(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) **EP 2 065 655 A2**

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
03.06.2009 Bulletin 2009/23

(51) Int Cl.:
F24F 11/00 *(2006.01)*

(21) Application number: **08168441.7**

(22) Date of filing: **06.11.2008**

(84) Designated Contracting States:
AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MT NL NO PL PT RO SE SI SK TR
Designated Extension States:
AL BA MK RS

(30) Priority: **28.11.2007 IT MI20072239**

(71) Applicant: **Bruno, Franco**
20090 Buccinasco MI (IT)

(72) Inventor: **Bruno, Franco**
20090 Buccinasco MI (IT)

(74) Representative: **Postiglione, Ferruccio**
Ufficio Internazionale Brevetti
Ing. C. Gregorj S.p.A.
Via L. Muratori 13/b
20135 Milano (IT)

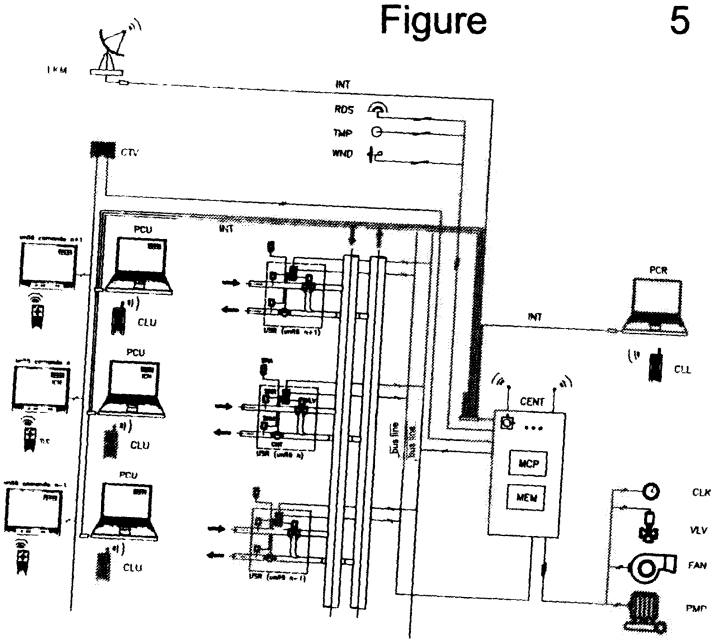
(54) **Method and device for energy saving by scheduling of the energy supplied for air-conditioning, according to the previous and/or expected power consumption and the knowledge in advance of weather data**

(57) It is the object of the present invention to create an articulated and automatic system, which allows the reduction the primary energy consumption for room air-conditioning.

Such objects are achieved by a device for automatic management and thermoregulation of central systems, that allows individual direct users, and only the users, in the most precise and absolutely democratic manner, to decide how the HVAC systems should operate, both in terms of operation duration and in terms of performance and yields.

It is another object of the invention a complex method which allows the carrying out of the automatic room thermoregulation both by knowing the immediate weather data, and by the information obtained from the weather forecast, integrated with the user decision to restrict or, however, to regulate the primary energy consumption for the room air-conditioning, in respect to duration times of air-conditioning and expected room climate parameters.

Figure 5



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Description

[0001] The present invention refers to a method and device to allow thermal energy saving for the winter heating by scheduling the energy supply according to the previous and/or expected power consumption and, inter alia, the knowledge in advance of weather data.

[0002] Present thermoregulation systems commonly employed in room air-conditioning systems for residential use, service-industry and usually for industrial use as well, are based on the immediate knowledge of outside weather conditions, mainly only the outside temperature. Such systems, according to these conditions, simply set the heat transfer fluid used in the systems (e.g. hot water in winter, refrigerated water in summer).

[0003] A small number of systems, mainly those intended for home air conditioning and in particular for winter heating, are equipped with indicators of the room temperature; however, practically no prior art system acquires weather parameter information, besides, as previously mentioned, the external temperature.

[0004] Only recently has a system, see Italian Patent Application MI 2006 A 000671 in the name of Franco Bruno et al., used solar radiation or information inferred by weather forecast to know in advance the climatic conditions and in particular the expected solar radiation.

[0005] Yet no system presently used allows the air-conditioning system users to automatically or semiautomatically decide, at any time during the day or in a preset or predefined moment, how much energy needs to be used or employed for the air-conditioning itself.

[0006] Such a problem is particularly important and worthy of interest, where the decision does not involve or depend on a single user, but multiple users, regardless of their number (e.g. owner-occupiers in a block of flats, office staff, buildings with a different intended use, industry departments characterized by different climatic needs, etc.). This circumstance represents a severe restriction to the prior art, not only in regard to whether users do not have either a real opportunity to globally, and not individually, act in real time, e.g. on board thermostat setting of a fan coil, turning on or off a HVAC (Heating Ventilation and Air Conditioning) system terminal, and the like, on central systems, nor to choose settings and yields of the above systems, according to not only environmental comfort criteria, but to effective and real energy saving and reduction of pollutant emissions in the atmosphere, where the HVAC systems are supplied with fossil fuel o even with biomass fuel.

