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(54) Title: MANAGING AND CONTROLLING REMOTE PRODUCTION MACHINES

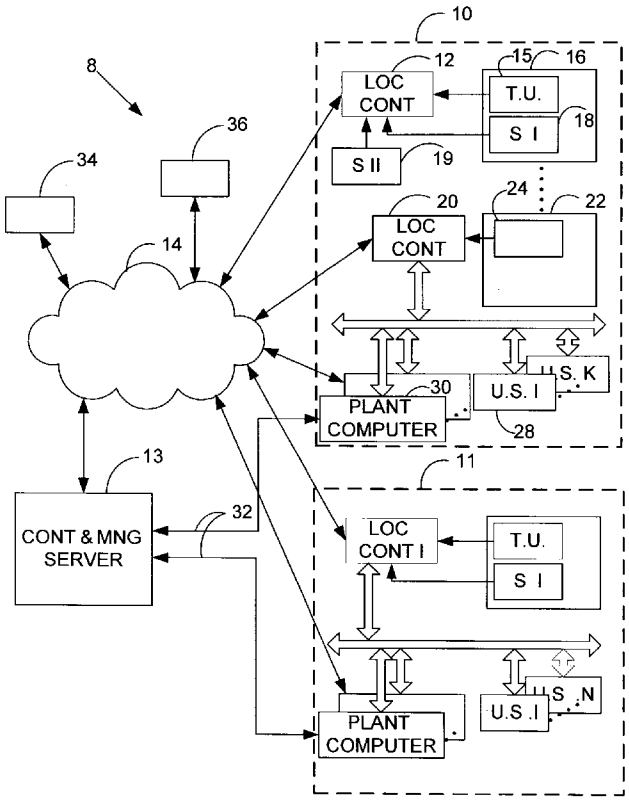


Fig. 1

(57) Abstract: System and method for controlling and managing remote cyclic production machines is provided. The system of the invention includes a server accessible through the internet, local communication controllers each of which coupled to at least one of the remote production machines, and at least one user station. The user stations can be any of desktop, laptop, or hand held computers and/or a mobile phones, such as 3rd generation phones providing for accessing an active webpage. Coupling a local controller to a remote production machine is accomplished at least by electrically connecting the controller to the timing unit of the production machine for receiving synchronizing signals related to the machine's cycles. The local controller can be further connected to various sensors for measuring features associated with the remote production machine. The local controllers are operative in acquiring working parameters of the respective production machines. The server of the system provides for associating characteristic profiles and/or statistics to the respective production machines, correlating them with stored characteristics, alerting a user when a deviation of a currently measured characteristic off a level of the respective stored characteristic occurs, and modifying one or more setup or configuration parameters of a selected remote production machine.

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MANAGING AND CONTROLLING REMOTE PRODUCTION MACHINES

FIELD OF THE INVENTION

The present invention relates in general to managing a production floor. More particularly the present invention relates to a system having a plurality of controllers respectively coupled to production machines within one or more plants, each controller is linked through the internet to a remote computer in which a history of working parameters of each production machine is respectively stored, analyzed and correlated with corresponding data acquired from respective computers of the plant considered.

BACKGROUND OF THE INVENTION

Updated data regarding the working parameters and statuses of the production machines, their environmental conditions, the flow of materials, levels of inventories related to various stages and features of the products' units, as measured at various stages along their production process, provide for significantly enhancing the effectiveness of managing the flow of the work and the entire production process. Acquiring such data in real time may significantly contribute to the quality of the products and the costs associated with their production. Systems providing for timely collecting such data are common. However introducing such systems and their integration into a production floor requires the availability of experienced personnel and is typically associated with considerable costs that might not be affordable. Quite often the production process has to be distributed among various plants located at different geographical regions. Accomplishing a geographically distributed production process, such that the products meet their quality requirements and the goals of the production planning, such that appropriate quantities of product units are

ready to be shipped and delivered in time, is logistically complicated and typically requires dedicating considerable managerial efforts. World patent application WO08063588 discloses a system for managing production floor that is capable to handle geographically distributed production processes the clients of which can be located at various different locations. The disclosed system comprises a plurality of computers that are linked among them by means of any network, such as LAN, WAN, intranet and internet, which is capable for transferring data and messages. However data concerning the statuses and levels of production machines, auxiliary equipment, such as material blending devices, various sensors that are either integral to the machinery or provide for measuring ambient parameters, levels of raw and/or processed materials at various stages of the production process, partially produced, and/or finished products has to be manually inputted at various stations by operators of the disclosed system. Obviously such data cannot be accurately updated in real time and is susceptible to errors accidentally introduced by the operators.

