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(54) **PC-PROGRAMMED IRRIGATION CONTROL SYSTEM**

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Publication Classification

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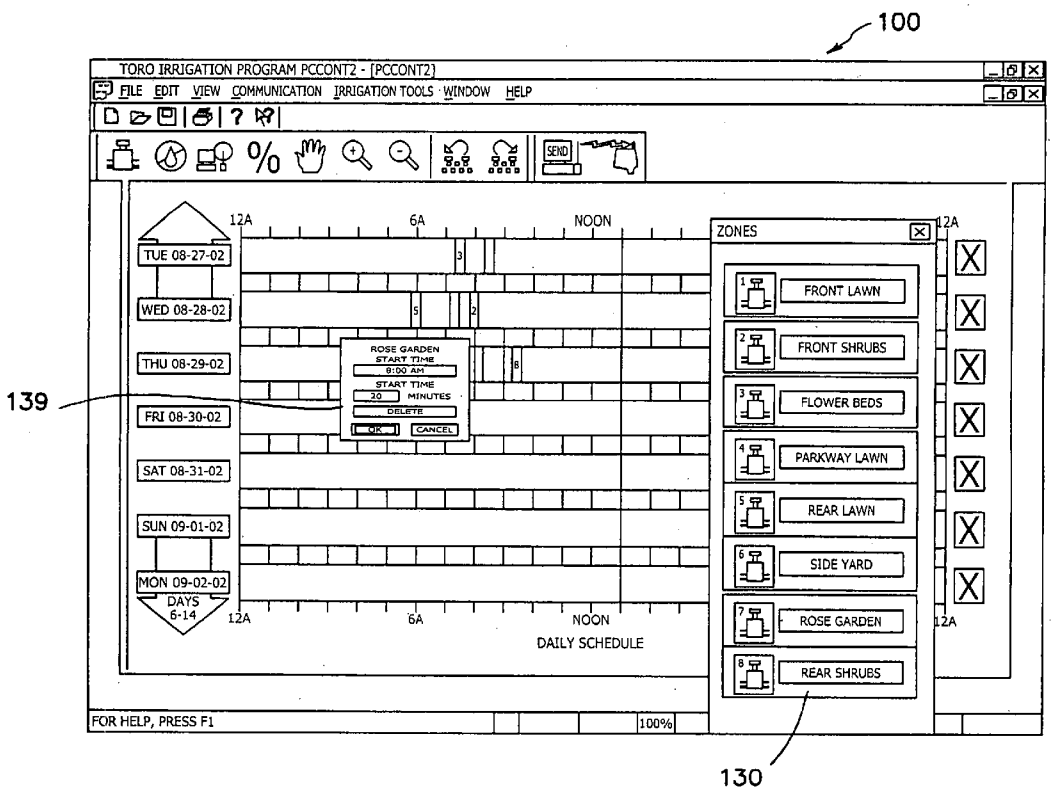
G05D 7/00 (2006.01)

(52) **U.S. Cl.** **700/284**; 700/15; 700/16

(57) **ABSTRACT**

A free-standing field irrigation controller is selectively programmed by a personal computer over a radio link. The computer is equipped with software that displays a screen with seven horizontal time bands representing one day each, arranged vertically to display one week's time. Box icons representing watering settings for a plurality of zones can be dragged and dropped onto the time bands, copied and modified thereon as desired, to form a freely selectable watering schedule. Other selectable screens allow odd-days or even-days watering, sophisticated interval watering, global watering time adjustment, and a variety of manual functions. Selectable portions of the main screen can be enlarged as desired. Based on the selected schedule, the computer calculates and displays the monthly cost of water. Selected zones can be temporarily disabled to deal with weather or maintenance issues. A handheld global shut-off and manual watering remote and/or a separate radio-linked computer may be used in field maintenance.