[0007] It is an object of the present invention to create an articulated and automatic system, which allows the reduction of the primary energy consumption for the room air-conditioning.

[0008] The object of the invention is achieved by a method for energy saving described by the appended independent claim 1. Particular embodiments of the method are depicted by the dependent claims 2-12. In accordance with another object, the invention relates to an energy saving system as described by claim 13 and its particular embodiments defined by claims 14-16.

[0009] In accordance with an example, such objects are achieved by a device for automatically managing and thermoregulating central systems by systems which allow direct single users, only the users, as punctually and absolutely democratically as possible, to decide individually how systems have to work, in terms of both working duration and performance and yield.

[0010] In accordance with a particular embodiment, the object of the invention is a complex method, that allows the carrying out of an automatic thermoregulation in rooms, both by the knowledge of immediate weather data, and by the information acquired from the weather forecast, integrated with the decision by the user to restrict or otherwise regulate the primary energy consumption for the room air-conditioning, according to both the air-conditioning duration and the expected room climate parameters.

[0011] Further particular features of the invention are set forth below. The invention will be hereinafter described in detail, by way of example, with reference to the appended drawings, wherein:

Figure 1 shows a scheme of a thermoregulation system design for a common central HVAC system (Heating Ventilation & Air Conditioning), widely used in both existing and newly manufactured systems, according to the prior art;

Figure 2 shows a scheme of a thermoregulation system design for a common central HVAC system, which can be remotely controlled and managed, used in both existing and newly manufactured systems, according to the prior art;

Figure 3 shows a scheme of a thermoregulation system design for a common central HVAC system, which has recently been introduced (Italian Patent Application MI 2006 A 000671 in the name of Franco Bruno et al.) installed in both new and existing systems, also capable of acquiring also weather forecasts in advance and more complete external climatic data, such as solar radiation, and processing therefrom a control rule of the system, which takes the above data into account and in particular solar radiation by an algorithm of the delay time calculation of solar radiation efficiency, of course keeping and widening the possibility of remote control and management;

Figure 4 shows a scheme of a thermoregulation system design for a common central HVAC system with remote satellite units, where sending heat transfer fluids to units that need air-conditioning is controlled by a room thermostat, of the relevant units, also with a remote control system for energy consumption data reading;

Figure 5 shows a scheme of a room-thermoregulation device according to the present invention.

[0012] The operational logic of the system according to the invention will be discussed below with reference to the logical-operational scheme in figure 5, which takes into account:

- the future weather-climate conditions known in advance, and automatically by, for example but non limited to, an internet connection to a weather station or other office capable of providing the required information from the station;
- the immediate weather-climate conditions in situ, measured by the in-field sensors;
- the solar energy immediate thermal supply, directly measured by the in-field sensors;
- the knowledge of the actuator status, i.e. their immediate or programmed real operating conditions;
- the knowledge of the environmental-climatic situations of the property and/or production units and the actuator system status onboard the remote satellite units;
- the knowledge of the energy consumption, not only immediate, but also prior, of the property and/or production units supplied by the remote satellite units;
- the knowledge of the HVAC system users' definite will about the required environmental conditions, scheduled HVAC service working times, and restrictions or, however, the regulation of the desired energy consumption.

[0013] In figure 1, the design of a thermoregulation system is depicted, according to the prior art, largely used in the present plant engineering, in respect to a general central HVAC system, which can be intended both for domestic and industrial users.

[0014] In figure 1, it can be appreciated that the control of energy supplied by the users' system occurs only by an actuator, in this example, a three-way mixer valve VLV installed on the distribution circuit of the heat transfer fluid, which regulate the fluid delivery temperature according to the external temperature sensed by a external temperature sensor TMP, according to a generally linear regulation curve, almost always manually set by the system manager and practically never by the thermal service end user. Such temperature data are transmitted to a control panel CENT comprising a control microprocessor TRM and a programming clock CLK. Sometimes the three-way mixer valve is replaced by a drive for one or more circulation pumps PMP which control the heat transfer fluid rate or by a drive for one or more air fans FAN.

[0015] The scheme depicted in figure 2 simply depicts an evolution of the system illustrated in the above instance, where the climatic regulation curve change can be carried out remotely by the system manager by means of a remote computer PCR connected by an Internet connection line INT, together with the readings of a number of system parameters, in most cases represented by the heat transfer fluid temperature.

[0016] The scheme depicted in figure 3 depicts a further evolution of the systems depicted in the previous schemes, and it is the subject of the above mentioned Patent Application in the name of Franco Bruno et al. In such a system, briefly, the control law of heat transfer fluid temperatures or other actuators' drives is determined, with reference not only to the local immediate external temperature provided by a TMP sensor, but also by using the immediate knowledge of the direct solar energy supply RDS, of wind speed provided by an air-speed indicator WND and in particular by the advance knowledge of the environmental climatic conditions provided by a weather-station LKM, by using automatic acquisition Internet connections INT, with sampling rates, set time after time, of the forecast weather data by mathematic models and shortly in evolution of the data itself, all this data being processed in a control panel CENT, including a microprocessor unit MCP and a storage unit MEM, connected to the Internet through a remote computer PCR. From the control panel CENT start the operating signals of the actuators composed of a clock CLK, a power-driven valve VLV, a fan FAN and a pump PMP.