Therefore a system providing for acquiring and collecting such real time data from remote production machines, by which segments of, and/or the entire, production process are monitored and analyzed is beneficial.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a segment of a block diagram of a system for managing remote production machines according to a preferred embodiment of the present invention;

Fig. 2 is a segment of a block diagram of a system for controlling and managing remote cyclic production machines according to another preferred embodiment of the present invention;

Fig. 3 is a segment of a block diagram of a system according to an embodiment of the present invention;

Fig. 4 is an exemplary report automatically generated by a system for controlling and managing remote production machines according to an embodiment of the present invention;

Fig. 5 is another exemplary report automatically generated by a system for controlling and managing remote production machines according to an embodiment of the present invention;

DETAILED DESCRIPTION OF THE PRESENT INVENTION

In accordance with the present invention a system and method for controlling remote production machines and for managing the flow of the work accomplished by remote production machines is provided. A system of the invention has at least one local communication controller having an internet protocol (IP) address that is coupled to a production machine, at least one user station and a controlling and managing server accessible through the internet. A system of the invention provides a user to monitor and control the operation of at least one production machine wherever he or she is located.

Production machines, such as injection molding machines of the plastic industry, in which the production process is cyclically accomplished are referred hereinafter as cyclic production machines (CPMs). Machines, in which the production process is continuous, such as extruders, can be artificially converted to CPMs by means of cyclic sampling of statuses of any of their component and at least one of their working parameters. Continuously operating machines that are such artificially converted into CPMs are referred hereinafter as CPMs. A sub-cycle that overlaps a complete cycle is regarded hereinafter also as a sub-cycle. Any server having an IP address and an active webpage; into which a user can be linked through the internet, and access data and/or activate a function to be accomplished by the operating software of the server; is referred hereinafter as a server accessible through the internet.

Reference is first made to **Fig. 1** in which a segment of a system for managing and controlling the work of remote CPMs according to a preferred embodiment of the present invention is shown. System for managing and controlling remote CPMs **8** provides for managing the work flow and the production process carried out by a number of CPMs located in various geographical locations. Some of the CPMs are installed in plant **10**, some other CPMs are installed in plant **11**, which is different from plant **10**, etc.. System **8** includes a plurality of local communication controllers, such as local controller **12** which is linked to control and managing server **13** through the internet **14**.

Each of these controllers is respectively coupled to at least one CPM. Coupling a local controller to its respective CPM is accomplished according to the present invention by connecting the controller to the timing unit of the respective CPM. Such coupling provides for receiving a time signal associated with say the leading and tailing points in time of either a cycle accomplished by an actual cyclic machine or synchronizing pulses or time signal, which provide for artificially converting a continuous production machine into a CPM. Local controller **12** is electrically connected to timing unit **15** of CPM **16** for receiving synchronizing pulses, such as the pulses starting at the beginning of a production cycle of CPM **16** and ending by the end of the first production sub-cycle of this machine. The pulse width in time equals the duration of the respective sub-cycle of the CPM. Optionally local controller **12** is further connected to one or more sensors such as sensor **18**, which is a sensor for periodically measuring a working parameter of CPM **16**, at a rate which is considerably higher than the cycling rate of CPM **16**. Such working parameters include for example a temperature or a pressure measured at specific points disposed within CPM **16**. Another exemplary working parameter that is measured at the same cycle of the CPM is an ID parameter associated with a currently manufactured product unit that may provide for its location along the production line. Local controller **12** is optionally further connected to sensor **19** providing for periodically measuring an environmental working parameter associated with CPM **16**, such as the ambient temperature or humidity. Such environmental working parameter is typically measured at a rate that is considerably lower than the cycling rate of CPM **16**. Similarly local controller **20** is coupled to CPM **22** by being connected to its timing unit **24**. Optionally local controllers of plant **10** are further connected to the respective controllers of the blending systems as well as to controllers of dosing and feeding devices feeding the respective CPMs with materials. Such coupled blending systems or dosing and dispensing devices can be regarded according to the present invention as CPMs and are hereinafter such referred.

Controlling and managing server **13** is accessible through the internet. Server **13** is linked trough the internet either directly or through a dedicated

communications computer of plant **10** to user stations installed in the respective plant such as user station **28**. Therefore data stored in the server can be accessed by the operator who is alerted by the system in cases in which deviations from the standards or limits within which working parameters of a CPM are normally ranged occur. Obviously an administrator who is an authorized user may activate and operate system **8** by means of such user station by employing a suitable password and/or identification process as known. Controlling and managing server **13** is further linked to one or more computers such as computer **30** of plant **10**. Such link may be provided according to the invention by a secured dedicated data and communications channel **32** and/or through the internet. User stations can be also linked to the system for controlling remote production machines of the invention through the internet. Exemplary remote user station **34** is a desktop or laptop personal computer (PC) installed at a user's home. Station **36** is implemented by any of the mobile phones that are at least of the kind providing for accessing an active webpage referred hereinafter as a 3rd generation mobile phones. Hand held computer normally referred as personal digital assistant (PDA) that are capable for accessing the internet can be used as a remote user station as well. Such remote user stations provide a user for linking to system **8** for accessing a stored data or activating a system function whenever he or she wishes to, and wherever he or she is located, by accessing a dedicated active home page of the system as known.