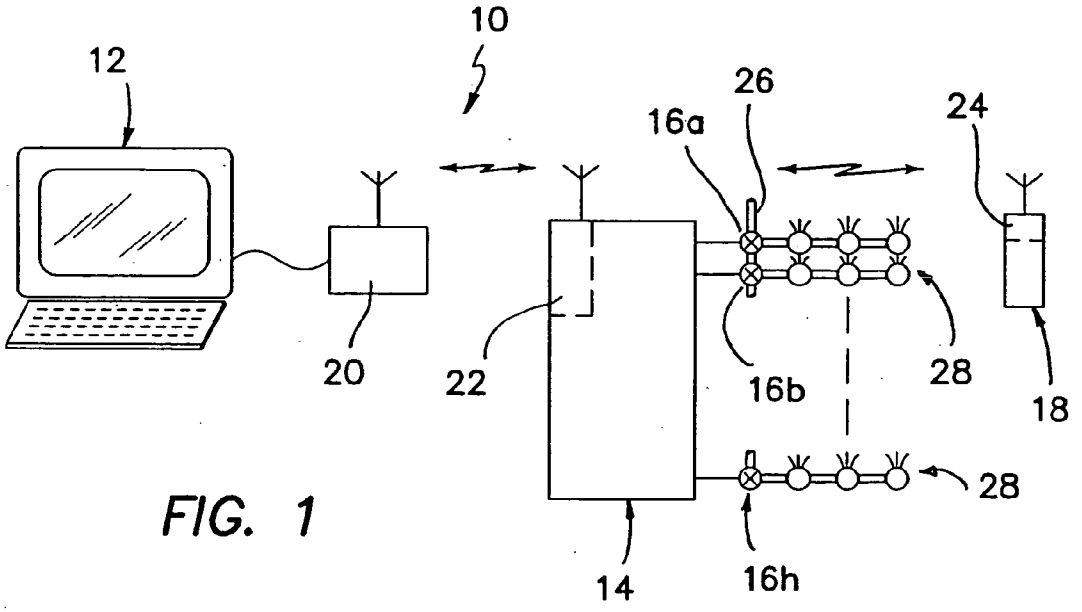

10
12
26
16a
24
20
22
16b
28
18
28
14
16h

FIG. 1

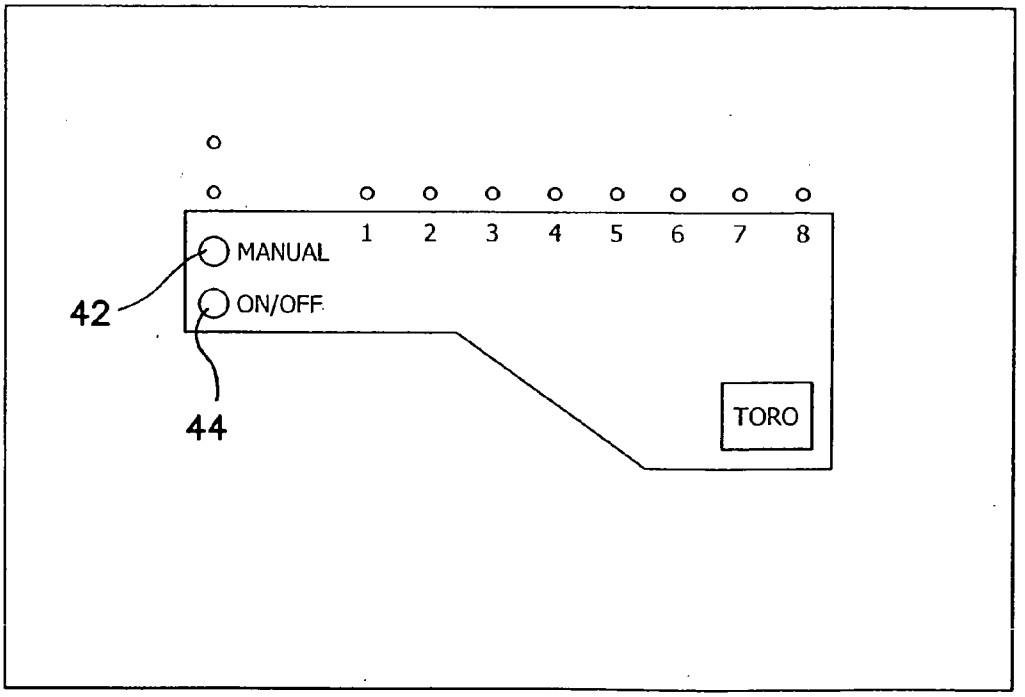

1 2 3 4 5 6 7 8
MANUAL
ON/OFF
42
44
TORO

FIG. 2A

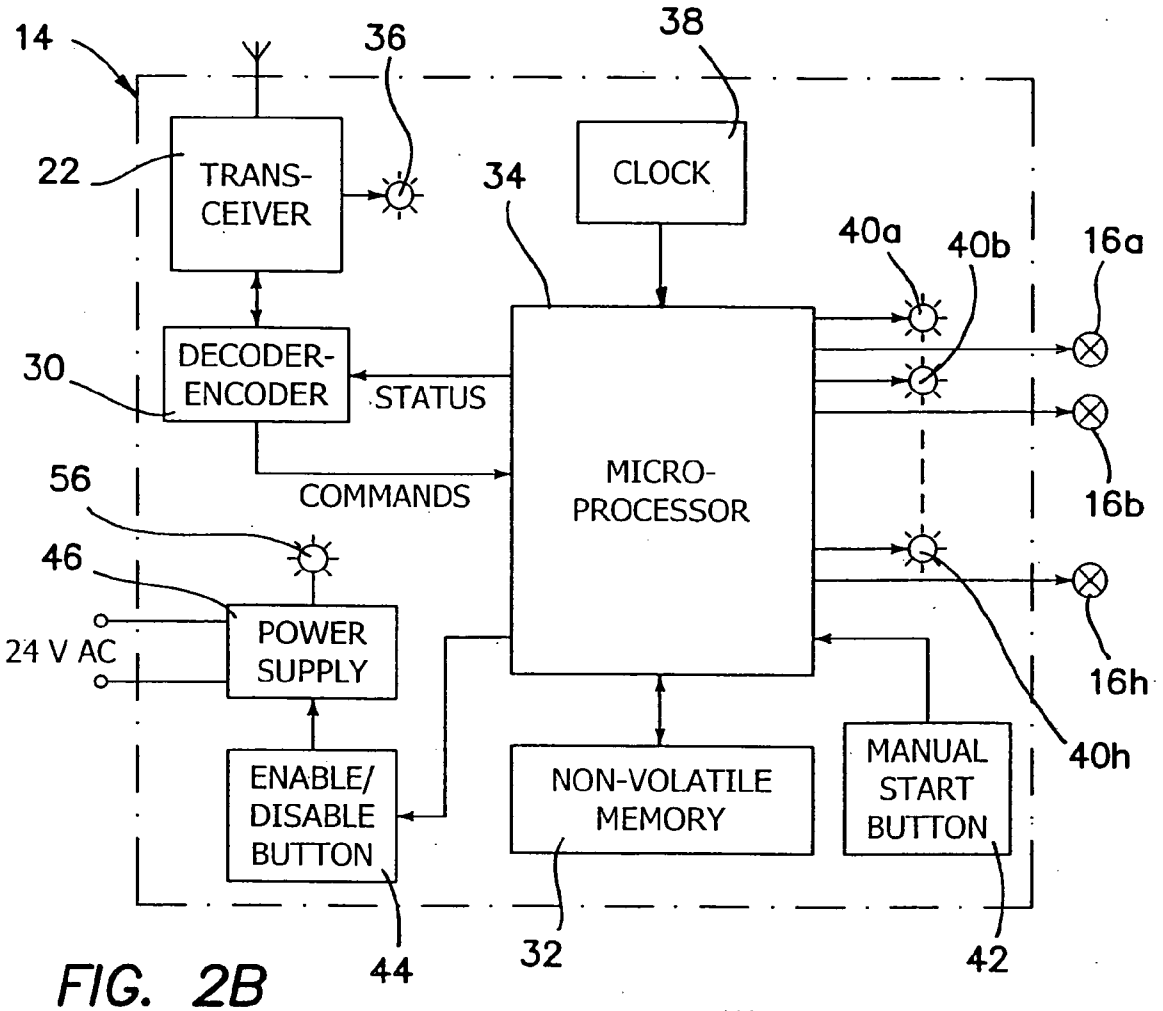

14
36
38
22
TRANS-
CEIVER
34
CLOCK
40a
40b
16a
30
DECODER-
ENCODER
STATUS
MICRO-
PROCESSOR
COMMANDS
16b
56
46
24 V AC
POWER
SUPPLY
16h
40h
ENABLE/
DISABLE
BUTTON
NON-VOLATILE
MEMORY
MANUAL
START
BUTTON
44
32
42

FIG. 2B

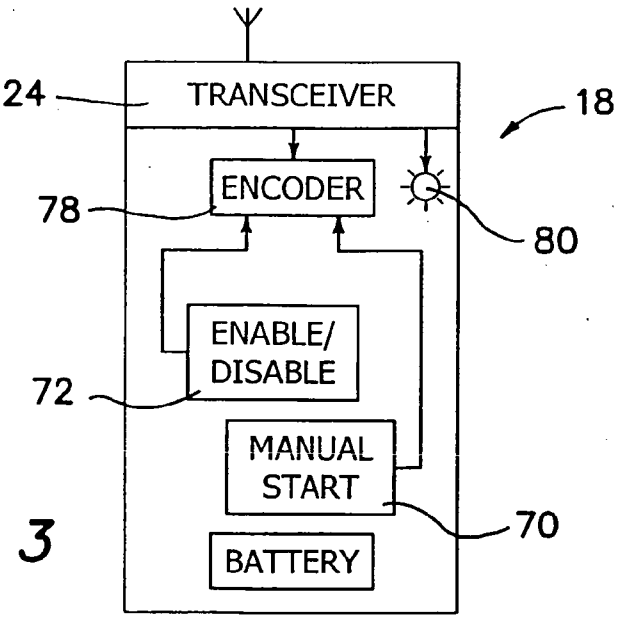

24
TRANSCEIVER
18
ENCODER
78
80
ENABLE/
DISABLE
72
MANUAL
START
70
BATTERY

FIG. 3

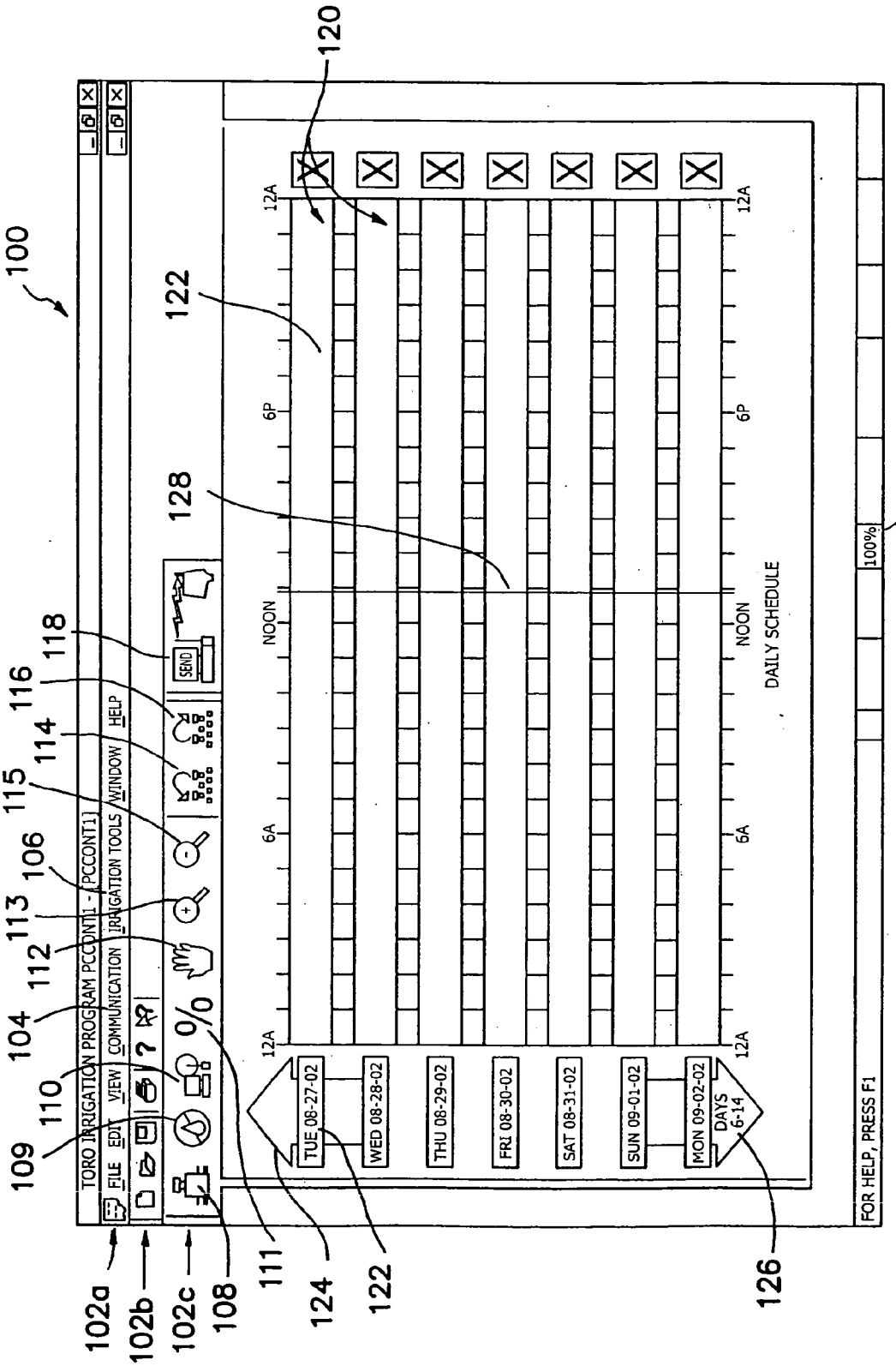

100
120
122
128
118
116
114
115
106
113
112
104
110
109
102a
102b
102c
108
111
124
122
126
119
TORO IRRIGATION PROGRAM PCCONT1 - [PCCONT1]
FILE EDIT VIEW COMMUNICATION IRRIGATION TOOLS WINDOW HELP
SEND
12A
6P
NOON
6A
DAILY SCHEDULE
TUE 08-27-02
WED 08-28-02
THU 08-29-02
FRI 08-30-02
SAT 08-31-02
SUN 09-01-02
MON 09-02-02
DAYS 6-14
100%
FOR HELP, PRESS F1