[0017] Thereby, by knowing the relative building or relative HVAC system structure heat parameters, and in particular their heat time constants, computational algorithms for the control rules are created, which, stored in the drive and control panel CENT, are able to manage the HVAC systems, by knowing in advance their behaviour under the climatic conditions which are going to shortly occur, and this is advantageous for both room comfort and energy savings achievable in terms of primary energy spent.

[0018] The scheme in figure 4 shows a kind of system which the present invention aims to improve. The depicted kind of HVAC system is largely used, mostly in cases of new buildings where heat transfer fluids are distributed in various property or production units, by sub-plants or "satellites" capable of locally controlling the supplied fluid temperature for each unit or their flow rate by local thermostatic control and - mandatory by law- recognition of the drawn energy. Every satellite unit includes a room temperature sensor SNA, a delivery temperature sensor SNM, a return fluid temperature sensor SNR, a power-driven valve VLV and a discharge meter CNT. All of the units are electronically connected to a bus line which carries the sensed data in the various units to the control panel CENT.

[0019] Besides, the common commercially available systems are equipped or equippable with remote control systems, but they almost never work by remote management of the remote satellite units, as far as the air-conditioning or energy consumption is concerned.

[0020] Moreover, such a system does not take into account at all:

- the near-term climatic conditions;
- the immediate direct solar radiation.

[0021] However, the most relevant and important datum to highlight is that such systems do not allow the great number of users to decide together and on a democratic basis, what the energy consumption can be, which is to be obtained daily at a central system level, because it is lacking in any ability to survey the users and ask them to carry out the setting of different control rules.

[0022] The novel system, schematically depicted in figure 5, wherein the various components are indicated by the same reference characters used in the previous figures, designed for central HVAC systems with satellite distribution, provides that to the control panel, comprising the microprocessor and the memory, the following units are connected:

- climatic sensors RDS, TMP, WND;
- link LKM to the weather station;
- driving units TLC through the television control panel ;
- private computers PCU through an Internet Connection INT;
- remote satellite units USR through bus lines;
- a remote computer PCR or a mobile telephone CLL.

[0023] With a central satellite distribution HVAC system complying with the present invention it is therefore possible:

- to take into account the short term expected climatic conditions by an Internet connection to the weather centre LKM, helping in forecasting the control rule processing of HVAC systems;
- to take into account the immediate direct solar radiation as well, measured by the radiometer RDS, beside other climatic parameters measurable in real time, such as wind speed and direction, sensed by the air-speed indicator WND for a more accurate calibration of the control rule, which, as a result, does not only take into account the external temperature;
- to obtain information from the remote satellite units USR about the room condition status through a sensor SNA and the actuator status (e.g. three-way mixer valve VLV, deviation valves, two way on/off valve, optional programming clocks CLK, etc.) onboard such units;
- to obtain information about the actuator status onboard heating/cooling and air ventilation-exchange systems (e.g. burners, pumps, three-way mixer and/or deviation valves, programming clocks CLK, fans FAN, suction fans, exchange batteries, humidifier, etc.);
- obtain information from the users who refer to the multiple satellite units USR in regard to forwarded requests to the central system (e.g. scheduling time, expected room temperatures and/or parameters);
- obtain information from the satellite units USR about ongoing energy consumption, store and integrate such data for the cumulative computing of drawn energy;
- process, according to the above collected data, possible system control rules for:
  - real time operation thereof;
  - the scheduled operation for the following day or shift;
- process, according to the scheduled operation for the following day or shift, several combined scenarios for keeping predetermined kinds of room comfort and energy consumption by introducing different management parameters (e.g. temperatures to be kept in the rooms, expected air-conditioning duration, introduction of gaps in the scheduled period characterised by turning off or reducing the thermal energy supply, etc.);
- interactively survey the satellite unit users, by surveying on video on private television sets connected to a TV control panel, connected, in turn, to a control panel CENT, by using a proper remote control TLC or by surveying on video on a private computer PCU or on a network, or by surveying on a private mobile phone display CLU, by an information icon ICN, capable of showing the different provided options to the user;
- to gather the user answers and, through a computational algorithm that refers to a weighed means or to criteria of condominium association dues or to criteria of energy needs, to form a final score;
- to use the final score to validate the provided options.
- to gather from the multiple users, the following day, by the same surveying system, the evaluation score, the acceptance rating of the previously obtained control rule, while communicating the energy saving achieved, both in absolute and percentual terms, from adopting the proposed and chosen control rules and, for example, also reduced CO_2 emissions, resulting from the primary fuel lower consumption used for air-conditioning;
- storing the consumption data or the chosen control rule in a database in a non volatile memory which can be referred to when such similar climatic-environmental conditions should occur over the time that the same chosen rule can be proposed again to users, by surveying;
- drive and control all the in-field actuators, namely the clock CLK, the power-driven valve VLV, the fan FAN and the pump PMP, onboard both the heating/cooling and air-ventilation/exchange systems, and the satellite units USR, each including a room temperature sensor SNA, a discharge temperature sensor SNM, a return fluid temperature sensor SNR, a power-driven valve VLV and a flow rate meter CNT, to carry out the above described control rules;
- carry out the aforementioned by in-field control or remote control, either by means of a compute or a mobile phone.