Pulses received from the timing units of the respective CPMs provide for synchronizing the local controllers with their coupled CPMs. By means of such synchronization time frames of a CPM can be suitably scaled and correlated with the timeframe of the controlling and managing server. Furthermore counting the pulses and measuring associated time intervals provide for estimating and/or counting the number and rate of production of product units. The time in which the CPM is operative and/or shut down times can be also assessed by comparing the pulses repetition rate and the number of cycles accomplished within a specified time interval with their desired respective values. Such working parameters are time tagged and temporarily stored in the memory of the local controller to be further transferred through the

internet to the controlling and managing server for further recording, processing and analysis.

Acquired sensor data, which is repeatedly sampled and gathered along machine cycles, provides for associating characteristic profiles with the respective working parameters related to the current production process carried out by the respective CPM. Similarly the data is analyzed statistically on the fly; characteristic statistics are derived and associated with some of the working parameters of a CPM. Exemplary characteristics profiles and or statistics and their utilization for controlling the production process carried out by the respective CPMs are detailed in world patent application WO07141785, the specification, drawings and examples of which are incorporated herein by reference. An exemplary working parameter according to an embodiment of the present invention is the production rate of a remote CPM. The number of units that can be produced along one cycle time of this CPM is multiplied by the number of cycles accomplished along a time unit. This value equals the instantaneous production rate currently acquired. Time profiles of such derived production rates are regarded as a characteristic profiles that can be compared to a standard production rate that is stored in the server. Similarly, statistical measures such as mean production rates and standard deviation levels are derived and further compared to previously stored statistics considering this CPM and/or or to standard statistics that is recorded in a database stored in the controlling and managing server of the system.

Reference is now made to **Fig. 2** showing a segment of a system of the invention in which at least one of the CPMs involved is an injection molding machine having a CPM controller and internal sensors for periodically measuring selected working parameters, as known. Local controller **50**, which is one of the communication controllers of system **52** that is a system for controlling and managing remote CPMs in accordance with another preferred embodiment of the present invention, is connected to timing unit **54** of CPM **56**. Local controller **50** is further connected by link **58** to the controlling and managing server through the internet, not shown. Link **58** is implemented either by a physical line or by a wireless link as known. For measuring and gathering

working parameters associated with CPM **54**, local controller **50** is further connected to CPM controller **62**. CPM controller **62** is linked to timing unit **56** for its synchronization. CPM controller **62** is further linked to various sensors, such as to temperature sensor **64** for measuring a temperature at a specified location within CPM **56**; to distance sensor **66** for measuring a distance along which the screw feeding the mold with materials moves while feeding the mold, and to pressure sensor **68** for measuring the back pressure exerted on the material fed into the mold. Optionally local controller **50** is further linked to a blending system and/or to a dosing and feeding device for feeding the CPM with raw materials. Link **70** provides for such linking. Link **70** may further provides for connecting local controller **50** to the computer communications network of the plant. Optional environmental sensors, such as environmental sensor **72** which is a thermometer for measuring ambient temperature at a periphery of CPM **56**, can be according to the invention directly linked to the local controller. Similarly features of the product acquired by an operator in situ and inputted into the plant computer system, are regarded according to the invention as working parameters of the respective CPM. Such manually inputted working parameters can be either uploaded to the controlling and managing server from the plant computer or transferred to local controller **50** through link **70**, to be temporarily stored in its memory and further transferred to the system server through link **58**. Timing signals, working parameters and sensors' data are periodically and successively collected by a local controller of the system of the invention either continuously, or along predefined time intervals starting at predefined points in time. Transferring the collected data to the controlling and managing server is carried out in either one of two modes. In one of these modes the server periodically visits the local controllers to read the data last stored. In the other mode the controller transmits the data to the server. Transferring the data in either way is accomplished through link **58**.

The bidirectional link connecting between local controller **50** and CPM controller **62** further provides for downloading newly modified setup parameters into CPM **56.** Such operation is activated by a user who wishes to modify any parameter from a respective set of changeable configuration parameters

associated with each CPM, blending system, and/or dosing and feeding devices coupled to system **52**. Activating such operation and modifying the values of the respective parameters can be done by means of any user station of system **52** when required. The modified data and a suitable activation command are transferred from the server to the respective local controller to be further transferred to the CPM controller through the bidirectional link connecting between them. Similarly an operator may modify the setup parameters of the respective blending system and/or dosing and feeding device coupled to CPM **56** by downloading the modified parameters from the user station he currently employs through local controller **50** and link **70**.

Optionally the integral controller of a CPM, dosing and feeding device and/or blending system that has an IP address can implement a local communication controller of a system of the invention. Such controller is normally synchronized by the timing unit of its respective machinery a CPM or auxiliary blending system and/or device, therefore it is coupled according to the present invention to its respective CPM. Further to its normal operation such as dosing and dispensing material into the intake of the respective CPM it is further operative in time tagging and temporarily storing the working parameters considered, such as dosing levels, concentrations, weights of portions of material dispensed along a cycle and or instantaneous rates of dispensing. Temporarily stored data that further includes the normal synchronization data can be transferred to the controlling and managing server of the system without any intermediary communication controller. Such controllers are also referred hereinafter as local controllers.