FIG. 4

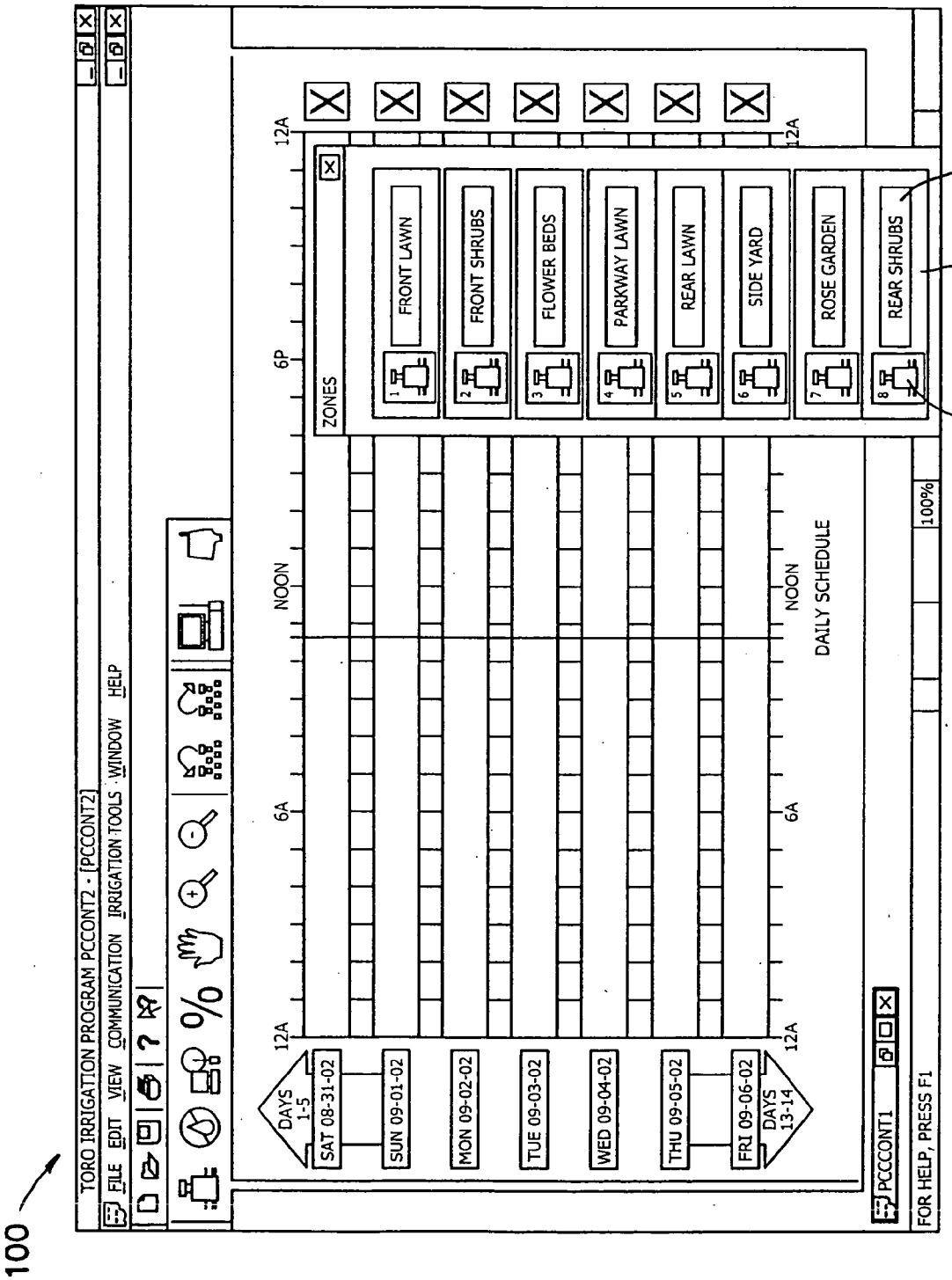

100
TORO IRRIGATION PROGRAM PCCONT2 - [PCCONT2]
FILE EDIT VIEW COMMUNICATION IRRIGATION TOOLS WINDOW HELP
12A
6A
NOON
6P
12A
ZONES
FRONT LAWN
FRONT SHRUBS
FLOWER BEDS
PARKWAY LAWN
REAR LAWN
SIDE YARD
ROSE GARDEN
REAR SHRUBS
1
2
3
4
5
6
7
8
DAYS 1-5
SAT 08-31-02
SUN 09-01-02
MON 09-02-02
TUE 09-03-02
WED 09-04-02
THU 09-05-02
FRI 09-06-02
DAYS 13-14
DAILY SCHEDULE
PCCCONT1
100%
FOR HELP, PRESS F1
132
130
134

FIG. 5

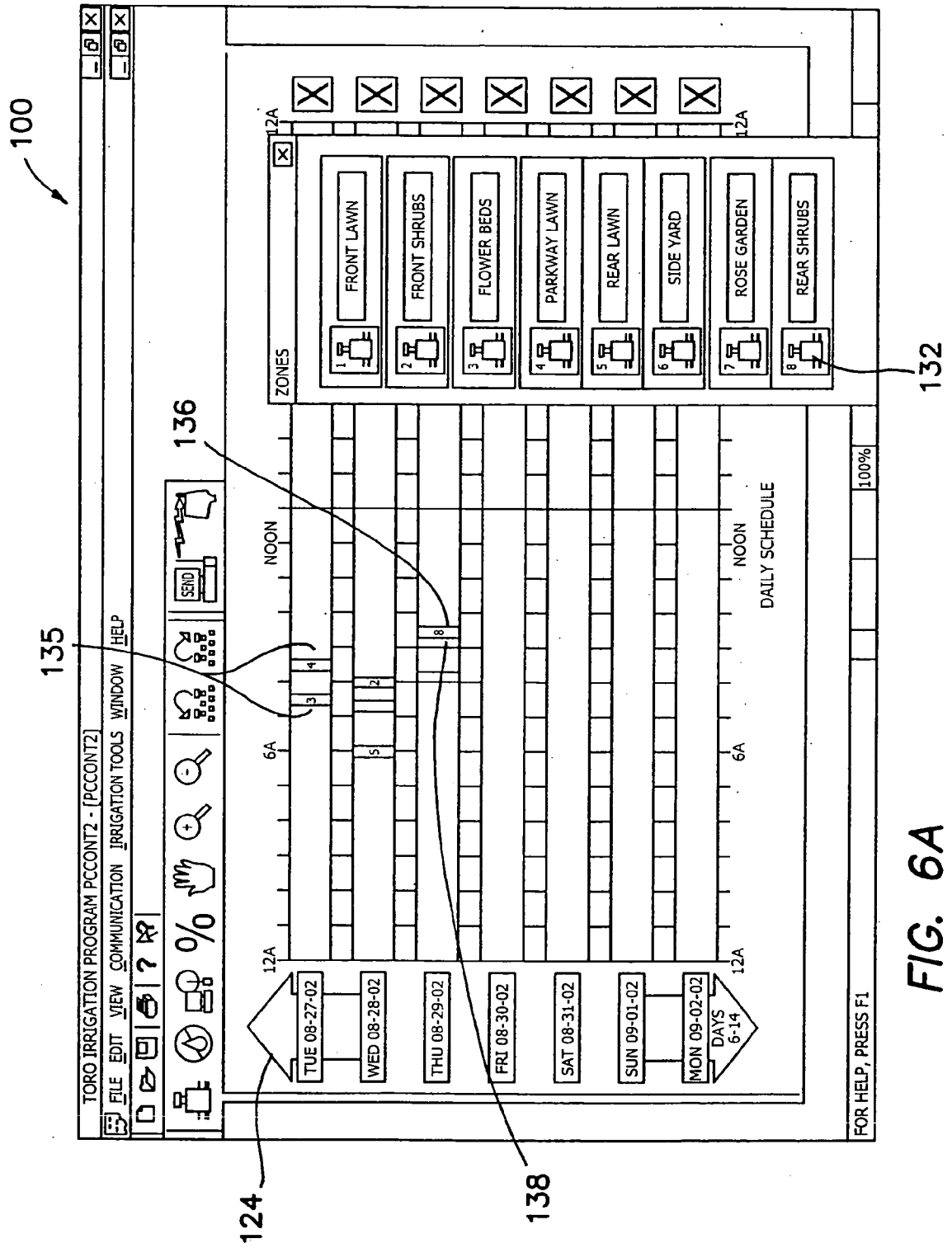

100
135
136
132
124
138
TORO IRRIGATION PROGRAM PCCONT2 - [PCCONT2]
FILE EDIT VIEW COMMUNICATION IRRIGATION TOOLS WINDOW HELP
SEND
ZONES
FRONT LAWN
FRONT SHRUBS
FLOWER BEDS
PARKWAY LAWN
REAR LAWN
SIDE YARD
ROSE GARDEN
REAR SHRUBS
12A
NOON
6A
DAILY SCHEDULE
100%
TUE 08-27-02
WED 08-28-02
THU 08-29-02
FRI 08-30-02
SAT 08-31-02
SUN 09-01-02
MON 09-02-02
DAYS 6-14
FOR HELP, PRESS F1

FIG. 6A

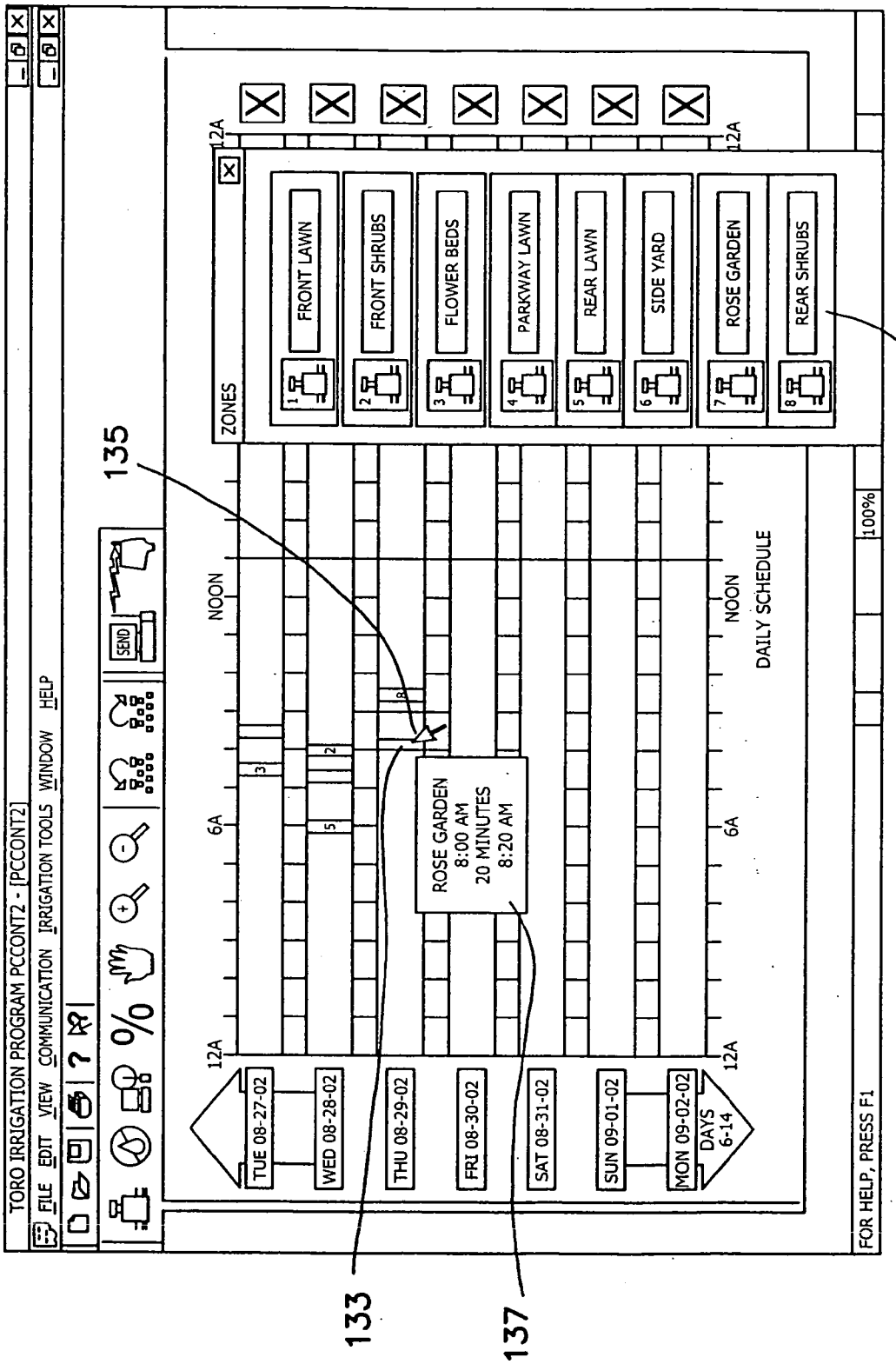

100
TORO IRRIGATION PROGRAM PCCONT2 - [PCCONT2]
FILE EDIT VIEW COMMUNICATION IRRIGATION TOOLS WINDOW HELP
SEND
ZONES
FRONT LAWN
FRONT SHRUBS
FLOWER BEDS
PARKWAY LAWN
REAR LAWN
SIDE YARD
ROSE GARDEN
REAR SHRUBS
12A
NOON
6A
ROSE GARDEN
8:00 AM
20 MINUTES
8:20 AM
DAILY SCHEDULE
TUE 08-27-02
WED 08-28-02
THU 08-29-02
FRI 08-30-02
SAT 08-31-02
SUN 09-01-02
MON 09-02-02
DAYS
6-14
100%
FOR HELP, PRESS F1
130
135
133
137

