet or communication by power cable.”

(Ex. 1004, ¶¶0052)(*see also* Ex. 1004, ¶¶0046-0057). The processor can be within the sensor 2 or outside of it (i.e. separate from the sensor 2), as shown by the P.C. in

Fig. 3.

98. In my opinion, Oswald further teaches that the processor **receives outside temperature measurements from at least one source other than said HVAC system.**

99. First, Oswald teaches that the system uses **outside temperatures** to construct a transient thermal model of the house. (Ex. 1004, ¶¶0024-0025, 0123-0133). Oswald explains as follows:

“A transient thermal model of the house can be generated and validated by the system.... [0128] Terms in the thermal model would include: [0129] Heat transfer coefficient inside house. [0130] Heat transfer coefficient outside house—terms including effect of wind, rain, humidity etc. [0131] Temperature inside. [0132] **Temperature outside.** [0133] Materials of construction including thickness, thermal insulation qualities, mass, specific heat.”

(Ex. 1004, ¶¶0123-0133)(Emphasis added). In order for the thermal model to use the temperature outside, that temperature must be measured and communicated to the system. Thus, the processor receives the outside temperature measurements, because it needs them to calculate the thermal model.

100. In my opinion, the outside temperature measurements are received **from at least one source other than said HVAC system.** I note that that this claim term refers to the “HVAC system” (*i.e.* the furnace and/or air conditioners

themselves), not the “HVAC control system” (*i.e.* the EMS). Oswald states:

“The household energy management system according to the second aspect of the invention may further comprise one or more temperature sensors for measuring the temperature inside the house; **a source of information about the temperature outside the house**; a modelling means, which uses the inside and outside temperature measurements to derive a transient thermal model of the house....”

(Ex. 1004, ¶0024, claim 27)(Emphasis added).

101. In the passage from Oswald quoted above, the inside temperature comes from a temperature sensor inside the house, whereas the outside temperature comes from “a source of information about the temperature outside the house.” A POSA would have known that in the relevant timeframe, standard HVAC equipment did not have the capability of measuring or communicating outside temperature. In my opinion, the passage quoted above teaches a person of ordinary skill in the art that that the information about outside temperature does not come from a sensor that is part of the HVAC system, but rather from an outside source.

102. I also observe that Oswald teaches that:

“The system can use network data to improve validity. For example it can be informed of **local weather** from existing Internet weather databases which have weather information from nearby weather stations.”

(Ex. 1004, ¶0137)(Emphasis added). In my opinion, a person of ordinary skill would

have considered local weather to include, at a minimum, information regarding the outside temperature. The reference to improving “validity” referred to the use of outside temperature to improve the validity of the transient thermal model, since the behavior of the temperature of the house depended on the outside temperature, as discussed above in ¶¶42-43.

103. In my opinion, Oswald’s teachings (1) to use outside temperature, (2) that outside temperature (in contrast to inside temperature) can be taken from “a source of information about the temperature outside the house,” and (3) that the system can access local weather information, disclose receiving a measurement of outside temperature from a source other than the HVAC system, either from a temperature sensor outside the house, or from local weather reports over the Internet.

104. Finally, in my opinion, the processor **receive[s] the measurement of outside temperature**, from either a sensor or Internet-based weather data, from other than the HVAC system. This is because the processor performs the analysis for the EMS, including of the transient thermal model, and thus would require receiving and using the measurement of outside temperature in order to perform that analysis (Ex. 1004, ¶0052)(*see also* Ex. 1004, ¶¶0046-0057).

105. Therefore, in my opinion, Oswald teaches one or more processors that receive outside temperature measurements from at least one source other than said HVAC system.

“[1e] wherein said one or more processors are configured to calculate one or more rates of change in temperature at said first location for periods during which the status of the HVAC system is ‘on’ and wherein said one or more processors are further configured to calculate one or more rates of change in temperature at said first location for periods during which the status of the HVAC system is ‘off’, and”

106. In my opinion, Oswald teaches that the **processor is configured to calculate one or more rates of change in temperature at said first location** for times when the **HVAC system is ‘on’** and times when it is **‘off’**. (Ex. 1004, ¶¶0103, 0123-0124, 0139, 0141, 0143, 0146-0147). Oswald teaches such calculations for the following reasons.

107. Oswald states as follows regarding its transient thermal model:

“The validated thermal transient model can be used to compare the house to national house norms. In this way the thermal characteristics of the house can be compared to acceptance limits and weaknesses in the house thermal characteristics can be identified and remedied. **For example the system may notice that the house cools down unusually quickly** on windy days and yet has a normal cooling characteristic under still air conditions. This will indicate that the house is susceptible to wind and is therefore draughty. An email could be sent to the householder or maintenance contractor to investigate and remedy the situation.”

(Ex. 1004, ¶0143)(Emphasis added). The above paragraph describes a situation in which a house cools down too quickly due to draughts. By “noticing” that the house

cools down quickly, the system is evaluating the rate of change in temperature in time.

108. Oswald likewise states:

“The transient thermal model can be used to determine the operational health of the heating system within the house. As explained previously, the system will continuously adjust coefficients within the transient thermal model to ensure it aligns with the true house thermal response. Over months of operation, these coefficients will drift as the thermal characteristics of the house worsen with age. This will be most noticeable with a heating boiler as it becomes fouled through use—the house will begin to take longer to heat up.”

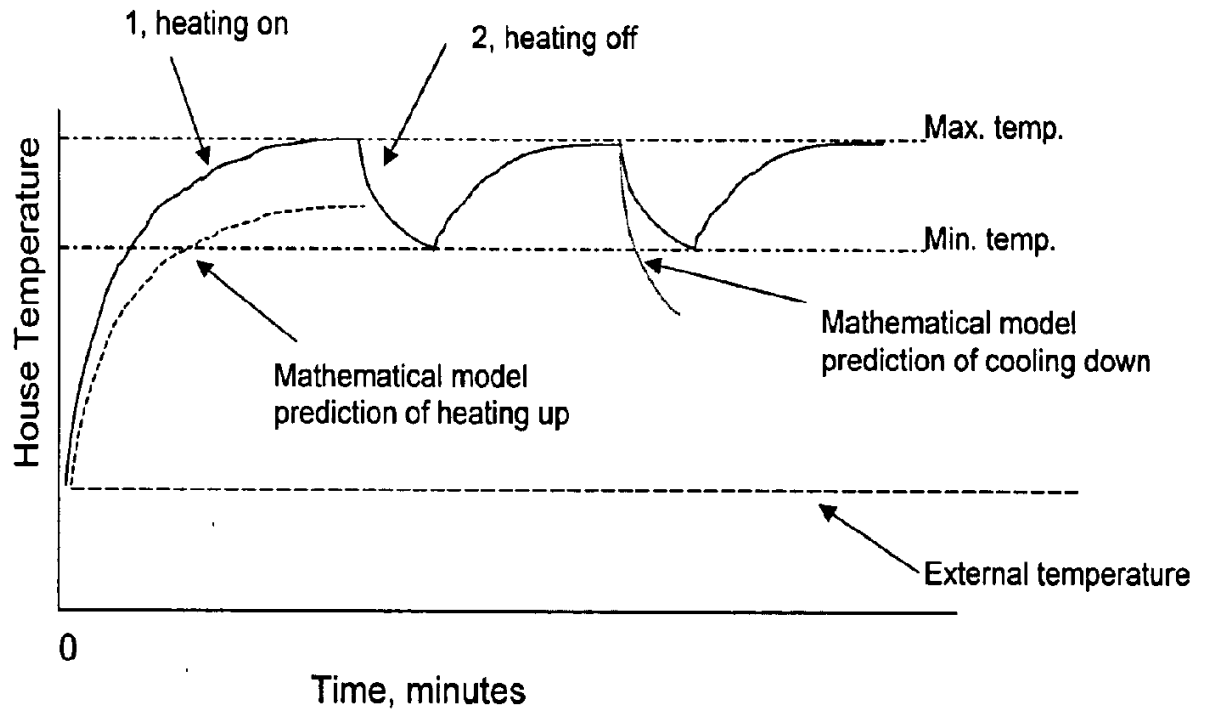
(Ex. 1004, ¶0146)(Emphasis added)(*see also* Ex. 1004, ¶0141)(“The transient model would be used to determine how fast the house heats up and cools down....”). The above paragraph discusses a situation in which a house heats up and the fact that it takes longer than is desirable to do that. Again, by noticing that the house takes longer to heat up, the system is evaluating the rate of change in temperature in time. Oswald further teaches using optimum start / stop calculations, which involve determining how fast the house heats up or cools down. (Ex. 1004, ¶¶0139, 0123-0124, 0103).

109. As discussed above, a person of ordinary skill in the art would understand that determining how fast a house heats up and cools down means

determining the **rates of change in temperature at said first location**, where the first location is inside the house where temperature is being measured. By calculating the rate at which the house heats up and cools down, Oswald was teaching to calculate the rate of change in temperature when the HVAC system is ‘on’ and ‘off’.

110. For example, if the outside temperature is higher than the inside temperature (a hot summer day), then the rate of cooling down is with the HVAC system ‘on’, whereas the rate of heating up is with the HVAC system ‘off’. If, however, the outside temperature is lower than the inside temperature (a cold winter day), then the rate of heating up is with the HVAC system ‘on’, whereas the rate of cooling down is with the HVAC system ‘off’.