The system of the invention provides for: acquiring currently updated working parameters associated with each CPM; storing their history; comparing current values with stored values; associating characteristics - profiles and or statistics with various working parameters; cross correlating among various characteristics and/or standard or pre-stored characteristics; detecting deviations between standard or pre-stored characteristics (profiles and/or statistics) and their respective current levels; alerting an operator when such deviations exceed the respective predefined thresholds, and supporting the

operator in assessing the need to modify settings or the configuration parameters of a production machine and/or the respective coupled machinery including blending system and or dosing and feeding devices. The system of the invention provides for modifying settings and configuration parameters of a remote CPM when such deviation of a currently derived characteristics from the respective standard or pre-stored characteristics is detected by employing any of the user stations of the system. A system of the invention provides a skilled personnel member or an expert even when he or she is off post for remote monitoring a specific CPM, such as might be required in cases of emergency.

The links that exist in accordance with the present invention between the controlling and managing server and the respective computers of a plant provide for uploading selected data into the controlling and managing server. Such data is typically related to work orders currently associated with the respective CPMs. Similarly auxiliary data associated with the specific work order which is available for example in the ERP system of the plant and/or the inventory values of raw materials and of finished products as well as levels and statuses of product units in various stages of the production process (referred hereinafter as work in process), and/or data related to purchasing orders as well as quality control reports, that are documented in the plant computer system. Such data when is correlated with the respective values derived from the estimated production rate and the number of completed product units promote the controllability of the flow of work and the level by which the production is managed. Furthermore, correlating quality control reports with specific pieces of history of some working parameters, dug out by drilling into the respective stored history, may promote the quality control scheme as well as the associated quality analysis processes and in turn improve the yield of the production process. Additionally the system of the invention provides a significantly improved visibility of the levels of inventory and the current statuses and levels of partially completed, finished products and/or levels of faulty units, thereby supporting managerial decisions related to meeting goals of production rates and costs as well as delivery times.

The system of the invention provides an application service provider for rendering a service of managing and controlling CPMs to sales, production, engineering and other managerial personalities and/or institutions of production plants. For rendering such service, suitable local controllers, similar or equivalent to the controllers described above, have first to be coupled to the selected CPMs. Then a user has to subscribe to the service. Optionally subscribing is accomplished by a subscribing module installed in the system server and activated by selecting the suitable option displayed in the active home page of the service provider. The coupled local controllers are further linked to the controlling and managing server of the system by activating the linking process of the server operating software. The user is prompted step by step to accomplish the linking of the local controllers as well as for linking selected computers and/or user work stations linked to the computer network system of the plant. Similarly a secured data and communication link is established to connect the server with selected computers of the plant. The operating software of the server supports one or more user work station that is installed within a plant as well as a number of remote user stations such as the above mentioned PDA. Following the completion of an initiation process in which the definitions of a security scheme, selected CPMs and the tasks of control and managing to be effective, in accordance with the terms and conditions of the service, the managing and control process is activated. From this moment on the operating program is accessed by an authorized personnel member by means of any user work station linked to the system, such as activating and accessing a common program of the kind of software on demand as known. Furthermore a subscriber to the service may incorporate a number of different plants each of which includes a different number of CPMs coupled by means of their respective local controllers to the system. Therefore a user may manage and control a geographically distributed production process from his user station located at his office, or in one of the incorporated plants as well as wherever he or she is located.

EXAMPLE

A system according to an embodiment of the present invention is described with reference to **Fig. 3**. A segment of system **80** is shown in **Fig. 3**. Control and managing server **82**, is linkable through the internet to a number of remote operator stations implemented such as by personal computer **84**, PDA **86** and third generation mobile phone **88**. Local controller **90** linked to control and managing server **82** is respectively connected to timing units **92** and **94** of CPMs **96** and **98** both of which are injection molding machines installed at manufacturing plant **100**. Local controller **90** is further connected as described hereinabove to one or more sensors installed within any of these CPMs, not shown. Exemplary such sensors provide for measuring the level of pressure exerted on the molten resin when is delivered into the mold, the distance along which the screw driving the molten resin into the mold moves, etc.. The controller of dosing and dispensing device **102**, not shown, is linked to control and managing server **82** through the internet thereby coupling device **102** to the system such that its working parameters are acquired. Dosing and dispensing device **102** provides for dosing and dispensing an additive material, such as color master-batch or recycled crushed material, into the intake of raw materials consumed by CPM **96**. Alternatively, dosing and dispensing device **102** can provide for coupling CPM **96** to the system according to the present invention and substitute local controller **90** as shown. Otherwise, dosing and dispensing device can be coupled to local controller **90** or to another local controller similarly to any other CPM that is coupled to system **80**. Plant computer **104** is linked to control and managing server **82** by means of secured communication link **106**. Local controller **90** is optionally further linked to plant computer communication network **108**. Such link provides for example for collecting data stored at plant computer **104** to be further transferred to control and managing server **82** and correlated with stored working parameters, their characteristic profiles and/or statistics, as described hereinabove.