FIG. 6B

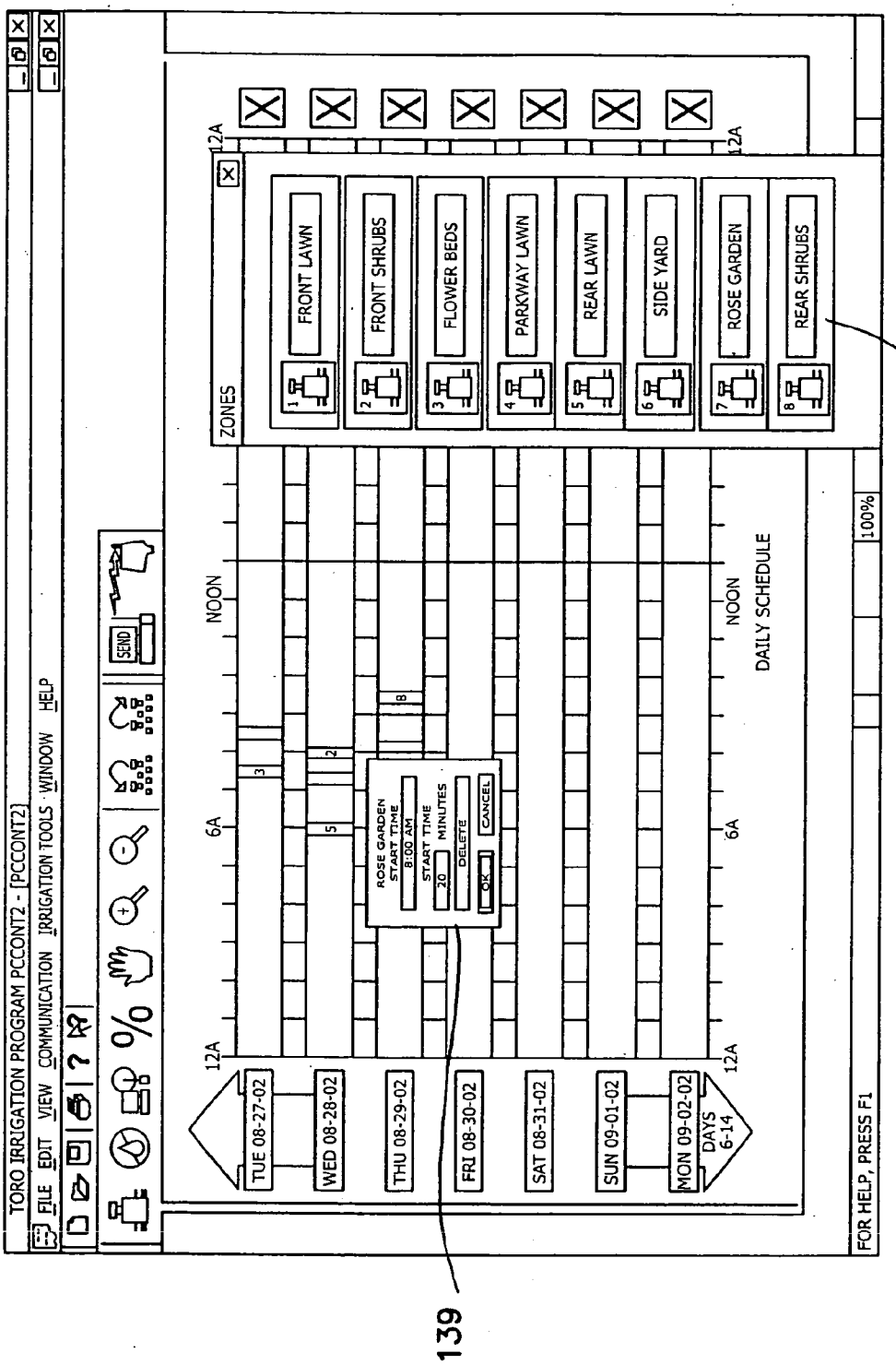

100
TORO IRRIGATION PROGRAM PCCONT2 - [PCCONT2]
FILE EDIT VIEW COMMUNICATION IRRIGATION TOOLS WINDOW HELP
SEND
ZONES
FRONT LAWN
FRONT SHRUBS
FLOWER BEDS
PARKWAY LAWN
REAR LAWN
SIDE YARD
ROSE GARDEN
REAR SHRUBS
12A
NOON
6A
ROSE GARDEN
START TIME
8:00 AM
START TIME
MINUTES
20
DELETE
CANCEL
OK
DAILY SCHEDULE
TUE 08-27-02
WED 08-28-02
THU 08-29-02
FRI 08-30-02
SAT 08-31-02
SUN 09-01-02
MON 09-02-02
DAYS
6-14
100%
FOR HELP, PRESS F1
130
139

FIG. 7

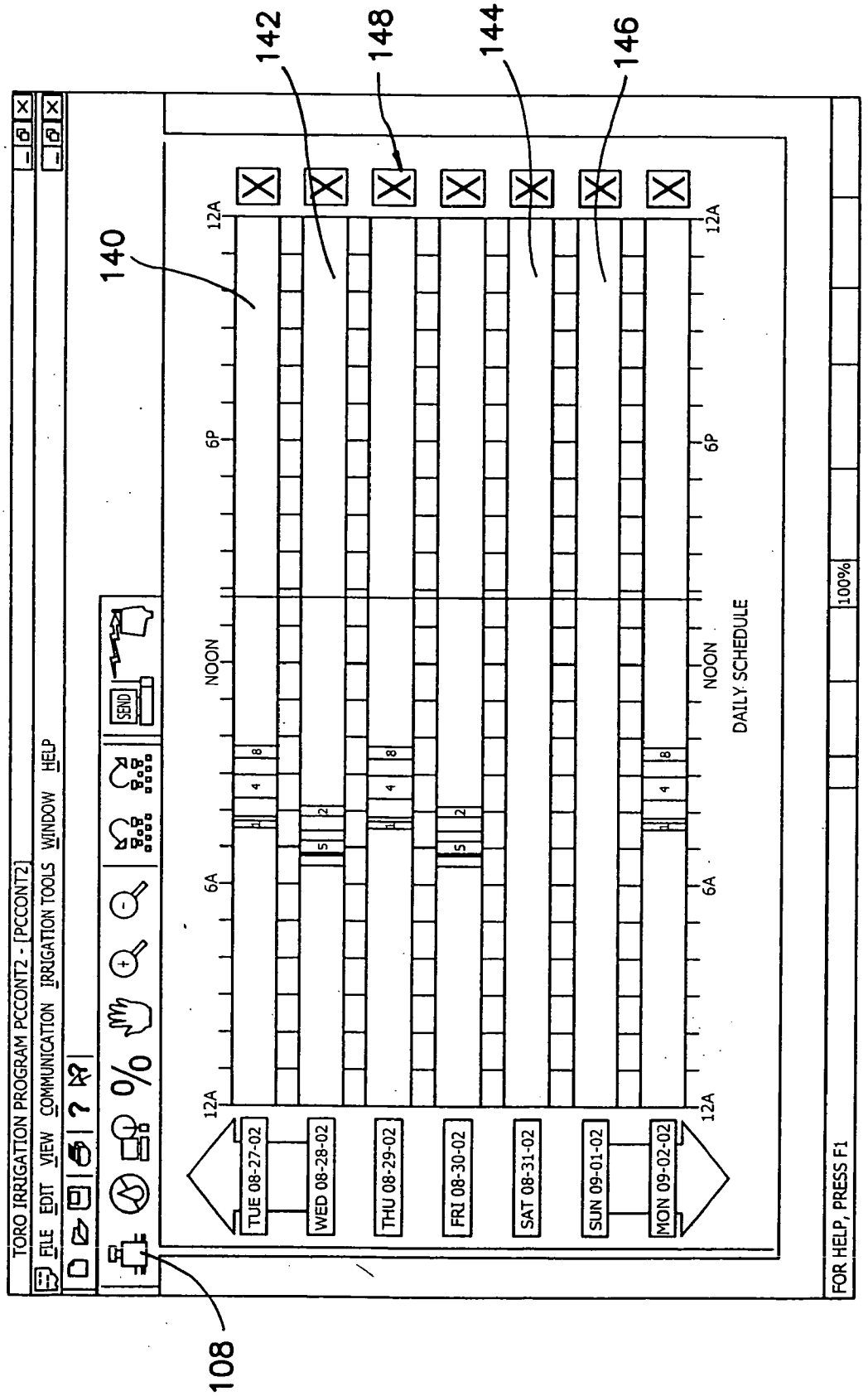

142
148
144
146
140
108
TORO IRRIGATION PROGRAM PCCONT2 - [PCCONT2]
FILE EDIT VIEW COMMUNICATION IRRIGATION TOOLS WINDOW HELP
SEND
12A
6A
NOON
6P
TUE 08-27-02
WED 08-28-02
THU 08-29-02
FRI 08-30-02
SAT 08-31-02
SUN 09-01-02
MON 09-02-02
DAILY SCHEDULE
100%
FOR HELP, PRESS F1