111. This latter case (a cold winter day) is shown, for example, in Fig. 8 of Oswald, reproduced below:



(Ex. 1004, Fig. 8, ¶¶0135-0136).

112. In Fig. 8, the external temperature is shown by the dashed line near the x-axis of the graph. A person of ordinary skill in the art would understand that this figure reflects a cold day, where the heating system would be active in order to raise the internal temperature. Figure 8 shows that the temperature increases when the heating system is on (“1, heating on” in the upper left), and the temperature decreases when the heating system is off (“2, heating off” in the upper middle). (Ex. 1004, Fig. 8, ¶¶0135-0136).

113. Thus, in my opinion, Oswald teaches that “the transient model would be used to determine how fast the house heats up and cools down”, (see Ex. 1004, ¶0141) which in turn teaches calculating rates of change in temperature at said first

location when the HVAC system is ‘on’ and when the HVAC system is ‘off’.

“[1f] to relate said calculated rates of change to said outside temperature measurements.”

114. In my opinion, Oswald teaches **relat[ing] said calculated rates of change to said outside temperature measurements.**

115. Specifically, Oswald teaches that outside temperature measurements are used in the transient thermal model. (Ex. 1004, ¶¶0024, claim 27, 0122-0137, Fig. 8). The transient thermal model is then used (as described above under element [1e]) to predict the rates of change of temperature when the HVAC system is ‘on’ and ‘off’. (Ex. 1004, ¶¶0141, 0024, claim 27, 0135-0136, Fig. 8).

116. Oswald teaches that:

“[t]he household energy management system according to the second aspect of the invention may further comprise one or more temperature sensors for measuring the temperature inside the house; a source of information about the temperature outside the house; a **modelling means, which uses the inside and outside temperature measurements to derive a transient thermal model of the house, which can predict changes in the inside temperature on the basis of the information about the outside temperature** and on the basis of the operation of heating and/or cooling electrical appliances identified as connected to the supply....”

(Ex. 1004, ¶0024, claim 27)(Emphasis added).

117. Oswald uses the outside temperature both to form and to update the transient thermal model. Oswald also teaches that the transient model is used to determine how fast the house heats up and cools down (*i.e.* the rates of change when the HVAC system is ‘on’ and ‘off’). Accordingly, in my opinion, Oswald teaches the processor relating said calculated rates of change to said outside temperature measurements.

CLAIM 4

“4. A system as in claim 1 in which said processors communicate with said HVAC system using a network that includes an electricity meter.”

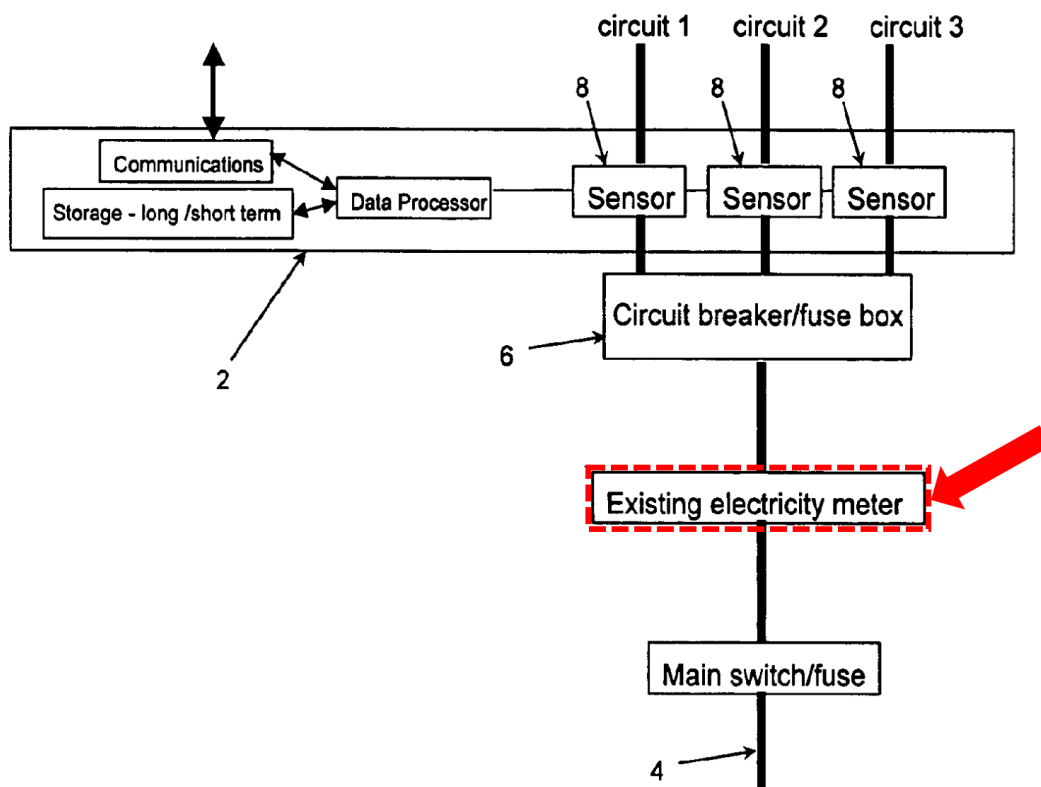
118. In my opinion, Oswald teaches a **processor that communicates with said HVAC system using a network that includes an electricity meter.** (Ex. 1004, ¶0052).

119. First, Oswald teaches that its processor (a computer) can communicate with the other components of the system (*e.g.* the HVAC system) over a network. Oswald states:

“The analysis is performed on computers either local to the house or on the Internet. **Communications between the various system items use standard known communication systems i.e. phone, radio, Internet or communication by power cable.”**

(Ex. 1004, ¶0052)(Emphasis added). The communication systems (*e.g.* the Internet and or communication by power cable) are **networks**.

120. Oswald also teaches the use of an existing electricity meter. (Ex. 1004, Fig. 2, ¶¶0054-0055). The electricity meter of Oswald is shown in Fig. 2, reproduced below with an added red-dashed box and red arrow indicating the meter:



121. As depicted above in Fig. 2, Oswald’s electricity meter is connected to sensors, which are in turn connected to data processing and communication functions. (Ex. 1004, Fig. 2). Furthermore, Oswald states that the processor (the system computer) can communicate with other system components “us[ing] standard known communication systems i.e. phone, radio, Internet or **communication by power cable.**” (Ex. 1004, ¶0052)(emphasis added)(see also Ex. 1004, ¶0057).

122. The “power cable” includes the electricity meter because the electricity meter is connected to the power cable network and interacts with the power cable. This is depicted in Figs. 1 and 2, and further, in my opinion, would be well-understood in the art. (*See also* Ex. 1004, ¶0054).

123. Thus, in my opinion, Oswald teaches that the processor communicate[s] with said HVAC system using a network that includes an electricity meter.

INDEPENDENT CLAIM 7

124. The limitations of independent claim 7 are similar to the limitations of claim 1, except that claim 7 is written in method form, and does not expressly require an HVAC control system in element [7b]. My opinions with respect to the anticipation of claim 7 by Oswald are similar to my opinions regarding claim 1.

“7[a]. A method for calculating a value for the operational efficiency of an HVAC system that comprises:”

125. *See* my analysis for claim 1, element 1[a], above. In my opinion, Oswald’s teachings of a system also describe a method that is performed by that system.

“[7b] receiving temperature measurements from at least a first location conditioned by at least one HVAC system;”

126. *See* my analysis for claim 1, element [1b], above.

“[7c] storing in one or more databases at least said temperatures measured at said first location over time;”

127. See my analysis for claim 1, element 1[c], above.

“[7d] receiving outside temperature measurements from at least one source other than said HVAC system; and”

128. See my analysis for claim 1, element [1d], above.

“[7e] calculating with one or more computer processors one or more rates of change in temperature at said first location for periods during which the status of the HVAC system is ‘on’ and calculating one or more rates of change in temperature at said first location for periods during which the status of the HVAC system is ‘off’,”

129. See my analysis for claim 1, element [1e], above.

“[7f] where said calculated rates of change are related to said outside temperature measurements.”

130. See my analysis for claim 1, element [1f], above.

CLAIM 10

“10. A method as in claim 7 that includes receiving information about electricity consumption in said first location from an electricity meter.”

131. In my opinion, Oswald teaches **receiving information about electricity consumption in said first location from an electricity meter.**

Specifically, Oswald teaches sensors that read electricity consumption and thus act

as electricity meters. (Ex. 1004, ¶¶0019, 0054-0055, 0106-0107). Oswald uses these sensors to receive information about electricity consumption. (*Id.*). Oswald states, for example:

“Meter Reading [0107] The system builds up and records detailed energy consumption data and by integrating this over time it can record the total energy (kWh) used and so become an energy meter. This allows billing information to be sent to the customer and the utility directly over the communications network, as shown in FIG. 4.”

(Ex. 1004, ¶¶0106-0107). That is, Oswald teaches having a portion of its system acting as an electricity meter, from which the system **receives information about electricity consumption**. (*Id.*). The consumption is related to “**said first location**”, because the first location is in a structure in which Oswald’s EMS operates (the house).