An operator, such as a member of the quality control personnel, typically inputs quality reports considering units produced by these CPMs by means of an operator station installed at plant **100**, such as station **110**. System **80** further provides an authorized operator, wherever he or she is located and

whenever he or she so wishes, for inputting such data and/or respectively modifying the setup parameters of for example blending device **102** by means of any of the remote operator stations as well as by means of operator station **110**. To reach a decision to modify such parameters the operator is assisted by reports displayed across the screen of the user station employed at his or hers request. Exemplary reports each of which is automatically generated by the operating software of control and managing server **82** are hereby described with reference to **Figs 4-5**. In **Fig. 4** a three dimensional graph presenting time profiles of the pressure exerted on the molten resin while being delivered into the mold are shown for a number of successive injection cycles. The pressure is measured in arbitrary units and the time is given by percentage of the entire injecting cycle of the injection molding machine considered. In **Fig. 5** plots of the speed in which the screw feeding the mold moves versus the distance along which the screw moves are shown for a number of successive cycles of the CPM considered are respectively compared against a maximal allowed level. By detecting irregularities in these and/or similar graphs, the operator may choose to change for example the concentration of recycled material to be blended with virgin raw material and/or modify the concentration of flow enhancing additives for improving the level of flow of the molten resin.

CLAIMS

1. A method for managing and controlling remote cyclic production machines (CPMs) by means of a system for controlling and managing remote CPMs, said method comprising the steps of

   i. acquiring at least one working parameter associated with at least one of said remote CPMs;

   ii. time tagging and storing said at least one acquired working parameter;

   iii. associating at least one characteristic with said acquired working parameter, wherein said at least one characteristic selected from a group of characteristics consisting of characteristic profiles, characteristic statistics and any combination thereof;

   iv. comparing deviations of said at least one characteristic from a respective stored characteristic to a measurement scale, and

   wherein said system for controlling and managing remote CPMs comprises

   - a controlling and managing server accessible through the internet for at least storing histories of said acquired at least one working parameter;
   - at least one local controller coupled to said at least one of said remote CPMs operative in said acquiring, wherein said local controller electrically connected to at least a timing unit of said at least one of said remote CPMs, and

wherein said local controller linked to said controlling and managing server, and

- at least one user station linked to said controlling and managing server for at least displaying said stored histories.

2. A method as in claim 1, wherein said at least one user station is remote from said controlling and managing server, and wherein said remote user station is any station selected from a group of stations consisting of a personal computer, a desktop computer, a laptop computer, a hand held computer and a 3rd generation mobile phone.

3. A method as in claim 1, further comprising modifying at least one configuration parameter of said at least one remote CPM by means of said at least one user station.

4. A method as in claim 1, wherein said at least one working parameter comprises any member selected from a group of members consisting of time cycles of said CPM, times of sub-cycles of said CPM, the number of sub-cycles of said CPM accomplished within a predefined time interval, ID of a product unit, rates of production of product units, signals received from at least one sensor associated with said CPM, a feature of a product unit, and any combination thereof, and wherein said at least one sensor is any sensor selected from a group of sensors consisting of temperature sensors, pressure sensors, sensors

for measuring a distance along which a member of said at least one remote CPM moves, sensors for measuring at least one feature of a product unit, rotational speed sensors, power sensors, flow sensors, humidity sensors and any combination thereof.

5. A method as in claim 1 wherein said at least one controller further linked to any machinery selected from a group of machineries consisting of blending system, dosing and feeding devices and any combination thereof, and wherein said at least one working parameter further comprises the level of at least one component of material dispensed into the intake of said at least one of said CPMs.

6. A method as in claim 1 wherein said acquired working parameters further correlated with data related to a work order associated with said at least one of said CPMs.

7. A method as in claim 1, wherein said acquiring is repeatedly accomplished.

8. A method as in claim 1, wherein said acquiring is successively accomplished along a predefined time interval.

9. A method as in claim 1, wherein said at least one acquired working parameter is read by said controlling and managing server from the memory of said at least one local controller.

10. A method as in claim 1, wherein said at least one controller transmits said at least one acquired working parameter to said controlling and managing server.

11. A system for controlling and managing remote cyclic production machines (CPMs), said system comprising

- a controlling and managing server accessible through the internet for storing histories of working parameters associated with at least one of said remote CPMs;
- at least one local controller having an internet protocol (IP) address coupled to at least one of said remote CPMs;
- at least one user station linkable to said controlling and managing server, and

wherein said at least one local controller is operative in acquiring said working parameters associated with said at least one of said CPMs, and wherein said controlling and managing server is operative in associating characteristics with said acquired working parameters, and wherein said coupling effected by electrically connecting said at least one local controller to a timing unit of said at least one of said CPMs.

12. A system as in claim 11, wherein one of said remote CPMs located at a first geographical location, and wherein another of said remote

CPMs located at a second geographical location that is different from the first one.

13. A system as in claim 11, wherein said at least one user station selected from a group of user stations consisting of personal computers, desktop computers, laptop computers, hand held computers and a 3rd generation mobile phones.