FIG. 8

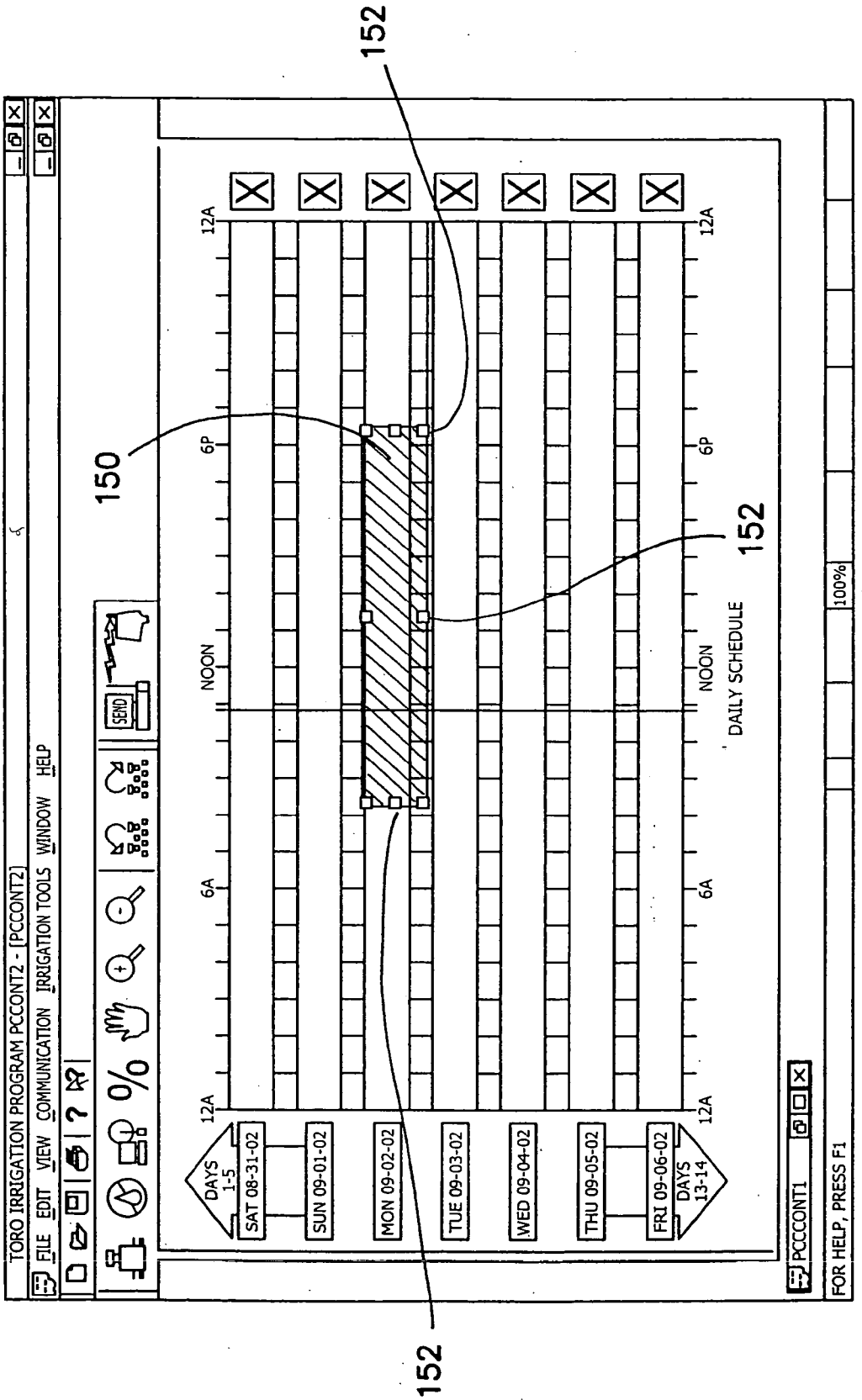

152
150
152
152
TORO IRRIGATION PROGRAM PCCONT2 - [PCCONT2]
FILE EDIT VIEW COMMUNICATION IRRIGATION TOOLS WINDOW HELP
SEND
12A
6A
NOON
6P
12A
DAILY SCHEDULE
DAYS 1-5
SAT 08-31-02
SUN 09-01-02
MON 09-02-02
TUE 09-03-02
WED 09-04-02
THU 09-05-02
FRI 09-06-02
DAYS 13-14
PCCCONT1
100%
FOR HELP, PRESS F1

FIG. 9

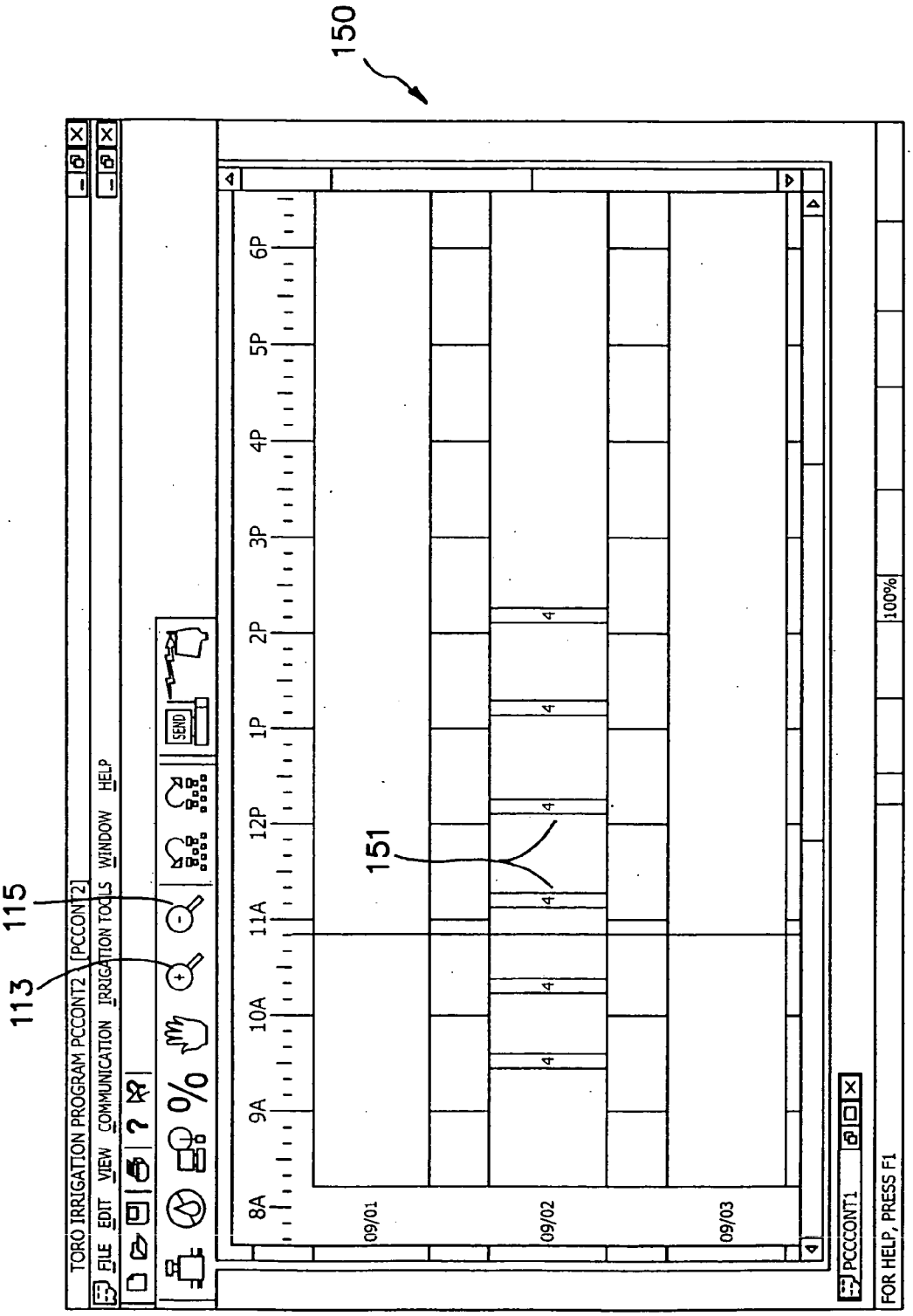

150
115
113
151
TORO IRRIGATION PROGRAM PCCONT2 [PCCONT2]
FILE EDIT VIEW COMMUNICATION IRRIGATION TOOLS WINDOW HELP
SEND
8A
9A
10A
11A
12P
1P
2P
3P
4P
5P
6P
09/01
09/02
09/03
100%
PCCCONT1
FOR HELP, PRESS F1

FIG. 10

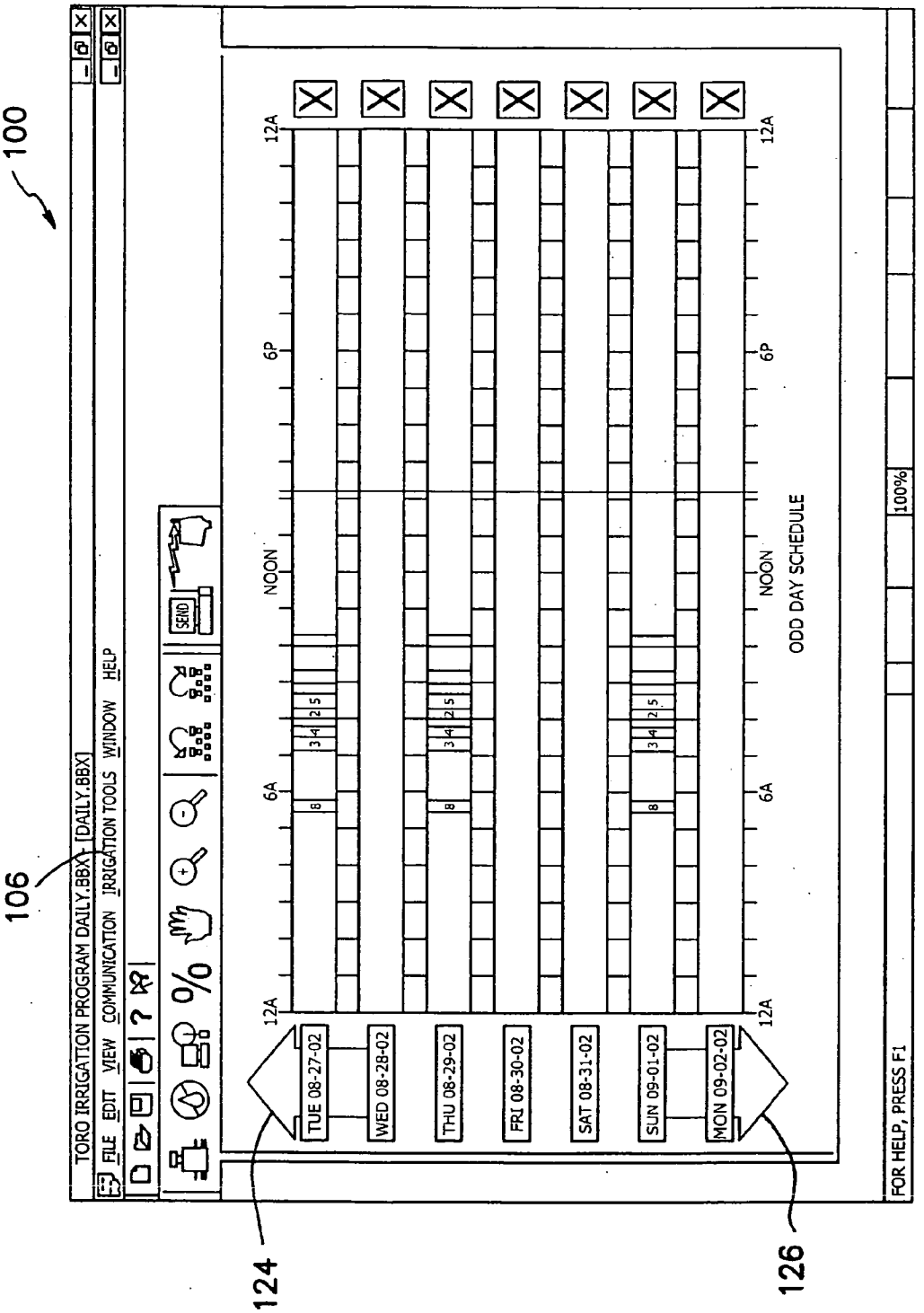

100
106
TORO IRRIGATION PROGRAM DAILY.BBX - [DAILY.BBX]
FILE EDIT VIEW COMMUNICATION IRRIGATION TOOLS WINDOW HELP
SEND
12A
6A
NOON
6P
12A
TUE 08-27-02
WED 08-28-02
THU 08-29-02
FRI 08-30-02
SAT 08-31-02
SUN 09-01-02
MON 09-02-02
ODD DAY SCHEDULE
124
126
FOR HELP, PRESS F1
100%