XI. GROUND 2: CLAIMS 1, 3-7, AND 9-12 ARE OBVIOUS OVER OSWALD IN VIEW OF CLER AND THE KNOWLEDGE OF A PERSON OF ORDINARY SKILL

132. In my opinion, claims 1, 3-7, and 9-12 are obvious over Oswald as I discuss above in Ground 1, in view of U.S. Pat. No. 4,897,798 (“Cler”) (Ex. 1005) and the knowledge of a person of ordinary skill in the art.

133. I generally describe Oswald above in Ground 1.

134. I note that Cler was not of record during the prosecution of any application leading to the '497 patent.

135. I can see from the face of Cler that the patent issued on January 30, 1990. I am informed that it is therefore prior art to the '497 patent.

A. Overview of My Obviousness Opinion

136. My opinions are based on Oswald as I set forth above with respect to Ground 1.

137. Cler is directed to an “[a]daptive environment control system.” (Ex. 1005, Title). Cler teaches that “[t]his adaptive environment control system provides an HVAC control system that adapts to the continually changing thermal characteristics of the building in which it operates.” (Ex. 1005, Abstract).

138. Cler’s control system incorporates measurements of inside temperature and outside weather conditions into a thermal model of a building. (Ex. 1005, 2:10-21). Using this model, Cler’s system can control the HVAC system in a more accurate way. (Ex. 1005, 2:10-21). Cler teaches that:

“The adaptive environment control system can calculate, through the estimates and measurements, the thermal performance of both the building and the HVAC system so that the HVAC system is operational sufficiently early to maintain the building’s interior temperature within a predetermined range of the set-point threshold level of the thermostat. The adaptive environment control system can thereby accurately control the interior temperature of the building in

spite of changing outside weather conditions and changes in the performance of the HVAC system.”

(Ex. 1005, 2:10-21).

139. Cler’s method of control allows the system to calculate optimum stop and start times for a setback schedule, using the rate of change of temperature inside the building. (Ex. 1005, 6:24-8:20)(describing “Optimal Start/Stop Operation” and “Transfer to Set-Back Operation). To accomplish this, Cler provides and makes use of a mathematical model of a building. (Ex. 1005, 3:39-5:41).

140. Cler’s thermal model uses an energy balance equation, with components that represent the rate of heat being added to or subtracted from the building by the HVAC system (**Q**), the rate at which heat is gained or lost through thermal transfer to the outside (**L**), and the rate at which heat is gained or lost by the thermal capacity (thermal mass) of the building (**M**). (Ex. 1005, 3:39-4:50)(“present[ing] a mathematical analysis of the various thermal components Q, M, L that characterize the building environment”). Cler expresses the relationship between these three terms in Eq. (3), reproduced here:

$$\mathbf{M=Q-L}$$

(Ex. 1005, 4:19-50).

141. In order to understand the relationship between the variables in this

equation, it is helpful to consider an example. If one considers the HVAC system to be in heating mode (*e.g.* on a winter day), then Eq. (3) means that heat is being put into the building by the HVAC system at rate (Q) and being lost to the outside at rate (L). The difference between Q and L , or the net rate of gain of heat into the building, is stored at the thermal mass rate M . (*See* Ex. 1005, 3:43-45)(teaching that M is the “time-rate-of-change of heat gain (or loss) of the thermal mass of the building”).

142. Beginning with the energy balance equation ($M=Q-L$), Cler makes use of both the rate of change in inside temperature, and the outside temperature to derive a transient thermal model. (Ex. 1005, Eqs. (1)-(2), (4)-(11), 3:19-5:41) (teaching that “we have an equation describing the interior temperature of the building as a function of time” and that “an approximation of the temperature in the building at time t in the future is determinable”). From the model, Cler provides a way to calculate the time it would take to heat up or cool down the building by a certain number of degrees. (Ex. 1005, 5:1-41, Eqs. (1)-(2), (4)-(11), 3:40-5:41). This information is then used to calculate optimum stop and start times.

143. Cler explains the basic concept as follows:

“[T]he adaptive environment control system can **accurately set the time** at which the HVAC system is **switched between the set-back unoccupied hours temperature level and the normal set-point building occupied temperature level**, through the estimates of how long it takes both the HVAC system to have an impact on the

building temperature as well as **the rate of change of the interior building temperature** based on **outside environment conditions**.

These estimates and measurements of the adaptive environment control system provide a more efficient control of the HVAC system as well as an indication of the level of performance of the HVAC system for maintenance purposes.”

(Ex. 1005, 2:23-35)(Emphasis added)(*see also, e.g.,* Ex. 1005, 7:7-10(“The efficiency of HVAC system 101 is thereby enhanced due to the fact that, at the setpoint and set-back time, HVAC system 101 is controlled in accordance with the actual thermal characteristics of the building 110.”)).

144. When performing optimum stop and start calculations, Cler’s system first checks whether the time is sufficiently close to a time when the setpoint will be set back to another temperature (when the system is about to turn ‘off’), or the time when the temperature setpoint will return to normal (when the system is about to turn ‘on’). (Ex. 1005, 6:38-50). If the time is nearing a transition to or from the setback temperature, the system calculates an optimum stop or start time, respectively. To calculate an optimum *stop* time, Cler assumes that the HVAC system is ‘off’, and calculates the time it would take for the building to reach a setback temperature on its own. (Ex. 1005, 7:17-62). To calculate an optimum *start* time, Cler assumes that the HVAC system is ‘on’, and calculates the time it would take for the HVAC system to drive inside temperature back to a desired setpoint.

(Ex. 1005 7:64-8:19).

145. As I explain above, Oswald anticipates claims 1, 4, 7, and 10. Even if Oswald did not do so, however, the claims challenged in this ground would have been obvious. Specifically, it is my opinion that it would have been obvious to have the HVAC control system receive inside temperature measurements (element [1b]), that it would have been obvious to have the database store inside temperature measurements over time (element [1c]), and that it would have been obvious for the processor to receive outside temperature measurements from a source other than the HVAC system (element [1d]). Furthermore, while Oswald teaches calculating the rates of change of inside temperature with the HVAC system ‘on’ and ‘off’ (claim element [1e]), and relating these rates to outside temperature (claim element [1f]), Cler provides the mathematical underpinnings for such calculations in the context of calculating optimum stop and start times. It would have been obvious to use Cler’s calculations with Oswald. I will also explain other, minor reasons why certain dependent claims would have been obvious, below.

146. In my opinion, the challenged claims are obvious over a combination of Oswald and Cler for the reasons explained below.

147. Additional bases for my opinions are also provided for dependent claims, as discussed below in the Claim Mapping section of my declaration.

B. Rationale (Motivation) Supporting Obviousness

148. I understand that it can be important to identify a motivation or reason that would have prompted a person of ordinary skill in the relevant field to combine the elements in multiple prior art references in the way the claimed new invention does. I discuss the rationales for the combination of Oswald and Cler below (and in the Claim Mapping section, as appropriate).

149. In my opinion, it would have been obvious at a general level to combine Cler with Oswald. Both Oswald and Cler both relate to energy management systems that track and seek to optimize the efficiency of heating and cooling systems, and are thus in the same field. (Ex. 1004, Abstract)(Ex. 1005, Abstract).

150. In my opinion, a person of ordinary skill in the art, would have looked to Cler when reviewing Oswald. As I explain in detail above, Oswald describes using a “transient thermal model.” (Ex. 1004, ¶¶0024-0025)(The system “uses the inside and outside temperature measurements to derive a transient thermal model of the house.”). While Oswald’s transient thermal model is disclosed *generally*, Oswald does not provide the mathematical details of its model. Cler, however, *does* provide detailed mathematics of a transient thermal model. (See, e.g. Ex. 1005, 3:39-5:41). In my opinion, Cler’s model is a “transient thermal model,” as Oswald uses that term, because it is based on a balance of the flow of heat into and out of the building. (Ex. 1005, 4:17-32). Therefore, in my opinion, it have been obvious for a

person of ordinary skill to examine the mathematics of known transient thermal models when reviewing Oswald to determine how best to implement portions of Oswald's teachings. (Ex. 1004, ¶0008).

151. Furthermore, as I explain in detail above, Oswald expressly discloses using a setback schedule with optimum stop and start times. Cler provides a specific technique for implementing such optimum times. For example, Oswald states:

“In traditional systems the householder uses a time controller to define when the heating (or air conditioning) should turn on and off. **With the use of the transient thermal model, the householder can now define when the house is to reach the controlled temperature schedule rather than when to start heating.** This allows the single central sensor system **to calculate the optimum time to turn on.** For example, say the householder returns home at 17:30 in the evening and wants the house at the desired temperature at 17:30. The system can use the transient model to calculate the time it will take to reach the desired temperature: on a cold windy day this might be 1 hour and on a mild day it might be 30 minutes. In this way the heating system is turned on for the minimum time and the house consumes the minimum heat energy.”

(Ex. 1004, ¶0139)(Emphasis added).