14. A system as in claim 11, wherein said at least one local controller further linked to a machinery, wherein said machinery is any machinery selected from a group of machineries associated with any of said remote CPM consisting of blending systems, dosing and dispensing devices.

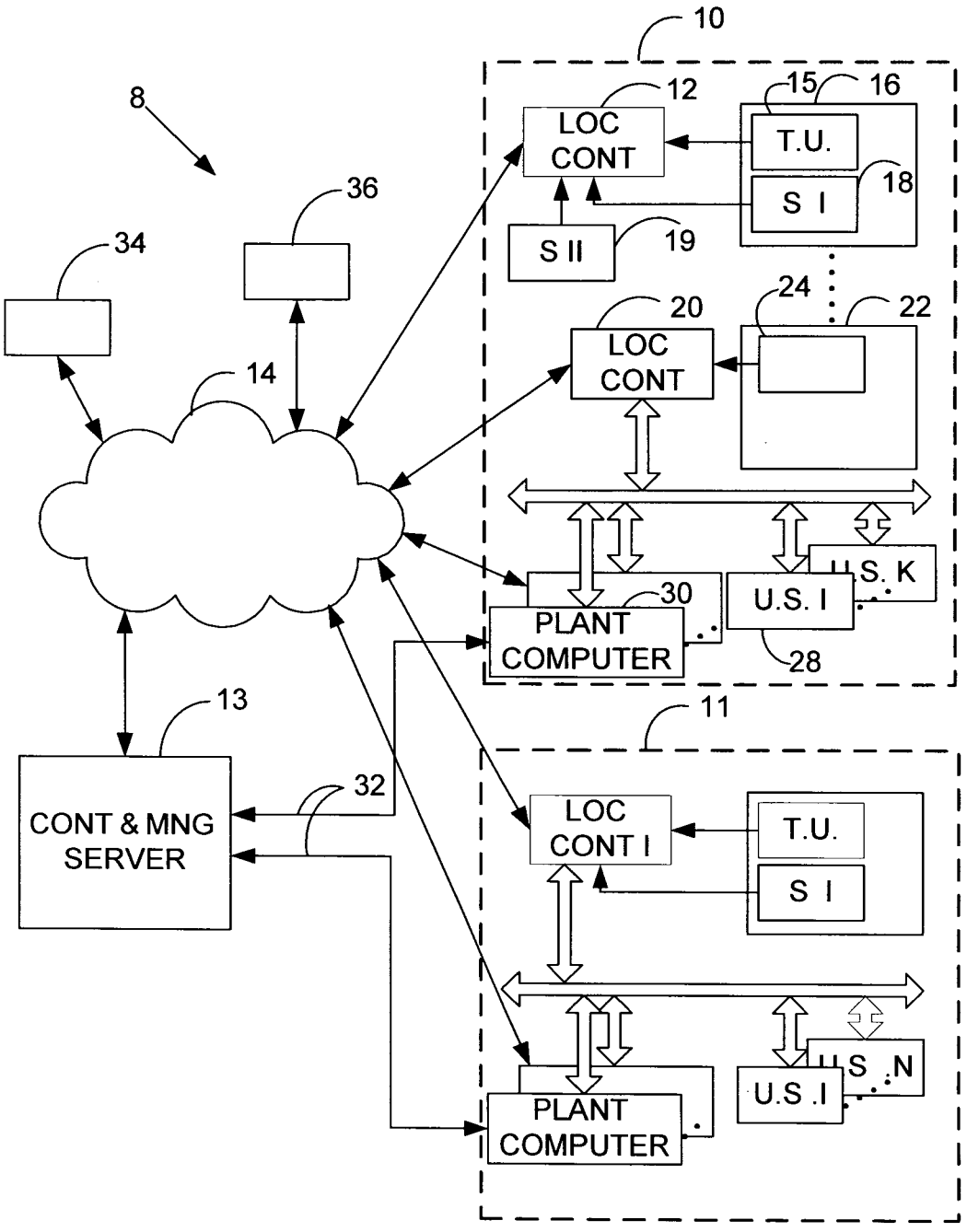

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Fig. 1

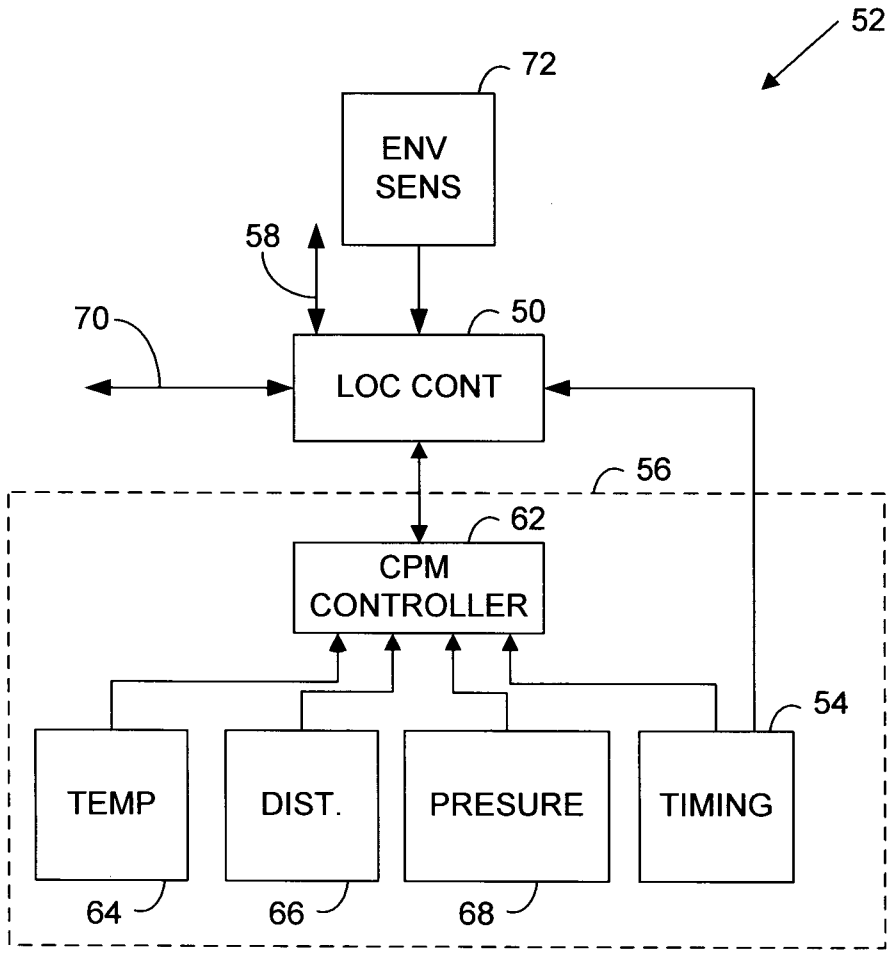

52
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CPM CONTROLLER
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Fig. 2