[0024] The advantages resulting from adopting the subject system of the present patent consist essentially of:

a) a lower primary energy consumption than control systems for central HVC systems with satellite units USR, for the same operation times and without direct control by service users;
b) further lower primary energy consumption, because of the opportunity given to users to determine, according to a democratic vote mechanism, criteria for managing and controlling climatic-room parameters computed from time to time and provided by the control panel of the system;
c) higher room comfort, in regard to the given opportunity to better govern the climatic-room conditions and, in particular, the room-temperature due to the use of information real and in advance about the degree, for example, of the solar radiation provided by the radiometer RDS or the wind speed and direction provided by the air-speed indicator WIND;
d) a lower emission output, present in the fossil fuel or, also, biomass combustion, due to the lower use thereof in absolute terms, because of the achieved and achievable energy saving.

[0025] Only by way of example, a possible option will be examined, in the case of winter central heating in a building for residential use. Imagine that, after having analysed the obtained weather forecast from a weather centre LKM and taking into account the answers gathered the day before, by surveying users, the control panel CENT:

- proposes to the same multiple users to decrease the internal temperature in all the rooms controlled by the satellite units by 0.7°C (for example: from +20°C to 19.3°C)
- proposes likewise to reduce the whole operation times from 14 hours to 13 hours a day, introducing, for example, a heating attenuation interval of precisely 1 hour during the period when, from the weather forecast, the highest external temperature during the entire day or the most intense solar radiation is expected, of course taking into account, in the latter case, the so-called "transfer function", peculiar of the heated building structure;
- shows the users the expected energy saving, in terms of lower fuel consumption and lower contingent electricity consumption, in respect to the standard management of the HVAC system, where the above proposals are accepted with a 100% percentage of the assents and also the resulting lower CO_2 emissions;
- asks users to vote for the management option proposed;
- calculates a final score based on the obtained answers and, according to the set algorithm, which takes into account an arithmetic or weighed mean according to criteria of condominium association dues or the standard energy needs, calculates that the answer has obtained a global assent of 80%.

[0026] As a result, the control rule, processed by the system control panel, will have to guarantee, for the following day, an average internal temperature in the rooms of +19.44°C in comparison to the +19.3°C initially proposed and the daytime attenuation interval will drop to only 48 minutes, in comparison to the 60 minutes proposed.

[0027] The present invention is, however, subject to many modifications and variants which fall within the protection scope of the appended claims.

Claims

1. Method for energy saving in residential and commercial room air-conditioning system, which takes into account the short term expected climatic conditions, by an Internet connection to a weather centre (LKM);

   - collecting information from remote satellite units (USR) operating in the air-conditioning system and associated with system users, said information comprising room condition status, ongoing energy consumption and requests forwarded to the remote satellite units by the users;
   - collecting further information about the status of actuators operating in said air-conditioning system;
   - processing the collected information to provide a plurality of air-conditioning system control possible rules associated with several combined scenarios for keeping predetermined kinds of room comfort and energy consumption;
   - interactively surveying the users by showing the several combined scenarios to the users and gathering user answers and, through a computational algorithm, forming a final score;
   - using the final score to validate a selected combined scenario and a corresponding selected control rule;
   - storing the selected control rule in a database;
   - driving and controlling the actuators in accordance with the selected control rule.

2. Method according to claim 1, wherein the room air-conditioning system, is configured for anticipating the processing of the control rule of HVAC ((Heating Ventilation and Air Conditioning) systems, and also the immediate direct solar radiation measured by the radiometer (RDS), besides other real time measurable climatic parameters, such as wind speed and direction sensed by the air-speed indicator (WND).

3. Method according at least one of the preceding claims, wherein collecting information about the room condition status includes using a sensor (SNA) and the actuators comprise at least one of the following devices: three-way mixer valves (VLV), deviation valves, two way on/off valves, programming clocks (CLK) .

4. Method according at least one of the preceding claims, wherein said actuators comprise at least one of the following further devices: onboard heating/cooling and air ventilation-exchange systems, such as burners, pumps, three-way mixer and/or deviation valves (VLV), programming clocks (CLK), fans (FAN), suction fans, exchange batteries, humidifiers.