152. Cler provides a specific method for implementing a setback schedule with optimum stop and start times. As I discuss above, Cler uses its transient thermal model to estimate the time it will take for building inside temperature to reach a

setback point (with the HVAC system ‘off’), and to estimate the time it will take to recovery to a normal temperature (with the HVAC system ‘on’). (Ex. 1005, 6:24-8:19). Cler teaches that its methods “provide a more efficient control of the HVAC system as well as an indication of the level of performance of the HVAC system for maintenance purposes.” (Ex. 1005, 2:31-35),

153. In my opinion, because Oswald suggests using optimum stop and start procedures, and Cler provides a detailed approach for how to implement such procedures with advantage, it would have been obvious for a person of ordinary skill in the art to implement Cler’s approach in Oswald’s system. Moreover, in my opinion, the use of Cler’s mathematics for optimum stop and start in Oswald’s system would have merely involved using a known technique (Cler’s mathematical approach) to improve the operation of Oswald’s system in a known way. In my opinion, a person of ordinary skill could have implemented Cler’s known technique with no unpredictable results.

154. Further motivation to modify Oswald is provided in the Claim Mapping section, below, under the claim limitation to which the motivation applies.

C. Reasonable Expectation of Success

155. I understand that it can be important to demonstrate that one of ordinary skill in the art could have pursued the known potential solutions in the art with a reasonable expectation of success. In my opinion, a person of skill in the art in the

relevant timeframe would have had a reasonable expectation of success in combining Oswald and Cler in the manner discussed in the Overview section above and the claim mapping section below.

156. I understand that a “reasonable expectation of success” is required only for the limitations actually recited in the claims. In other words, I understand that there must be a reasonable expectation of success in achieving what is claimed in the patent-at-issue.

157. In my opinion, the art in the relevant timeframe was predictable. Here, the claim limitations of the '497 patent deal with well-known mechanical and software systems and concepts. By September 2007 (the earliest possible priority date of the '497 patent), more than sufficient skill existed to incorporate Cler's techniques in Oswald's system in the manner I describe.

158. Specifically, in the relevant timeframe, the basic components that made up systems like Oswald had been well-known in the art for decades. HVAC systems, including HVAC control systems, thermostats, processors, software and databases were widely known and understood. In my opinion, it would have been a simple matter for a person of ordinary skill to execute the necessary modifications to Oswald' system to allow it to make use of Cler's techniques for calculating optimum start and stop times.

D. Oswald and Cler Are Analogous Art

159. In my opinion, Oswald and Cler are analogous art because they are in the same field as the '497 patent (indoor environmental condition control and energy management systems/thermostat systems), and further because their methods would have been reasonably pertinent to the problems facing the named inventors. (Ex. 1004, Abstract)(Ex. 1005, Abstract).

E. Claim Mapping

160. In the paragraphs below, I map the elements of Oswald and Cler to meet the claim language of the '497 patent, rendering claims 1, 4-7, and 10-12 obvious over Oswald and Cler. The claim language appears in bold-italics. At times, I have added numbering in square brackets (e.g., [1b], [1c]) to facilitate discussion.

INDEPENDENT CLAIM 1

“1[a]. A system for calculating a value for the operational efficiency of a heating, ventilation, and air conditioning (HVAC) system comprising:”

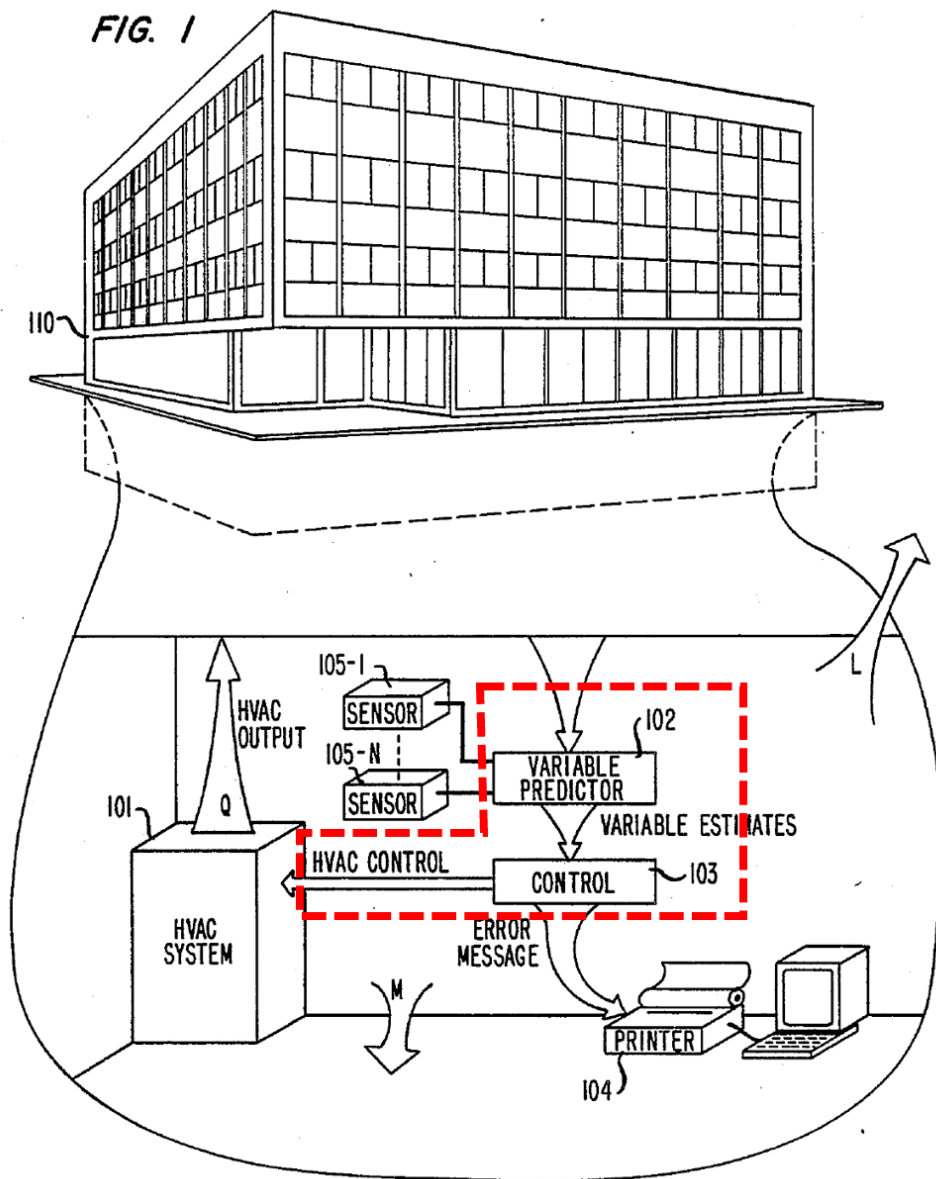
161. In my opinion, Oswald teaches this element, as I explain above regarding Ground 1, element 1[a]. Oswald teaches calculating building a transient thermal model, which calculates the operational efficiency of an HVAC system. (Ex. 1004, Abstract, claims 27-28, ¶¶0036, 0146-0148, 0024-0025).

“[1b] at least one HVAC control system that receives temperature measurements from at least a first location conditioned by at least

one HVAC system;”

162. In my opinion, Oswald teaches this element, as I explain above regarding Ground 1, element [1b].

163. In my opinion, Cler also teaches an HVAC control system, in the form of variable predictor 102 and control system 103, as illustrated by the added red-dashed box in Fig. 1 of Cler, reproduced here:



164. As can be seen from Fig. 1 of Cler, the HVAC control system (comprised of the variable predictor and control elements) receives input from sensors 105-1 through 105-N.

165. Among Cler's sensors are sensors that sense inside temperature. Cler explains:

“The adaptive environment control system of the present invention is illustrated in block diagram form in FIG. 1. This system is located in a building 110 and consists of a number of control elements 102 to 105-n in conjunction with the building heating, ventilation, and air conditioning (HVAC) system 101. **The control elements consist of various sensor devices 105-l to 105-n, such as thermostats and humidity sensors. Variable predictor 102 is connected to the various sensor devices 105-l to 105-n to obtain measurements of the building environment.**”

(Ex. 1005, 2:44-54)(Emphasis added). A person of ordinary skill in the art would understand from this statement that Cler’s thermostats sense the temperature inside the building. Cler further explicitly teaches that “thermostats” have temperature sensors. (Ex. 1005, 1:15-18)(“The control of the HVAC system is accomplished by the use of thermostats which sense the actual temperature in a particular building space”).

166. Although this claim element is already taught by Oswald, it would further have been obvious to have Oswald’s HVAC control system receive inside temperature measurements from a first location. Oswald, like Cler, teaches using a thermostat (Ex. 1004, ¶0148), and it was typical for thermostats to have a temperature sensor. For example, Cler teaches such a thermostat with a temperature sensor, and the ’497 patent discusses such thermostats in its Background section, which I also understand to be relevant. (Ex. 1005, 1:13-22)(Ex. 1001, 1:25-35).

167. Oswald also teaches a thermostat that communicates information to the sensor 2 to allow the sensor 2 to determine when temperature limits have been reached and adjust the transient thermal model to better fit the thermal response (*i.e.* the temperature). (Ex. 1004, ¶0148). Oswald states:

“[A] special house thermostat that communicates with the single central sensor 2 can be used. This thermostat acts as a normal house thermostat—switching open and closed as the temperature rises and falls through set limits. However, **it communicates this to the single central sensor 2 so that the system can still determine when temperature limits are reached and the transient thermal model can still be aligned with the real thermal response.**”

(Ex. 1004, ¶0148)(Emphasis added). A POSA would have found it obvious to have the sensor 2 (HVAC control system) receive temperature measurements from at least a first structure conditioned by at least one HVAC system, because it would have made it easier to “determine when temperature limits are reached”, and to ensure that the “transient thermal model can still be aligned with the real thermal response.”