FIG. 11

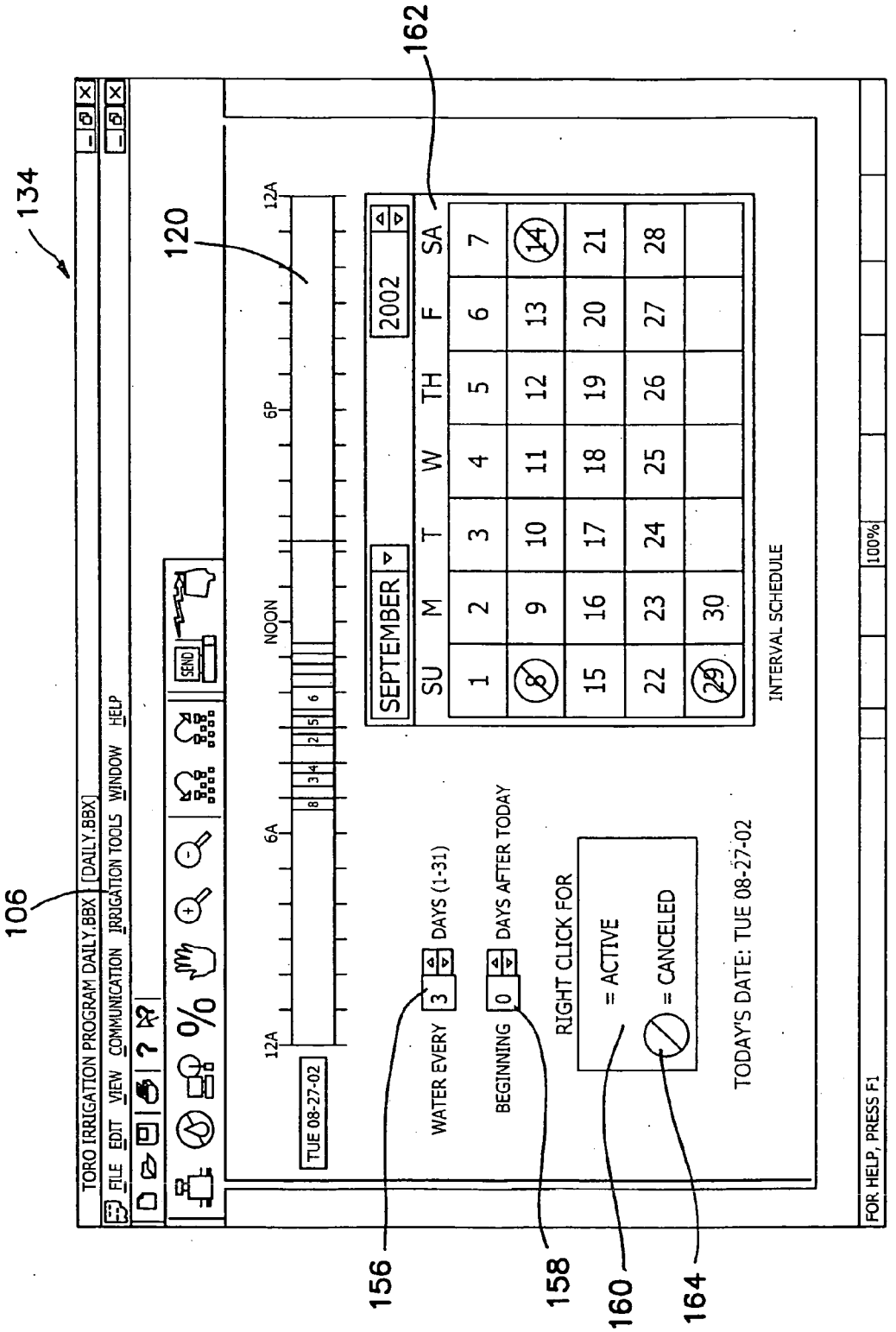

134
106
120
162
TORO IRRIGATION PROGRAM DAILY.BBX [DAILY.BBX]
FILE EDIT VIEW COMMUNICATION IRRIGATION TOOLS WINDOW HELP
SEND
12A
6A
NOON
6P
12A
TUE 08-27-02
SEPTEMBER
2002
SU M T W TH F SA
1 2 3 4 5 6 7
8 9 10 11 12 13 14
15 16 17 18 19 20 21
22 23 24 25 26 27 28
29 30
INTERVAL SCHEDULE
WATER EVERY 3 DAYS (1-31)
BEGINNING 0 DAYS AFTER TODAY
RIGHT CLICK FOR
= ACTIVE
= CANCELED
TODAY'S DATE: TUE 08-27-02
FOR HELP, PRESS F1
100%
156
158
160
164

FIG. 12

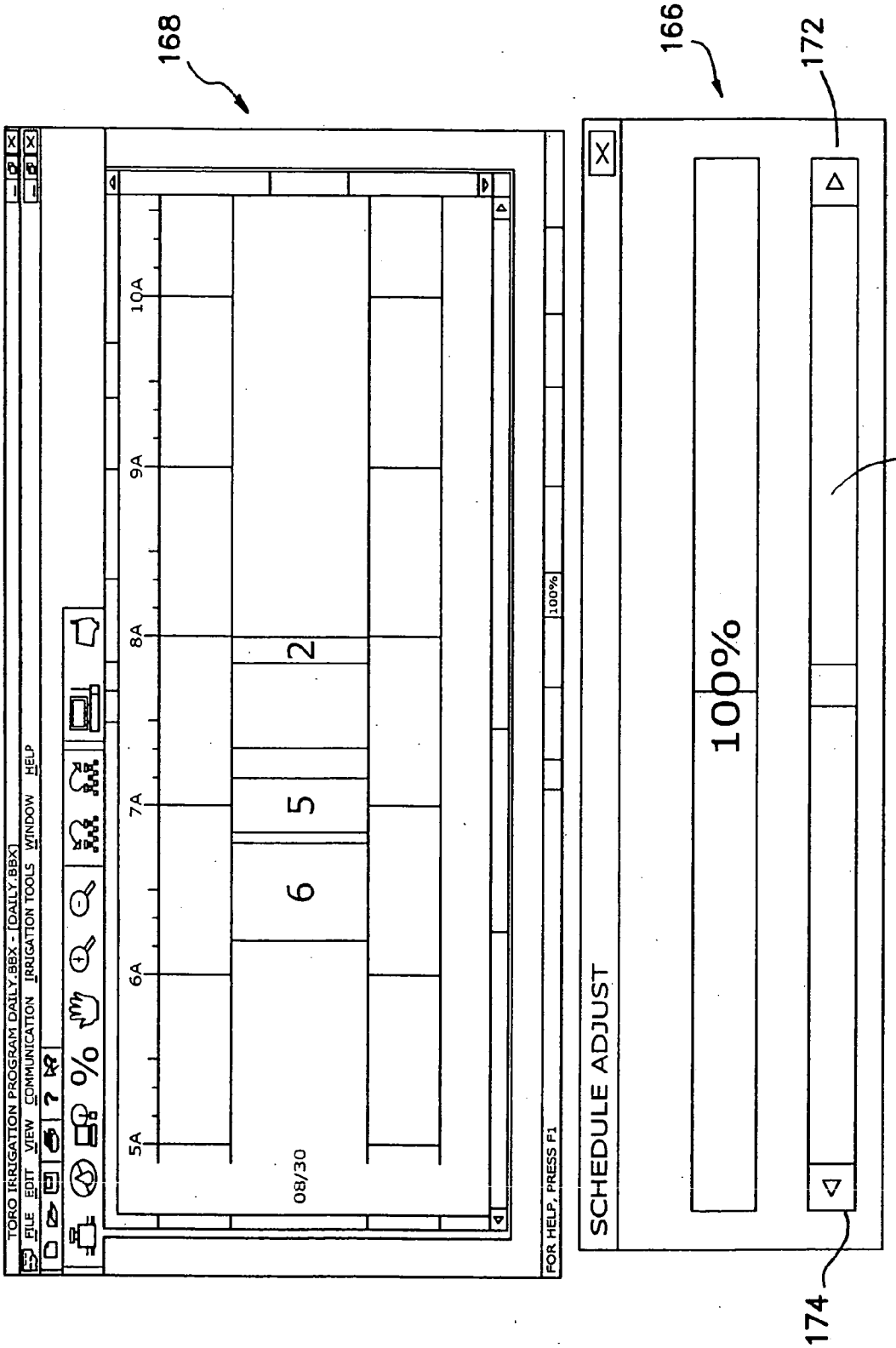

168
166
172
171
174
TORO IRRIGATION PROGRAM DAILY.BBX - [DAILY.BBX]
FILE EDIT VIEW COMMUNICATION IRRIGATION TOOLS WINDOW HELP
5A
6A
7A
8A
9A
10A
08/30
2
5
6
100%
FOR HELP, PRESS F1
SCHEDULE ADJUST
100%