5. Method according at least one of the preceding claims, wherein:

- the requests forwarded to the air-conditioning system by the users include: scheduling times, expected room temperatures and/or parameters and the information ; and
- the information about the ongoing energy consumption is stored and integrated for a cumulative computing of drawn energy.

6. Method according at least one of the preceding claims, wherein said plurality of air-conditioning system control rules includes rules for:

■ real time operation of the air-conditioning system;
■ scheduled operation for the following day or shift of the air-conditioning system.

7. Method according at least one of the preceding claims, wherein processing the collected information to provide possible plurality of air-conditioning system control rules includes:

introducing different management parameters, such as temperatures to be kept in the rooms, expected air-conditioning duration, introduction of intervals in the scheduled period **characterised by** turning off or reducing the thermal energy supply, and the like.

8. Method according at least one of the preceding claims, wherein interactively surveying the users includes:

surveying on video on private television sets connected to a TV control panel, connected, in turn, to a control panel (CENT), by using a proper remote control (TLC) or by surveying on video on a private computer (PCU) or on a network, or by surveying on a private mobile phone display (CLU), by an information icon (ICN).

9. Method according at least one of the preceding claims, further comprising:

- gathering from the users, the following day the acceptance rating of the previously selected control rule and simultaneously communicating the energy saving achieved, both in absolute and percentual terms, from adopting the proposed and chosen control rules and also reduced CO_2 emissions, resulting from the primary fuel use.

10. Method according at least one of the preceding claims, wherein storing the selected control rule in a database includes storing also consumption data in a non volatile memory which can be referred to when such similar climatic-room conditions should occur over the time that the same selected rule can be proposed again to users, by surveying.

11. Method according at least one of the preceding claims, wherein driving and controlling actuators includes driving and controlling, namely the clock (CLK), the power-driven valve (VLV), the fan (FAN) and the pump (PMP), on board both of the heating/cooling and air-ventilation/exchange systems, and the satellite units (USR), each including a room temperature sensor (SNA), a delivery temperature sensor (SNM), a return fluid temperature sensor (SNR), a power-driven valve (VLV) and a flow rate meter (CNT).

12. Method according at least one of the preceding claims, wherein driving and controlling is carried out by in-field control or remote control, either by means of a PC or a mobile phone.

13. Energy saving system in residential and commercial room air-conditioning system, which takes into account the short term expected climatic conditions, by an Internet connection to a weather centre (LKM);

- means for collecting information from remote satellite units (USR) operating in the air-conditioning system and associated with system users; said information comprising room condition status, ongoing energy consumption and requests forwarded to the remote satellite units by the users;
- means for collecting further information about the status of actuators operating in said air-conditioning system;
- means for processing the collected information to provide a plurality of air-conditioning system control possible rules associated with several combined scenarios for keeping predetermined

kinds of room comfort and energy consumption;
- means for interactively surveying the users by showing the several combined scenarios to the users and gathering user answers and, through a computational algorithm, forming a final score;
- means for processing the final score to validate a selected combined scenario and a corresponding selected control rule;
- means for storing the selected control rule in a database;
- means for driving and controlling the actuators in accordance with the selected control rule.

14. Energy saving system in accordance with claim 13, wherein the means for interactively is configured to surveying on video on private television sets connected to a TV control panel, connected, in turn, to a control panel (CENT), by using a proper remote control (TLC) or by surveying on video on a private computer (PCU) or on a network, or by surveying on a private mobile phone display (CLU), by an information icon (ICN).

15. Energy saving system in accordance with claim 13 or 14, wherein:

the requests forwarded to the air-conditioning system by the users includes: scheduling times, expected room temperatures and/or parameters and the information ; and
the information about the ongoing energy consumption is stored and integrated for a cumulative computing of drawn energy.

16. Energy saving system in accordance with at least one of claims 13-15, wherein said plurality of air-conditioning system control rules includes rules for:

■ real time operation of the air-conditioning system;
■ scheduled operation for the following day or shift of the air-conditioning system.

17. Energy saving system according to at least one of claims 13-16, comprising a control panel (CENT) equipped with a memory (MEM) and a microprocessor (MCP), said microprocessor (MCP) being able to process a thermoregulation program, operating by acquiring data which represent the room and its exterior, said microprocessor being able to emit driving signal for the thermoregulation, by means of proper control rules, wherein in said memory at least algorithms representing said control rules are resident, the device further providing sensors to sense the external and internal conditions of said room and means for obtaining data and sending them to said microprocessor, and means for obtaining digital commands processed by said microprocessor and generally converting them into commands to be sent to the driving units associated to the air-conditioning systems in said room, means for obtaining advance weather forecast data by an Internet connection to the weather centre (LKM), to be sent to said microprocessor, means for taking into account the immediate direct solar radiation measured by the radiometer (RDS), besides other climatic parameters measurable in real time, such as wind speed and direction sensed by the air-speed indicator (WND).