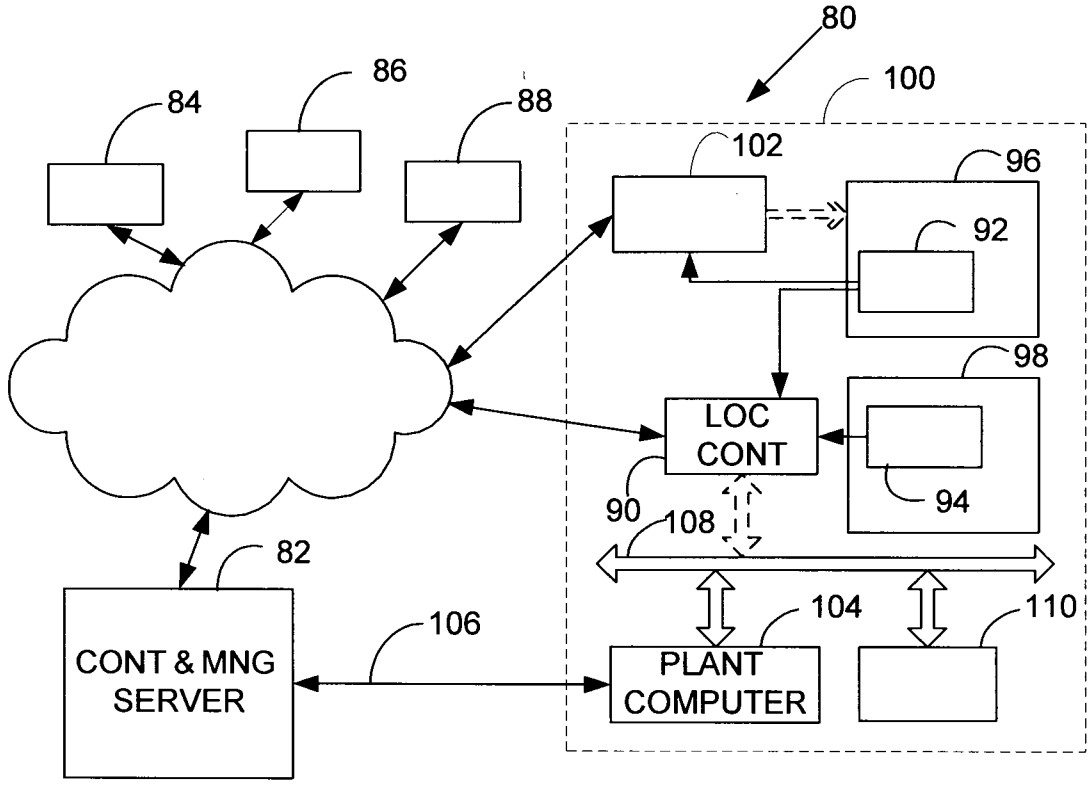

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COMPUTER

Fig. 3

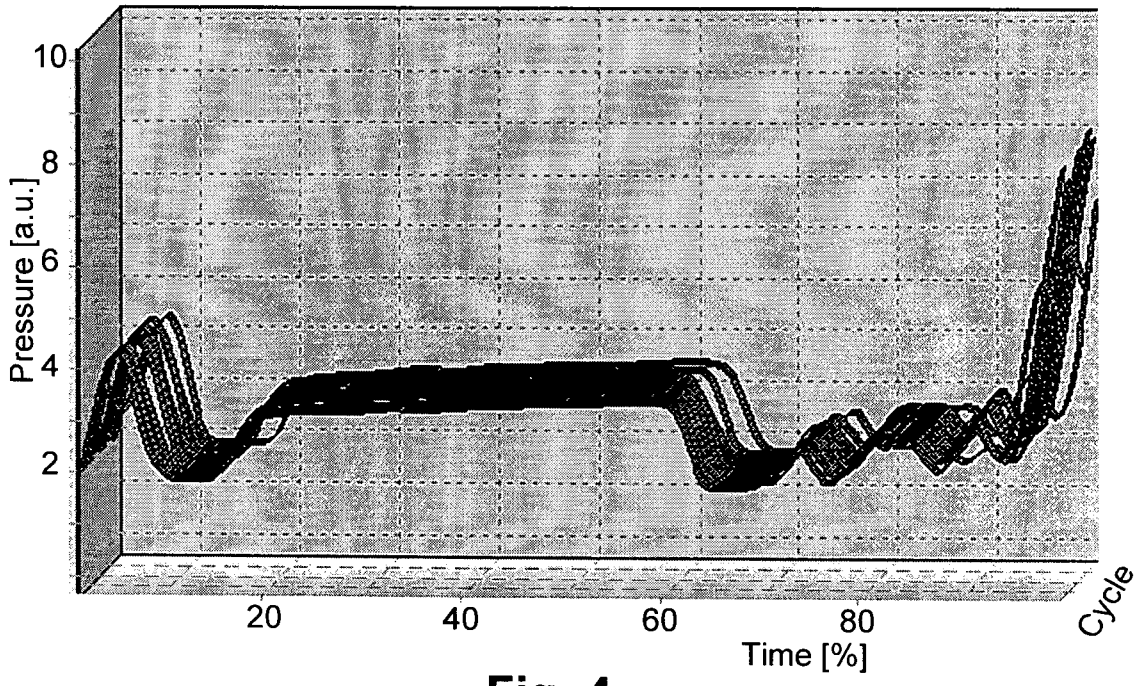

10
8
6
4
2