FIG. 13

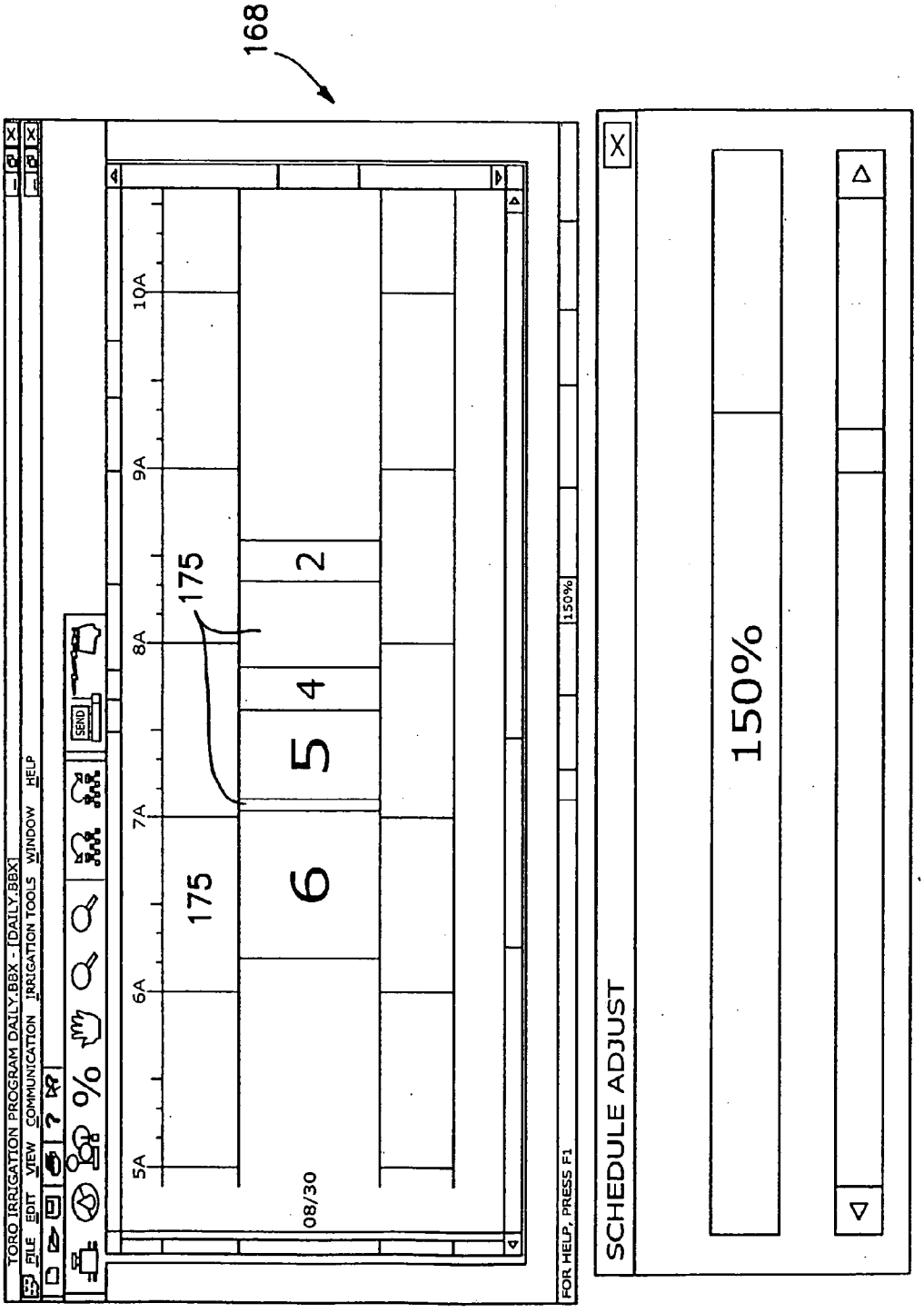

168
TORO IRRIGATION PROGRAM DAILY.BBX - [DAILY.BBX]
FILE EDIT VIEW COMMUNICATION IRRIGATION TOOLS WINDOW HELP
SEND
5A
6A
7A
8A
9A
10A
175
175
6
5
4
2
08/30
150%
FOR HELP, PRESS F1
SCHEDULE ADJUST
X
150%

FIG. 14

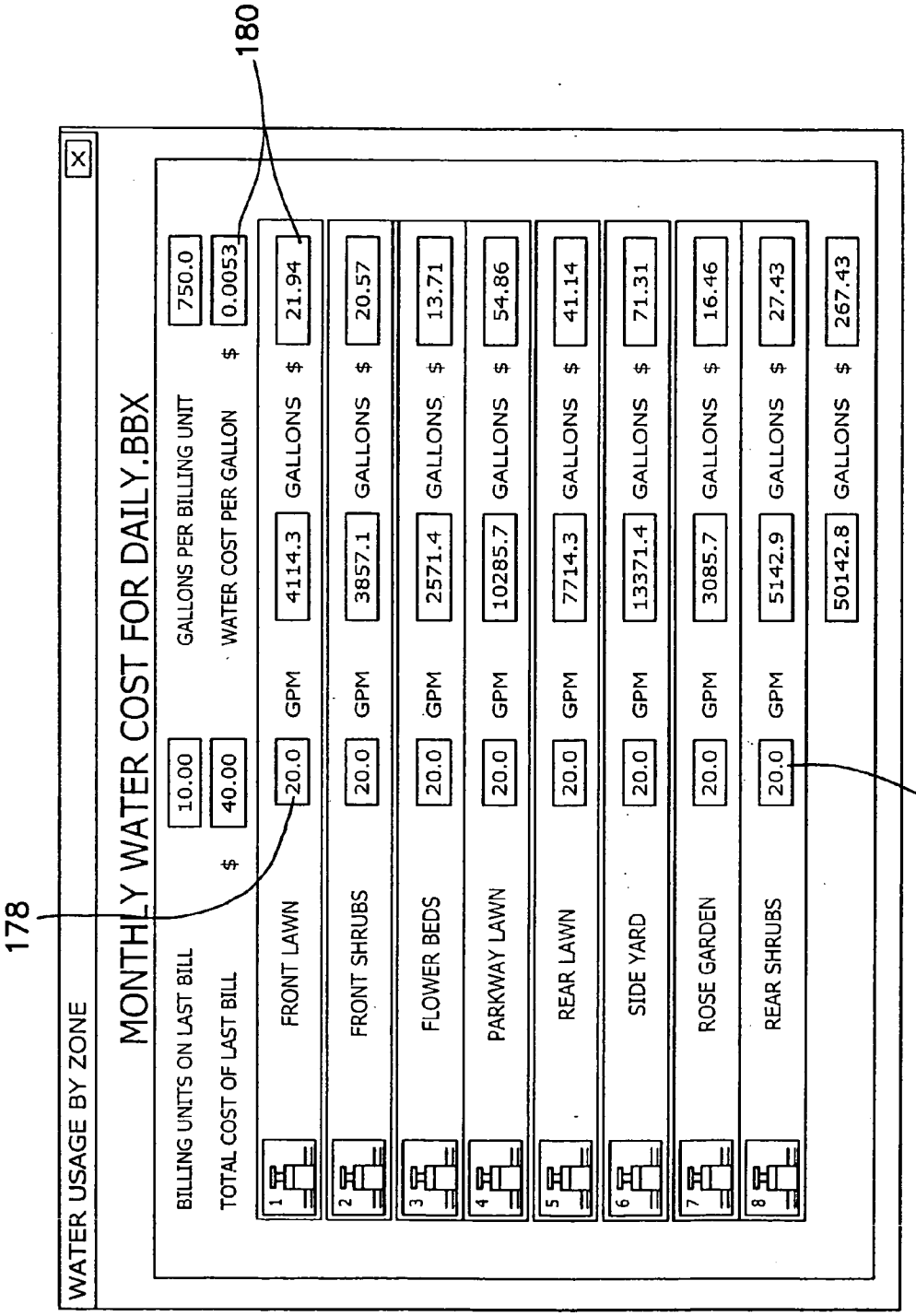

WATER USAGE BY ZONE
MONTHLY WATER COST FOR DAILY.BBX
BILLING UNITS ON LAST BILL
10.00
GALLONS PER BILLING UNIT
750.0
TOTAL COST OF LAST BILL
$ 40.00
WATER COST PER GALLON
$ 0.0053
1 FRONT LAWN 20.0 GPM 4114.3 GALLONS $ 21.94
2 FRONT SHRUBS 20.0 GPM 3857.1 GALLONS $ 20.57
3 FLOWER BEDS 20.0 GPM 2571.4 GALLONS $ 13.71
4 PARKWAY LAWN 20.0 GPM 10285.7 GALLONS $ 54.86
5 REAR LAWN 20.0 GPM 7714.3 GALLONS $ 41.14
6 SIDE YARD 20.0 GPM 13371.4 GALLONS $ 71.31
7 ROSE GARDEN 20.0 GPM 3085.7 GALLONS $ 16.46
8 REAR SHRUBS 20.0 GPM 5142.9 GALLONS $ 27.43
50142.8 GALLONS $ 267.43
178
180
176

FIG. 15

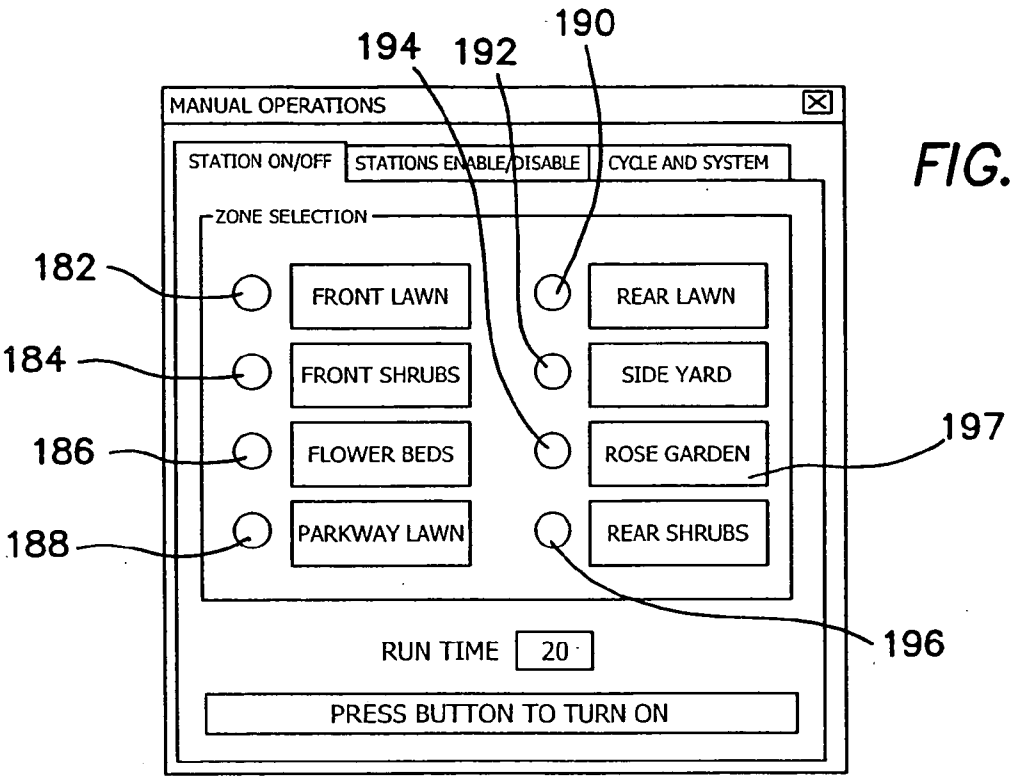

194
192
190
MANUAL OPERATIONS
STATION ON/OFF
STATIONS ENABLE/DISABLE
CYCLE AND SYSTEM
ZONE SELECTION
182
184
186
188
FRONT LAWN
FRONT SHRUBS
FLOWER BEDS
PARKWAY LAWN
REAR LAWN
SIDE YARD
ROSE GARDEN
REAR SHRUBS
197
196
RUN TIME
20
PRESS BUTTON TO TURN ON