Figure 1

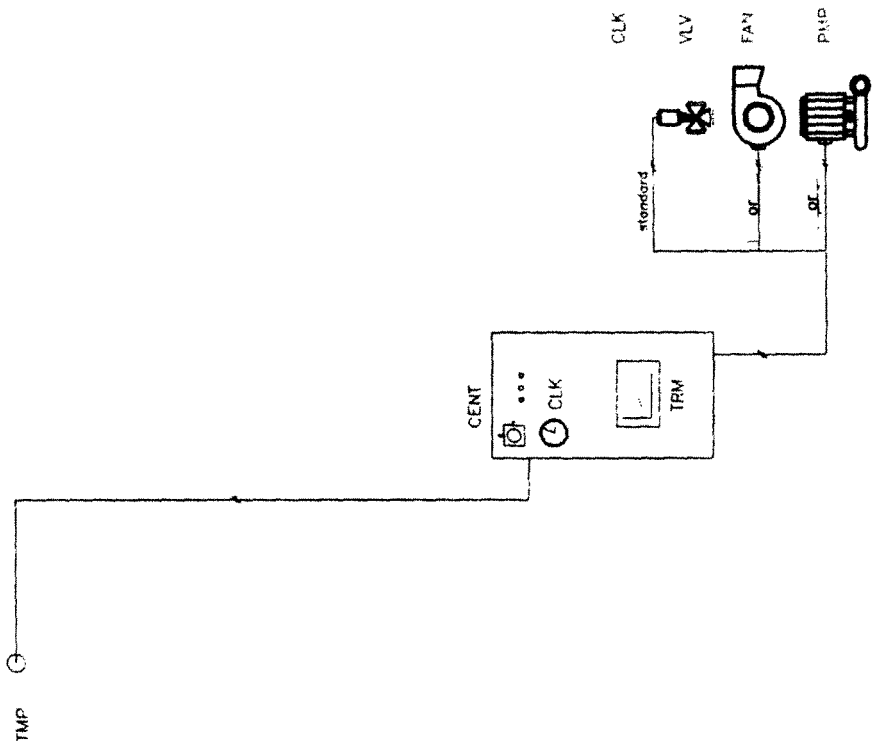


Figure 2

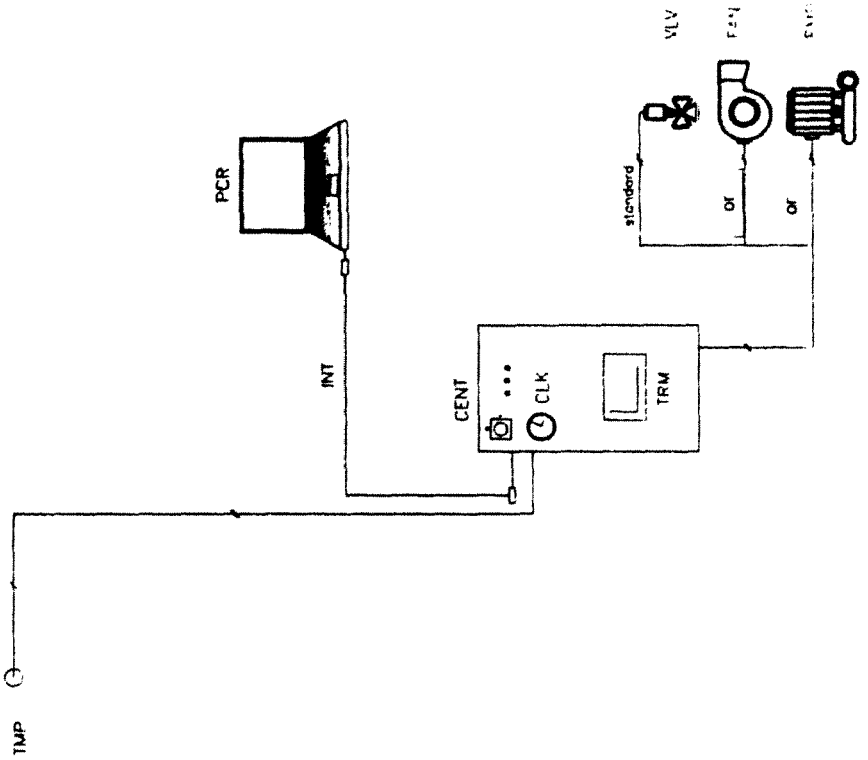