Pressure [a.u.]
20
40
60
80
Time [%]
Cycle

Fig. 4

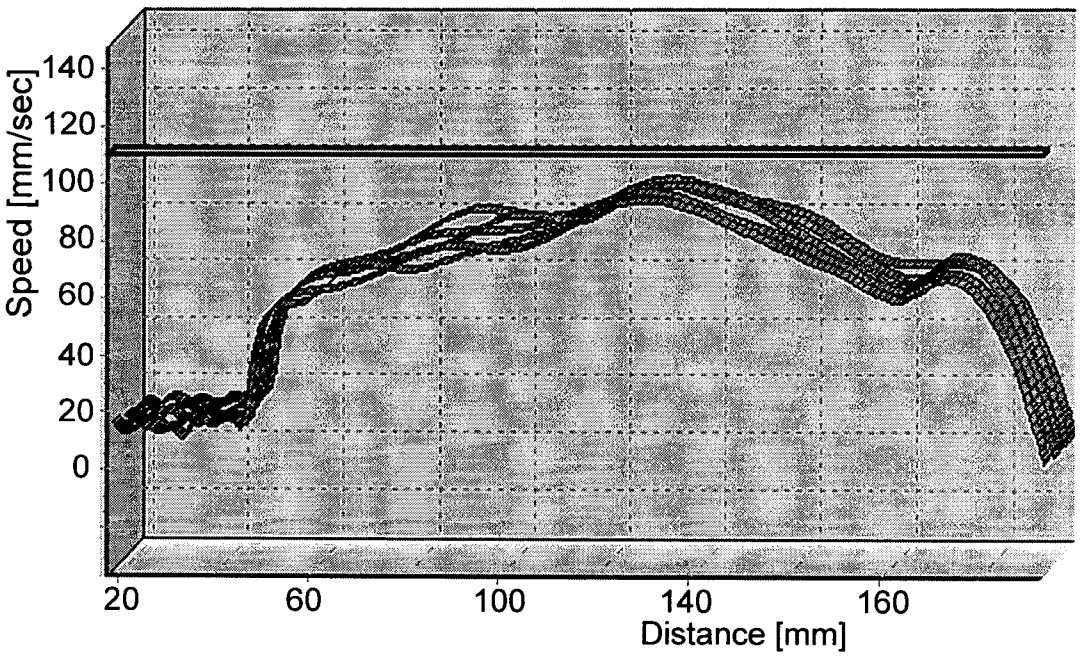

Speed [mm/sec]
140
120
100
80
60
40
20
0
20
60
100
140
160
Distance [mm]

Fig. 5