(Ex. 1004, ¶0148). As I explain above (¶¶71,88), aligning the transient thermal model to match the “real thermal response” meant adjusting the model such that its output (inside temperature over time) best fits the actual measurements of inside temperature over time. It would have been obvious to have Oswald’s sensor 2 (the HVAC control system) receive inside temperature measurements to perform these

functions.

168. Similarly, Oswald teaches that the HVAC control system (sensor 2) is controlling the HVAC system to adjust temperature for the comfort of the occupants. (Ex. 1004, ¶¶0101, 0139, 0098-0100, 0016). An obvious way to do this was the standard way known in the art, namely by having a target temperature (setpoint) and switching the HVAC system ‘on’ or ‘off’ until the target is reached, as taught by Cler and admitted by the ’497 patent. (Ex. 1005, 1:17-51)(Ex. 1001, 1:25-35). Oswald likewise teaches that the sensor 2 performs an optimum start / stop function. To accomplish these activities, it would also have been obvious to have the HVAC control system (sensor 2) receive inside temperature measurements, to allow the HVAC control system (sensor 2) to better control the HVAC system (*e.g.* to stop when the HVAC system when the desired temperature is reached).

169. Furthermore, Oswald states that its system uses inside temperature measurements from an inside temperature sensor to construct a transient thermal model of the house. (Ex. 1004, ¶¶0024, claim 27, 0131, 0127-0136). Although the transient thermal model is calculated by the “processor” (Ex. 1004, ¶0052) and not the HVAC control system, the HVAC control system is the hub that collects information from all other elements of the system, as shown in Fig. 3 of Oswald, reproduced below:

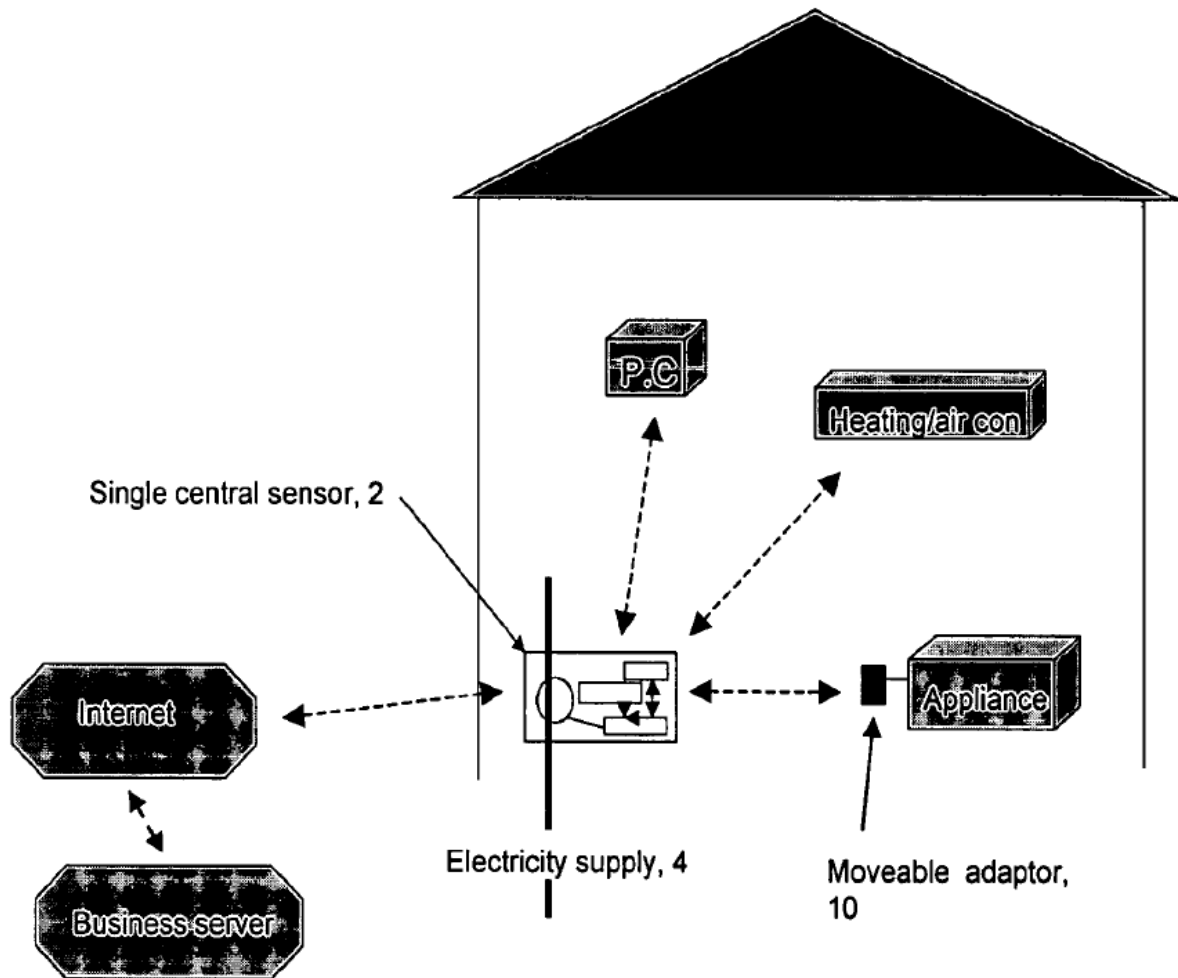


Figure 3

In my opinion, it would have been obvious from Fig. 3 to have the single central sensor 2 act as the central point for all communications, with no components communicating with other components but through the sensor 2. Thus, from Fig. 3, a POSA would have found it obvious to transmit temperature measurements from the single central sensor 2 to the PC (processor).

170. Because Oswald teaches that its sensor 2 receives information from a thermostat, performs HVAC control operations, and also serves as a communications link for a processor that calculates a transient thermal model, it would have been obvious based on Oswald and Cler to have Oswald's HVAC control system (sensor 2) **receive temperature measurements from at least a first structure conditioned by at least one HVAC system.** This would have had the advantage of allowing the sensor 2 to better control the HVAC system for user comfort.

171. Thus, in my opinion, it would have been obvious based on both Cler and Oswald to have Oswald's HVAC control system receive temperature measurements from at least a first location conditioned by at least one HVAC system, in order to allow Oswald's HVAC system to control inside temperature according to the user's preferences.

“[1c] one or more databases that store at least said temperatures measured at said first location over time; and”

172. My opinions concerning how Oswald teaches this claim limitation are set forth above in my analysis in Ground 1, element 1[c].

173. I am furthermore of the opinion that it would have been obvious based on Oswald's teachings to have Oswald's database store **at least said temperatures measured at said first location over time.** This is for two reasons. First, Oswald

teaches that the database stores “acquired data”, and data from temperature sensors is “acquired”. Second, as I discuss above (¶¶71,88), a POSA would have understood Oswald to be using temperature data over time in aligning the transient thermal model to the real thermal response. (Ex. 1004, Fig. 8, ¶¶0135-0136). Because Oswald uses temperature measured at said first location over time, it would have been obvious to store that information over time in the storage facility provided by Oswald: the database. (Ex. 1004, ¶0059).

“[1d] one or more processors that receive outside temperature measurements from at least one source other than said HVAC system,”

174. My opinions concerning how Oswald teaches this claim limitation are set forth above in my analysis in Ground 1, element [1d].

175. In my opinion, it furthermore would have been obvious based on Oswald’s teachings to have the outside temperature come **from at least one source other than said HVAC system**. Oswald states that:

“The system can use network data to improve validity. For example it can be informed of **local weather** from existing Internet weather databases which have weather information from nearby weather stations.”

(Ex. 1004, ¶0137)(Emphasis added). In my opinion, a person of ordinary skill would have considered outside temperature to be a necessary and obvious part of local

weather data. As I explain above (§§42-43, 102), a POSA would have considered outside temperature to be a necessary and obvious part of local weather data, and would have understood “validity” in the above quote to pertain to the need to incorporate outside temperature into a transient thermal model (because without taking outside temperature into account, the model is invalid). (Ex. 1004, §§0024, 0130, claim 27).

176. Oswald also teaches:

“The household energy management system according to the second aspect of the invention may further comprise one or more temperature sensors for measuring the temperature inside the house; **a source of information about the temperature outside the house;** a modelling means, which uses the inside and outside temperature measurements to derive a transient thermal model of the house....”

(Ex. 1004, §§0024, claim 27)(Emphasis added). In the passage of Oswald quoted above, the inside temperature comes from a temperature sensor inside the house, whereas the outside temperature comes from “a source of information about the temperature outside the house.” This contrast suggests that the information about outside temperature does not come from a sensor that is part of the HVAC system, but rather an outside source. I note again that the claim requires that the source of outside temperature be “other than said HVAC system”, and not “other than said HVAC control system”.