Figure 3

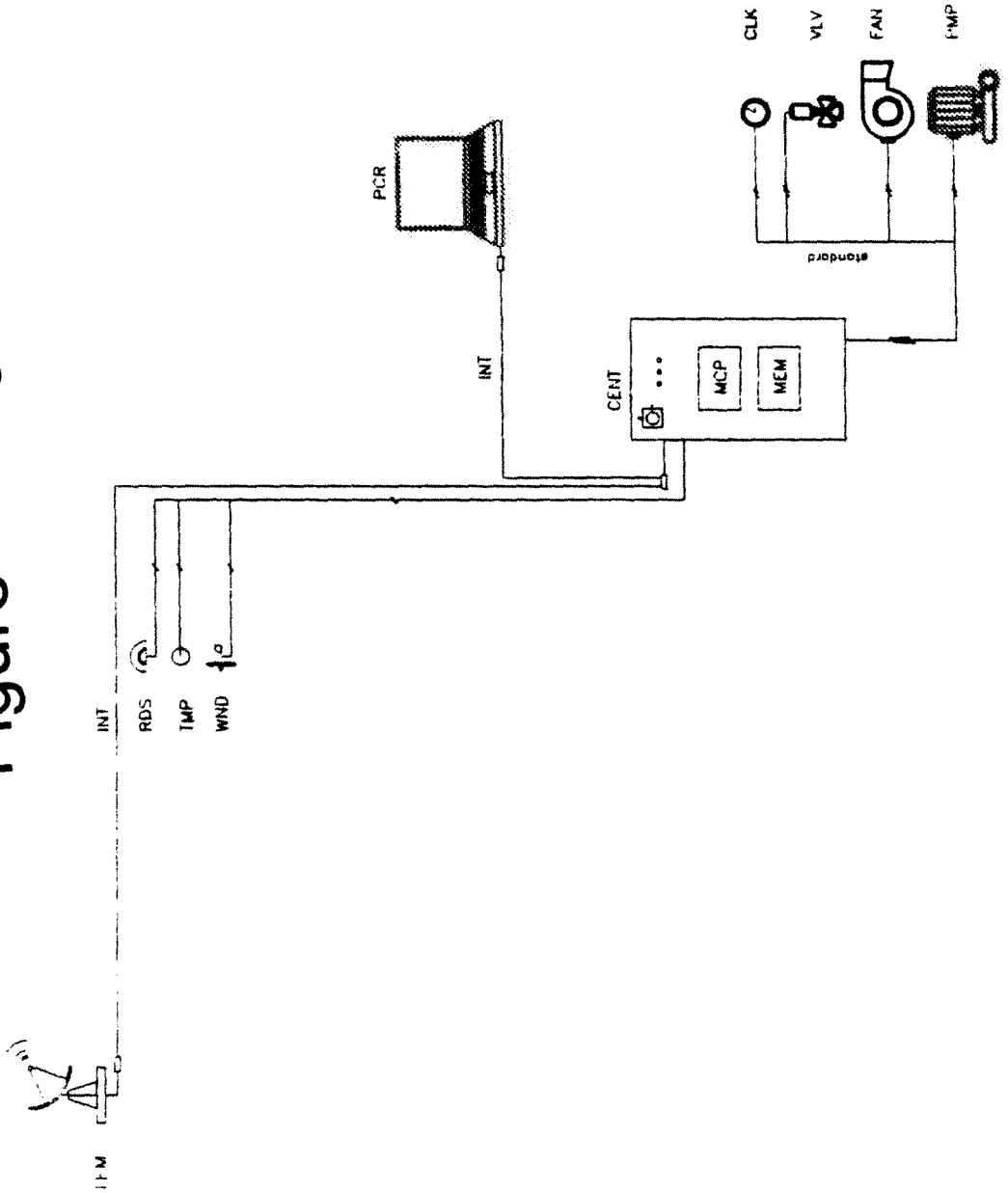


Figure 4

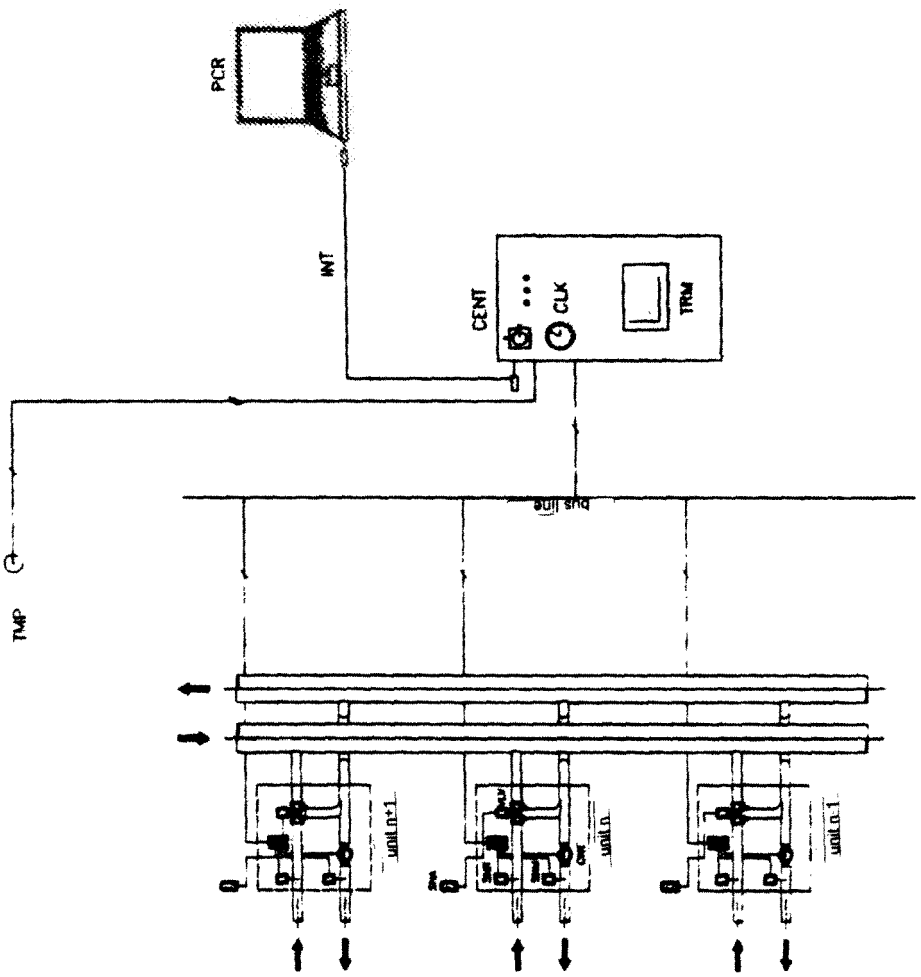
