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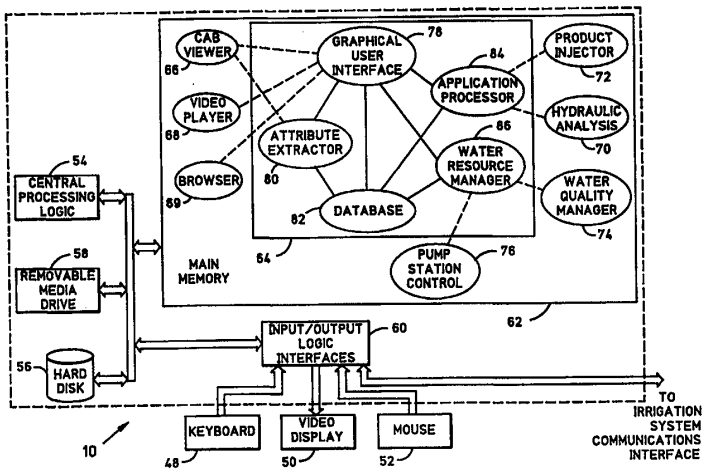

(57) Abstract

A computer–controlled irrigation system, computer program product, and computer–implemented method of operation includes a site map–based graphical user interface (GUI). The GUI includes animations and hyperlinked irrigation system elements that allow a user to traverse the site, zoom in on an irrigation system element or water resource element and adjust its programming parameters or monitor its operation by selecting it with a mouse button click or similar selection mechanism. Graphics representing the site, irrigation system elements and water resource management elements, as well as hydraulic attributes and other attributes describing the functions of such elements may be extracted from a conventional CAD drawing file. The invention may also promote efficient use of water resources by performing hydraulic simulation of the irrigation network using a hydraulic analysis software engine. Hydraulic analysis also maximizes irrigation in accordance with priorities selected by the user. Hydraulic analysis also optimizes product injection by taking loading and other factors into account.

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IRRIGATION AND WATER RESOURCE MANAGEMENT SYSTEM

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to computer-controlled irrigation control systems of the type used in golf courses, master planned housing developments, cemeteries, parks and the like.

Description of the Related Art

Irrigation system controllers allow a user to program the system to irrigate specified zones of a golf course or similar site for specified time periods or until specified volumes of water have been applied. Such conventional systems are difficult for a user to program. Typically, a system may display configuration and programming information in a tabular format on the computer screen, and the user enters information in a tabular format. Elements of the irrigation system, such as pumps, valves and irrigation heads are designated by numeric or alphanumeric labels. The various pipes of the irrigation network may be designated by labels or by graphical formats that indicate their location in the hierarchy of main supply pipes branching into smaller pipes. For example, the display may indicate by means of a label "1st Hole" indented slightly to the right and below a label "2 Inch Branch," which is in turn indented slightly to the right and below a label "10 Inch Main," that the irrigation heads in the zone relating to the first hole of the golf course are supplied by a certain two-inch branch pipe that is in turn supplied by a certain ten-inch main pipe.

Computer-controlled irrigation systems for golf courses have been developed that include graphical user interfaces (GUIs). The GUI may display a map of the site on the computer screen. The site map indicates the fairways, greens, tees, roughs, bunkers and lakes and other features, as well as the locations of pipes and irrigation heads in relation to those features. In operation, the system graphically indicates which heads are in use and which are not, and may also indicate other pertinent information. To set up such systems prior to use, the user must enter the site map in the form of a suitable digital image. Once the site map has been entered into the system, the system prompts the user to enter the positions of the irrigation heads and pipes.

The term "hydraulic management" in the context of irrigation systems refers generally to controlling irrigation in response to flow rate information. A hydraulic tree is the basis of conventional hydraulic management. A user enters hydraulic tree information into the irrigation system by specifying the connectivity of the network as well as the user's estimate of the maximum flow rate in each pipe. In operation, the system may compute the flow rate at any irrigation head in response to the open or closed status of network valves. The system computes the flow rate along a straight path between the pressure source (typically a pump) and each head. Hydraulic management may be used to facilitate programming the system to apply a specified volume of water to a specified zone by computing the time required to operate certain heads based on the flow rates at those heads.

In reality, a hydraulic system comprising a network of irrigation pipes behaves in a more complex manner than can be modeled by a hydraulic tree. A head or section of pipe may be fed by several pipes that are ultimately coupled together at some point in the network closer to the source. In other words, the network includes loops. Hydraulic management systems that are based upon the hydraulic tree model cannot model loops because they simplify the problem to the computation of flow rate along a straight path.

Hydraulic analysis software programs are used by civil engineers in the design of municipal water supplies, water treatment plants, and similar industrial operations. Examples of commercially available hydraulic analysis programs include KYPIPE, produced by The University of Kentucky, and CYBERNET, produced by Haestad Methods, Inc. of Waterbury, Connecticut. Designers of irrigation systems have also used such programs. Hydraulic analysis programs can model the dynamic behavior of a complete piping network, including loops and other features, and can compute not only flow rate at any pipe section but also water velocity, dynamic pressure, and volume in any pipe section. Furthermore, such programs take into account changes in elevation, turbulent flow, and other real-world conditions.

Irrigation systems have long included product injection units to mix liquid nutrients, i.e., fertilizers, into the irrigation water, a process known as fertigation. More recently, they have been used to apply beneficial microorganisms ("biologics"), pesticides and soil amendment minerals. Injection units are typically operated for a programmed time period or as a ration of measured discharge flow. The injection unit operation is not otherwise coordinated with

irrigation programming. Another challenge of using irrigation systems to distribute products is known as pipe "loading." The piping network between the injection unit and the irrigation head may hold a considerable volume of water. It may be desirable to apply a product, such as a biologic to suppress fungus, yet minimize irrigation volumes to avoid overwatering. Such a scenario is typical during a time of rainfall. If the system is operated for a sufficiently short time to avoid overwatering, the injected product may not reach outlying areas furthest away from the injection unit by the end of the application period.

Golf courses often contain lakes and other bodies of water that serve not only as obstacles to challenge golfers but also as irrigation water reservoirs. Golf courses may include water resource management systems that control the filling of such reservoirs from the water supply and the draining of them into the irrigation system. More sophisticated systems may also include aeration systems in reservoirs to assist in water quality management. Water resource management systems may include various pumps, valves, air compressors and oxygen injectors.

It would be desirable to provide an irrigation control system that enhances ease of programming and monitoring and that includes improved hydraulic management. It would also be desirable to provide an irrigation control system with improved product injection that is coordinated with irrigation programming and that takes loading and other hydraulic factors into account. Furthermore, it would be desirable to provide an improved lake water resource management system that is coordinated with irrigation programming and that is easy to program and monitor. These needs are satisfied by the present invention in the manner described below.

SUMMARY OF THE INVENTION

The present invention relates to a computer-controlled irrigation system, computer program product, and computer-implemented method of operation that includes a site map-based graphical user interface that displays information on the computer screen and receives information input by a user, and an application processor that generates irrigation controller commands in response to the programming information received from the user. The irrigation system itself may include any combination of irrigation heads, valves, pipes, water sources and other elements of the types commonly used in irrigation systems for golf

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