177. Oswald teaches: (1) to use outside temperature, (2) that outside temperature (in contrast to inside temperature) can be taken from “a source of information about the temperature outside the house”, and (3) that the system can access local weather information to improve the validity of the data. In my opinion, these teachings would have made it obvious to a person of ordinary skill in the art to a) either obtain temperature from some local source (such as a sensor) other than from the HVAC system, or b) use local weather data to provide a measurement of outside temperature. In my opinion, the latter option would have had the advantages of avoiding the cost of an extra sensor, and improving the accuracy of the data through the use of professionally-maintained temperature sensing equipment from a weather service. Furthermore, using Internet-based weather data was a known technique for the known problem of obtaining outside temperature (as demonstrated by Oswald). In my opinion, the use of Internet-based weather data could have been implemented without unpredictable results.

178. Finally, in my opinion, the processor discussed above would obviously **receive the measurement of outside temperature** from local weather data. This is because the processor performs the analysis for the EMS, including of the transient thermal model, and thus would require the measurement of outside temperature in order to conduct that analysis. (Ex. 1004, ¶0052)(*see also* Ex. 1004, ¶¶0046-0057, 0024-0025, claims 27-28).

“[1e] wherein said one or more processors are configured to calculate one or more rates of change in temperature at said first location for periods during which the status of the HVAC system is ‘on’ and wherein said one or more processors are further configured to calculate one or more rates of change in temperature at said first location for periods during which the status of the HVAC system is ‘off’, and”

179. My opinions concerning how Oswald teaches this claim limitation are set forth above in my analysis in Ground 1, element [1e].

180. Additionally, in my opinion, it would have been obvious to calculate the claimed rates of change based on both Oswald itself, and also based on Oswald in view of Cler.

181. The **first** reason is based on my analysis of Oswald alone. As I discuss above under Ground 1, claim element [1e], Oswald teaches calculating how quickly the house heats up or cools down, which are the claimed rates of change of temperature. (Ex. 1004, ¶¶0143, 0146, 0141). These rates of change are furthermore for when the HVAC system is ‘on’ and when it is ‘off’, for the reasons I explained above under Ground 1, claim 1, element [1e].

182. In my opinion, it would further have been obvious to perform these calculations in view of Oswald’s teachings because Oswald teaches using a setback schedule with optimum start / stop. (Ex. 1004, ¶¶0139, 0123-0124, 0103). In order to use this functionality, it would have been obvious to a person of ordinary skill in the art to calculate the best time to stop the HVAC system for setback, and the best

time to start the HVAC system for subsequent recovery. To calculate these times, it would have been obvious to know how fast the house would cool down and heat up, *i.e.* to use rates of change in temperature when the HVAC system is ‘on’ and ‘off’.

183. Knowing these rates would allow Oswald’s system to project the house temperature into the future, and calculate the length of time necessary to heat or cool the house to the setback or recovery temperatures. As was well understood in the art, by knowing an estimate of the rate of change in temperature with time, one can divide a desired temperature difference by the rate of change to get an estimate of the time required to cause the change in temperature, according to the following general formula: $\Delta t = \Delta T / (dT/dt)$, where ΔT is the desired change in temperature, dT/dt is the rate of change in temperature with respect to time, and Δt is the estimate of the quantity of time it will take to effect the desired change in temperature. Such an estimate would obviously have used a different dT/dt depending on whether the HVAC system was ‘on’ or ‘off’, in other words, whether the optimum stop time prior to setback, or the optimum start time prior to recovery, was being calculated. Such calculations and the above-described relations are basic mathematics, and in my opinion, would have been well within ordinary skill in the relevant timeframe.

184. The **second** reason is based on Oswald in combination with Cler. Specifically, it would have been obvious to calculate the claimed rates of change using Cler’s method. As discussed above in ¶¶137-144, above, Cler teaches using a

setback and recovery schedule with optimum start / stop times (Ex. 1005, 6:24-8:19).

To calculate the start / stop times, Cler uses estimates of the rate of change in temperature at the first location. Cler teaches:

“In addition, the adaptive environment control system can accurately set the time at which the HVAC system is switched between the setback unoccupied hours temperature level and the normal set-point building occupied temperature level, through the estimates of how long it takes both the HVAC system to have an impact on the building temperature as well as the **rate of change of the interior building temperature based on outside environment conditions**. These estimates and measurements of the adaptive environment control system provide a more efficient control of the HVAC system as well as an indication of the level of performance of the HVAC system for maintenance purposes.”

(Ex. 1005, 2:22-2:35)(Emphasis added). As in Oswald, it was obvious that the rate of change in house temperature during setback was with the HVAC system ‘off’, whereas the rate of change in house temperature during recovery to normal temperature was with the HVAC system ‘on’. (Ex. 1005, 6:46-7:7 (for setback), 7:65-8:19 (for recovery)).

185. To use the rate of change in a setback and recovery application, Cler teaches a simplified way to calculate the time it would take to change the temperature of the conditioned building to a setpoint temperature, using an estimate of the rate

of change in temperature at said first location. (Ex. 1005, 5:6-41). Specifically, Cler solves its Eq. (7) for time by using a Taylor series estimate of the exponential solution for $T_{in}(t)$. (Ex. 1005, 5:6-41). This results in an expression for the time needed to go from a current temperature to a setpoint, expressed in Eq. (11), reproduced here:

$$t = \frac{T_{set} - T_{in}(t)}{k(T_{out}(t) + \gamma - T_{in}(t))}$$

(Ex. 1005, 5:27-41)

186. In this Eq. (11), the denominator on the right-hand side of the equation is the **rate of change in temperature at a first location**. Specifically, ‘t’ (on the left side) is the “the amount of time for the building temperature to cycle to the set point/back temperature”, which we can write as Δt . (Ex. 1005, 5:31-35). Furthermore, $T_{in}(t)$ (right side) is the inside temperature evaluated at start time t, while (right side) T_{set} is the desired setpoint temperature. Thus, the numerator on the right side of Eq. (11) (which is $T_{set} - T_{in}(t)$) represents the difference between the desired setpoint temperature and the temperature at the start of setback or recovery, or the number of degrees by which the system desires to change the inside temperature. We can write this as ΔT . Thus, Eq. (11) has the form $\Delta t = \Delta T / D$, or written out: the change in time equals the change in temperature divided by a

denominator D (which is $k(T_{\text{out}}(t) + \gamma - T_{\text{in}}(t))$). By solving for the denominator D , it can be seen that $D = \Delta T / \Delta t$. In other words, the denominator D of Eq. (11) is a **rate of change in temperature** (the desired change in inside temperature divided by the time it takes to make the change).

187. In order to estimate the amount of time it would take to change the temperature by a desired amount using Eq. (11), it would be obvious to have the processor calculate the denominator D , as Cler obviously did. (Ex. 1005, 5:27-41). The denominator D is the rate of change in temperature **at said first location** (in the house, where the temperature sensor is located). (Ex. 1005, 3:39-60, 4:10-11). Furthermore, in the combination, it would have been obvious to calculate the rates of change in temperature in the denominator of the right side of Eq. (11) of Cler, in order to then calculate the necessary amount of time to make a desired temperature change, and thus to calculate optimal stop and start times.

188. The rate of change from Eq. (11) (the denominator on the right-hand side) applies both when **the HVAC system is on and when it is off**. Specifically, Cler teaches that the parameter ' γ ' relates to the amount of heat that the HVAC system adds to the building interior compared to the outflow of heat from the building. (Ex. 1005, 4:54-57). Cler explains that γ can be set to zero when the HVAC system is 'off';

“Thus, by determining a reasonable estimate of the parameters k and

γ , an approximation of the temperature in the building at time t in the future is determinable. A particular application of this capability is the above-mentioned optimal start/stop capability. For this application, the amount of time for the building temperature to cycle to the set point/back temperature is: [Eq. (11) omitted] For short time intervals, $T_{out}(t)$ is approximately a constant and the equation is reduced in complexity. In addition, **for the case of the unoccupied building with the HVAC system off, $\gamma=0$ since $Q=0$.**”

(Ex. 1005, 5:27-41)(Emphasis added). The variable Q , in Eq. (11) represents “the thermal output of the HVAC system”. (Ex. 1005, 4:14-16, 3:21) In other words, when the HVAC system is ‘off’ γ equals zero, because there is no output from the HVAC system. Conversely, when the HVAC system is ‘on’, γ has a value other than zero, because there is some output from the HVAC system. The fact that γ is included at all in Eq. (11) indicates that the HVAC system can be ‘on’ for certain calculations of Eq. (11), and the fact that Cler states that $\gamma=0$ for the case where the HVAC system is ‘off’ indicates that the HVAC system can be ‘off’ for certain calculations of Eq. (11). This was also obvious from the fact that Eq. (11) can be used to estimate the time need for both the optimum stop start and the optimum start, which require the HVAC system to be ‘off’ and ‘on’ respectively (as explained above in ¶¶45-46).

189. In my opinion, a POSA would reasonably have expected success in calculating one or more rates of change in temperature at said first location for

periods during which the status of the HVAC system is ‘on’ and ‘off’ based on either Oswald or Cler, because calculating rates of change involved relatively simple mathematics that could have been performed without unpredictable results.