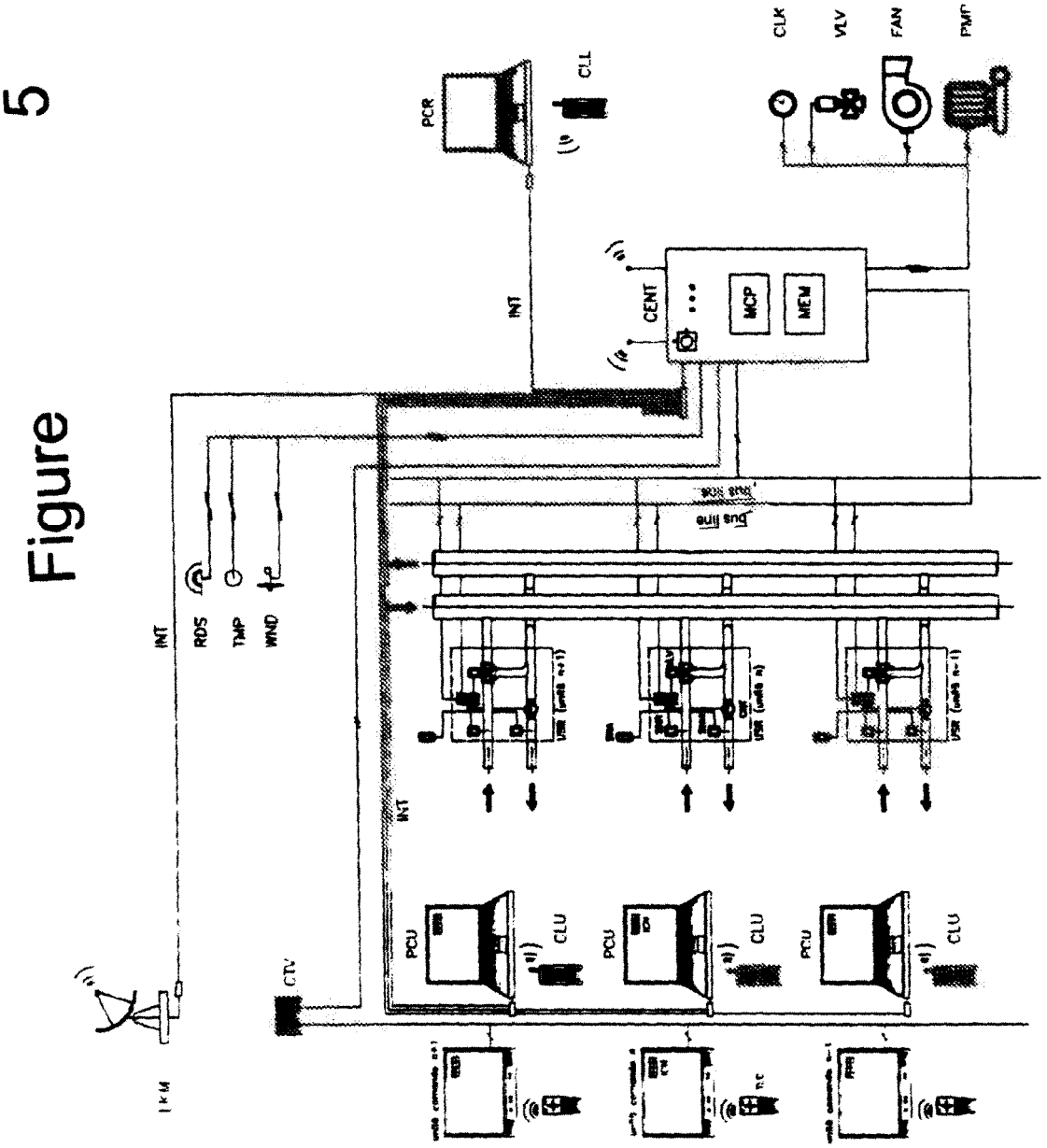


Figure 5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