190. It would have been obvious to use the equations of Cler in Oswald for the reasons I provide above in ¶¶155-161.

191. Thus, in my opinion, Oswald in view of Cler renders obvious calculating one or more rates of change in temperature at said first location for periods during which the status of the HVAC system is ‘on’ and when the system is ‘off’, because (1) Oswald renders this obvious based on its own teachings (2) Cler renders this obvious by providing a calculation for the time necessary for either optimum start or stop that utilizes the rate of change of inside temperature when the HVAC system is ‘on’ and when it is ‘off’.

“[1f] to relate said calculated rates of change to said outside temperature measurements.”

192. My opinions concerning how Oswald teaches this claim limitation are set forth above in my analysis in Ground 1, element [1f].

193. In my opinion, this claim element is also obvious in view of Cler. Specifically, Cler teaches that his methods use a measurement of outside temperature within its model calculations. For example, Cler’s equation for the rate of heat transfer of the building to the surrounding environment, Eq. (2), uses the difference

between the indoor temperature ($T_{i,in}(t)$) and outdoor temperature ($T_{i,out}(t)$) at each surface i:

$$L = \sum_i^{\text{all surfaces}} U_i A_i [T_{i,in}(t) - T_{i,out}(t)]$$

(Ex. 1005, 3:62-4:13). Cler also uses the outside temperature together with inside temperature, in Eqs. (7)-(11). For example, Eq. (11) has in the denominator of the right-hand side (which is the rate of change in temperature as discussed above under claim element [1e]), the term $k(T_{out}(t) + \gamma - T_{in}(t))$, where $T_{out}(t)$ is the outside temperature measurement. (Ex. 1005, 5:27-41, 4:12-13). Thus, Cler further teaches relating said calculated rates of change to said outside temperature measurements. Thus, in my opinion, Cler further teaches relating said calculated rates of change to said outside temperature measurements.

194. In my opinion, it would have been obvious to use these equations of Cler for the reasons provided above under claim element [1e] and also for the reasons I discuss above.

CLAIM 3

“3. A system as in claim 1 further comprising a programmable thermostat that communicates with said HVAC control system using the Internet.”

195. In my opinion, Oswald in view of Cler renders obvious a

programmable thermostat that communicates with said HVAC control system using the Internet.

196. Oswald teaches using a thermostat. (Ex. 1004, ¶¶0136, 0140-0141, 0148). It would further have been obvious to use a **programmable** thermostat. Programmable thermostats were well-known in the relevant timeframe as taught by Cler, and would have included a microprocessor and allowed for user-determined protocols for temperature vs. time (*e.g.* setback) functionality. (Ex. 1005, 1:23-30). Because it would have been obvious to use a setback functionality as discussed above in ¶¶183-194, above, it likewise would have been obvious to use a programmable thermostat with setback functionality.

197. Oswald further states that its system components can communicate over the **Internet**:

“Communications between the **various system items** use standard known communication systems *i.e.* phone, radio, **Internet** or communication by power cable.”

(Ex. 1004, ¶0052)(Emphasis added). Oswald specifically teaches that the sensor 2 (part of the EMS) can be made to communicate with a thermostat. (Ex. 1004, ¶0148)(teaching that “a special house thermostat that communicates with the single central sensor 2 can be used”).

198. Thus, in my opinion, Oswald in view of Cler renders obvious the

programmable thermostat communicating with said HVAC control system using the Internet.

CLAIM 4

“4. A system as in claim 1 in which said processors communicate with said HVAC system using a network that includes an electricity meter.”

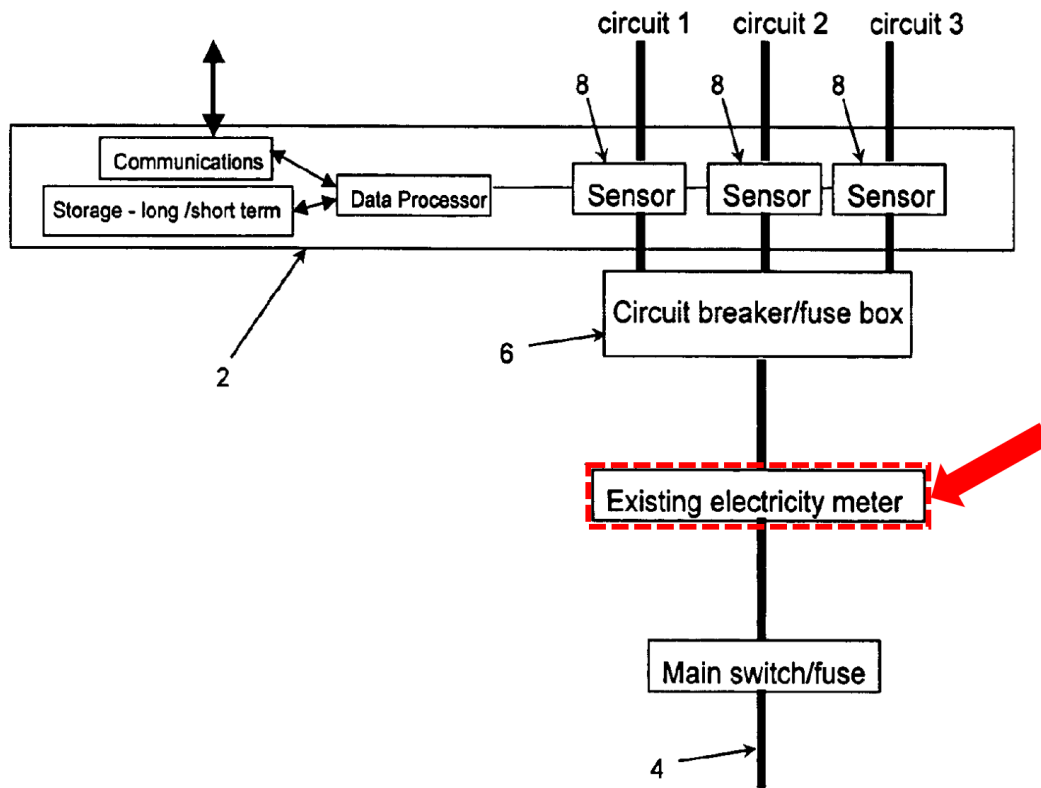
199. As I discussed above under Ground 1, claim 4, in my opinion, Oswald teaches that **said [one or more] processors communicate with said HVAC system using a network that includes an electricity meter.**

200. This claim would furthermore have been obvious over Oswald. Oswald teaches the processor can communicate with the other components of the system (e.g. the HVAC system) over a network. Oswald states:

“The analysis is performed on computers either local to the house or on the Internet. Communications between the various system items use standard known communication systems i.e. phone, radio, Internet or communication by power cable.”

(Ex. 1004, ¶0052)(Emphasis added).

201. The electricity meter of Oswald is shown in Fig. 2, reproduced below, with an added red-dashed box and red arrow indicating the meter:



As can be seen above in Fig. 2, Oswald’s electricity meter is connected to sensors, which are in turn connected to Oswald’s data processing and communication functions. (Ex. 1004, Fig. 2).

202. Additionally, Oswald states that the processor can communicate with other system components “us[ing] standard known communication systems i.e. phone, radio, Internet or communication **by power cable.**” (Ex. 1004, ¶0052). In my opinion, it would have been obvious based on these disclosures for Oswald’s processor to **communicate with said HVAC system using a network that includes an electricity meter.**

203. Furthermore, Oswald teaches that his household energy management

system itself can function as an electricity meter:

“A household energy management system in accordance with the invention, which monitors the energy consumption of household appliances, **can also act as an electricity meter** and may indicate the electricity consumption reading to the householder or transmit the reading directly to the electricity provider.”

(Ex. 1004, ¶0026)(Emphasis added). In my opinion, a person of ordinary skill in the art would have recognized that, a system that acts as the electricity meter obviously communicates with an HVAC system over a network that includes an electricity meter.

CLAIM 5

“5. A system as in claim 1 further comprising a programmable thermostat and said programmable thermostat is the sole source for current data regarding temperature inside said location conditioned by said HVAC system.”

204. As I discussed above under Ground 2, claim 3, in my opinion, Oswald teaches **a programmable thermostat that communicates with said HVAC control system using the Internet.**

205. In my opinion, Oswald further demonstrates the obviousness of having the thermostat be the **sole source for current data regarding temperature inside said location conditioned by said HVAC system.** Specifically, Oswald teaches the use of **“one or more temperature sensors** for measuring the temperature inside the

house.” (Ex. 1004, ¶0024)(Emphasis added). Because Oswald discloses “one or more” temperature sensors, Oswald discloses the use of a single temperature sensor. (See also Ex. 1001, 1:23-52).

206. Furthermore, in my opinion, in the case of a smaller building such as a house (disclosed by Oswald, Ex. 1004, at ¶¶0001, 0012-0018), it would make sense to have only a single temperature sensor in the thermostat. It was (and is) typical practice to have a thermostat with a single, built-in internal temperature sensor for HVAC systems during the relevant time. (Ex. 1008, 1:17-36). A single temperature sensor was typically used to keep costs low, and further because multiple temperature sensors within a small wall-mounted unit would be close together, and thus expected to read the same temperature. Thus, for those users desiring the cost-saving and other enhanced features of Oswald in a residence that requires only a single temperature sensor, in my opinion, it would have been obvious to use a single thermostat with a single temperature sensor therein.

CLAIM 6

“6. A system as in claim 1 in which said temperature measurements inside said first location occur at only one physical location.”

207. See my analysis above for claim 5. In my opinion, a single temperature sensor within a single thermostat would typically be wall-mounted, and thus take **temperature measurements at only one physical location.**

INDEPENDENT CLAIM 7

208. The limitations of independent claim 7 are similar to the limitations of claim 1, except that claim 7 is written in method form, and does not expressly require an HVAC control system. My opinions with respect to the obviousness of claim 7 in view of Oswald and Cler are similar to my opinions regarding claim 1.

“7[a]. A method for calculating a value for the operational efficiency of an HVAC system that comprises:”

209. See my analysis above for claim 1, element 1[a], above in this Ground. In my opinion, the system shown in claim 1 also exemplifies a method.

“7b] receiving temperature measurements from at least a first location conditioned by at least one HVAC system;”

210. See my analysis for claim 1, element [1b], above in this Ground.

“7c] storing in one or more databases at least said temperatures measured at said first location over time;”

211. See my analysis for claim 1, element [1c], above in this Ground.

“7d] receiving outside temperature measurements from at least one source other than said HVAC system; and”

212. See my analysis for claim 1, element [1d], above in this Ground.

“7e] calculating with one or more computer processors one or more rates of change in temperature at said first location for periods

during which the status of the HVAC system is ‘on’ and calculating one or more rates of change in temperature at said first location for periods during which the status of the HVAC system is ‘off’,”

213. See my analysis for claim 1, element [1e], above in this Ground.

“[7f] where said calculated rates of change are related to said outside temperature measurements.”

214. See my analysis for claim 1, element [1f], above in this Ground.

CLAIM 9

“9. A method as in claim 7 where said temperature measurements from at least a first location conditioned by at least one HVAC system further are received from a programmable thermostat that communicates with said HVAC control system using the Internet.”

215. See my analysis for claim 3, above in this Ground. I note that claim 9 differs from claim 3, in that claim 9 further requires that **said temperature measurements from at least a first location are received....using the Internet.** However, in my opinion, the same reasoning applied for claim 3 also applies for claim 9, because Oswald’s thermostat has a temperature sensor (*see* claim 1, element [1b], above), and Oswald expressly discloses that its system components can communicate using the Internet. (Ex. 1004, ¶¶0148, 0052).

CLAIM 10

“10. A method as in claim 7 that includes receiving information about electricity consumption in said first location from an electricity meter.”

216. See my analysis above for claim 4, under this Ground, which has the same claim language in system form.

CLAIM 11

“11. A method as in claim 7 in which said data regarding temperature inside said location conditioned by said HVAC system is supplied by a programmable thermostat.”

217. See my analysis above for claim 5, under this Ground, which has the same claim language in system form.

CLAIM 12

“12. A method as in claim 7 in which said temperature measurements at said first location occur at only one physical location.”

218. See my analysis above for claim 6, under this Ground, which has the same claim language in system form.

XII. GROUND 3: CLAIMS 2 AND 8 ARE OBVIOUS OVER OSWALD AND CLER AS IN GROUND 2, IN FURTHER VIEW OF ROSEN

219. In my opinion, claims 2 and 8 are obvious over Oswald in view of Cler, in further view of U.S. Pat. No. 6,789,739 (“**Rosen**”)(Ex. 1010).

220. I generally describe Oswald and Cler above in Ground 2.

221. I understand that Rosen was cited in an Information Disclosure Statement (“IDS”) (together with 78 other references) during the prosecution of the application that issued as the ’497 patent, but was never discussed or applied on the record. (Ex. 1011, pp. 87-90). I also understand that Rosen was cited by an

Examiner in a rejection of an alleged parent application of the '497 patent (U.S. Pat. App. Ser. No. 12/211,733, Ex. 1013, pp. 68-71). However, that application issued as a different patent (U.S. Pat. No. 7,848,900), and the Applicants did not contest the Examiner's rejection, but instead simply canceled the rejected claims. (Ex. 1013, p. 58).

222. I can see from the face of Rosen that the patent issued on September 14, 2004. I am informed that it is therefore prior art to the '497 patent.

A. Overview of My Obviousness Opinion

223. My opinions are based on Oswald and Cler as I set forth above with respect to Ground 2.

224. Claims 2 and 8 of the '497 patent each require "receiv[ing] outside temperatures for geographic regions based on ZIP codes." Oswald and Cler do not expressly teach using weather that is localized using a ZIP code, but Rosen does. In my opinion, it would have been obvious to combine Rosen's teaching of weather by ZIP code with Oswald's system for the reasons provided below.

B. Rationale (Motivation) Supporting Obviousness

225. I understand that it can be important to identify a motivation or reason that would have prompted a person of ordinary skill in the relevant field to combine the elements in multiple prior art references in the way the claimed new invention does. I discuss the rationales for the combination of Oswald and Cler below in the

Claim Mapping section, as appropriate.

C. Reasonable Expectation of Success

226. I understand that it can be important to demonstrate that one of ordinary skill in the art could have pursued the known potential solutions in the art with a reasonable expectation of success. In my opinion, a person of skill in the art in the relevant timeframe would have had a reasonable expectation of success in combining Oswald and Cler in the manner discussed in the Overview section above and the claim mapping section below.

227. I understand that a “reasonable expectation of success” is required only for the limitations actually recited in the claims. In other words, I understand that there must be a reasonable expectation of success in achieving what is claimed in the patent-at-issue.

228. As I explain above (¶157), the art in the relevant timeframe was predictable.

229. In my opinion, a person of ordinary skill in the art would have been able to easily integrate Rosen’s use of ZIP codes and the Internet into Oswald’ systems. Specifically, in the relevant timeframe, the use of ZIP codes to localize weather data was well known in the art. Furthermore, the use of the Internet for communications was widely known and understood and it would have been a straightforward exercise to use the Internet in Oswald’ system for communications.

In my opinion, it would have been a simple matter for a person of ordinary skill to execute the necessary modifications to Oswald's system.

D. Oswald, Cler, and Rosen Are Analogous Art

230. In my opinion, Oswald, Cler, and Rosen are analogous art because they are in the same field as the '497 patent (indoor environmental condition control and energy management systems/thermostat systems), and further because their methods would have been reasonably pertinent to the problems facing the named inventors. (Ex. 1010, 2:1-38).

E. Claim Mapping

231. In the paragraphs below, I map the elements of Oswald, Cler and Rosen in a way that would meet the claim language of the '497 patent, rendering claims 2 and 8 obvious over Oswald in view of Cler and further in view of Rosen. The claim language appears in bold-italics. At times, I have added numbering in square brackets (*e.g.*, 1[b], 1[c]) to facilitate discussion.

CLAIMS 2 AND 8

232. Claims 2 and 8 have similar requirements, and thus I address them both together.

“2. A system as in claim 1 in which said processors receive outside temperatures for geographic regions based on ZIP codes from sources other than said HVAC system.”

“8. A method as in claim 7 in which said outside temperatures are

received for geographic regions based on ZIP codes from sources other than said HVAC system.”

233. As I discuss above, Oswald discloses that its system can receive local weather information over the Internet. Oswald states:

“The system can use network data to improve validity. For example it can be informed of **local weather from existing Internet weather databases** which have weather information from nearby weather stations.”

(Ex. 1004, ¶0137)(Emphasis added). As I discussed above under Ground 2, claim element [1c], in my opinion, it was obvious to use weather information to provide outside temperature.

234. Oswald does not expressly state that its weather service provider localizes data using a ZIP code. Rosen, however, teaches a thermostat that receives location-specific weather data (including temperature) from a weather service, over the Internet, by providing a ZIP code. (Ex. 1010, 7:19-45 (“[L]ocation data of a thermostat is transmitted from transmission means (a modem) through the Internet to a website maintained to have access to weather or climate information (the remote device). The weather website (the remote device) receives the location data and associates it with local weather data for the thermostat location, which is then transmitted to the thermostat through the modem (a response of the remote device)....This location data in one form can be as simple as a . . . a zip or postal

code”), 6:50-61 (“Those other devices may be Internet sites transmitting weather data to the thermostat based on the geographic location of the thermostat.”), 2:31-38, 7:58-8:41).

235. Because Oswald teaches retrieving “local” weather data from an Internet weather service provider, but does not specify a way to localize the data, the person of ordinary skill would have sought out known means for doing so. Rosen provides a simple means to do so: by having a thermostat programmed with the ZIP code of the structure, which is then provided over the Internet to a weather data provider. (Ex. 1010, 7:19-45, 6:50-61, 2:31-38, 7:58-8:41). The ZIP code is a commonly-used form of approximate location in the United States, and would have been familiar to a person of ordinary skill. In my opinion, the use of zip codes in Oswald’s system would have been straightforward and a person of ordinary skill in the art could have implemented their use in Oswald’s system with no unexpected results.

XIII. OATH

236. This declaration and my opinions herein are made to the best of my knowledge and understanding, and based on the material available to me, at the time of signing this declaration. I declare under penalty of perjury under the laws of the United States of America that all statements made of my own knowledge are true and that all statements made on information and belief are believed to be true. I understand that willful false statements and the like are punishable by fine or imprisonment, or both (18 U.S.C. 1001) and may jeopardize the validity of the application or any patent issuing thereon.

Date: 5-12-2020

Signed: Rajendra Shah