FIG. 16

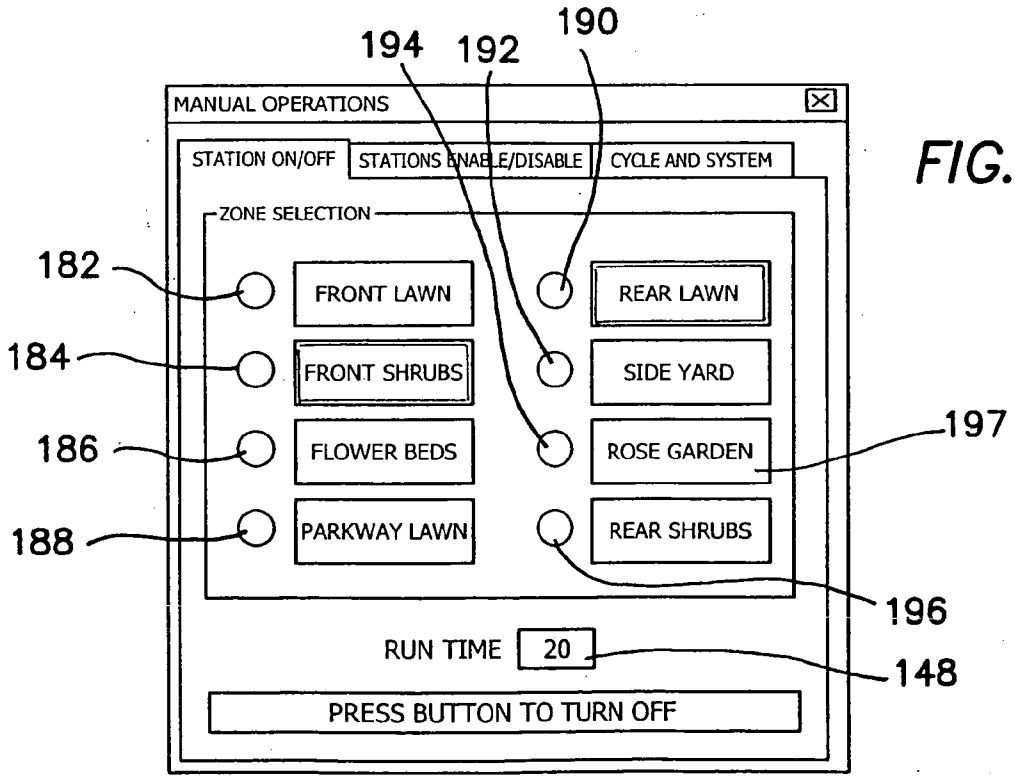

194
192
190
MANUAL OPERATIONS
STATION ON/OFF
STATIONS ENABLE/DISABLE
CYCLE AND SYSTEM
ZONE SELECTION
182
184
186
188
FRONT LAWN
FRONT SHRUBS
FLOWER BEDS
PARKWAY LAWN
REAR LAWN
SIDE YARD
ROSE GARDEN
REAR SHRUBS
197
196
RUN TIME
20
148
PRESS BUTTON TO TURN OFF

FIG. 17

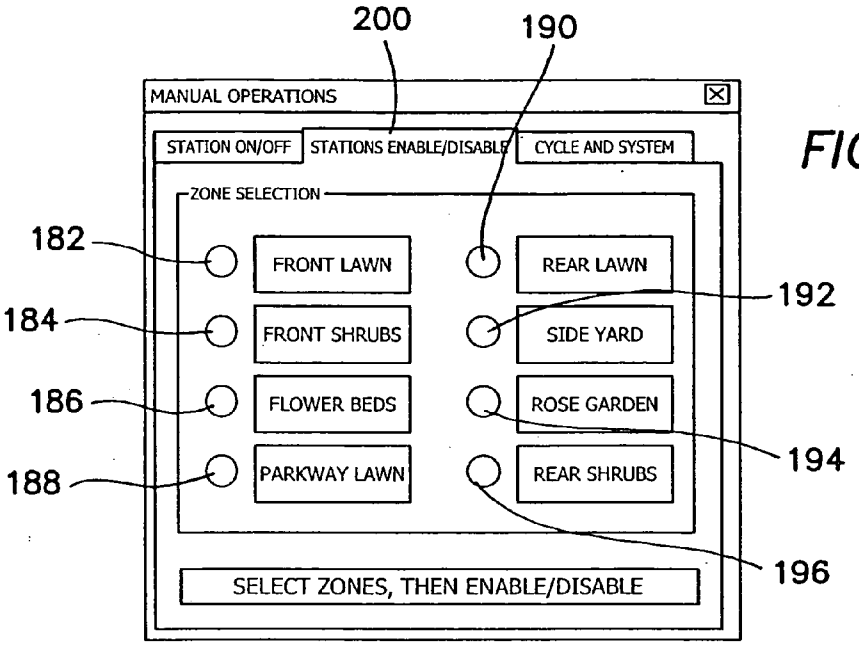

200
190
MANUAL OPERATIONS
STATION ON/OFF
STATIONS ENABLE/DISABLE
CYCLE AND SYSTEM
ZONE SELECTION
182
FRONT LAWN
REAR LAWN
192
184
FRONT SHRUBS
SIDE YARD
186
FLOWER BEDS
ROSE GARDEN
194
188
PARKWAY LAWN
REAR SHRUBS
196
SELECT ZONES, THEN ENABLE/DISABLE

FIG. 18

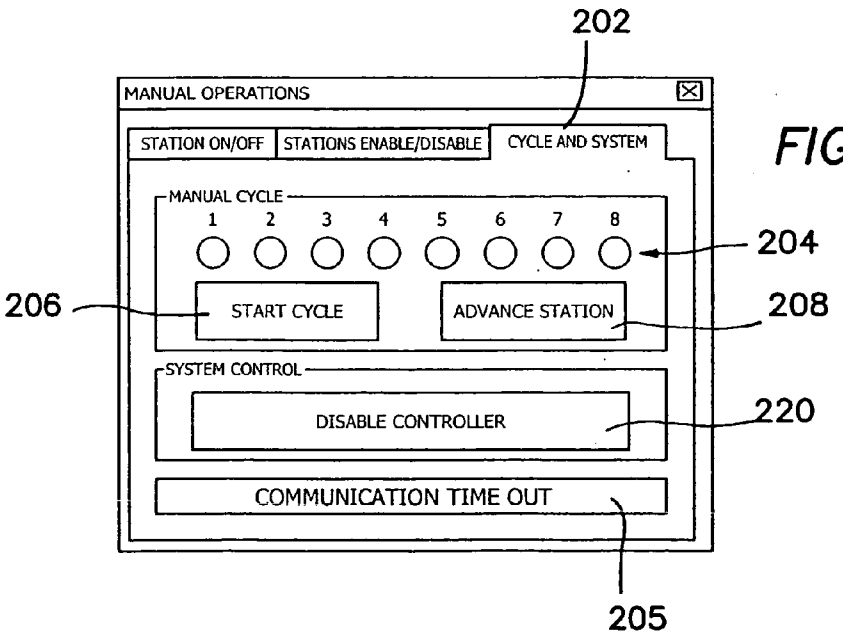

202
MANUAL OPERATIONS
STATION ON/OFF
STATIONS ENABLE/DISABLE
CYCLE AND SYSTEM
MANUAL CYCLE
1 2 3 4 5 6 7 8
204
206
START CYCLE
ADVANCE STATION
208
SYSTEM CONTROL
DISABLE CONTROLLER
220
COMMUNICATION TIME OUT
205

FIG. 19

PC-PROGRAMMED IRRIGATION CONTROL SYSTEM

FIELD OF THE INVENTION

[0001] This invention relates to irrigation control systems, and more particularly to a system using a free-standing field controller programmed by a conventional personal computer with the aid of a novel interactive graphic interface.

BACKGROUND OF THE INVENTION

[0002] Irrigation controllers are used in irrigation systems to electrically operate valves that deliver water under pressure to sprinklers or other distribution devices for watering turf or plants. Controllers are normally installed and programmed after the irrigation system has been designed. Technical skills and experience relating to such installations vary greatly from first-time do-it-yourselfers to professional landscaping crews. Furthermore, once the watering schedules are set on initial installation, they need to be changed or adjusted from time to time to adapt the system to climate or seasonal changes, growth of plants, or unanticipated conditions of soil or topography that result in inadequate or excessive watering in some areas of the system.

[0003] During the design and installation of the irrigation system, the system is divided into zones, each of which irrigates an area of turf or plants having similar growth characteristics and consequently similar water needs. Thus, the amount and frequency of watering can be controlled uniformly and individually for any given grouping of vegetation in the system. The number and frequency of the periodic adjustments that need to be made to the system depends on the complexity of the landscaping and the changes in the variable water requirements.

[0004] Many of the controllers currently available on the market offer a wide array of features and options. These are typically accessed by dials, knobs, buttons and switches, while information is primarily displayed by alphanumeric displays and/or indicator lights. Thus, altering the watering schedule of a controller can be a bewildering, frustrating experience for users, such as homeowners, who seldom find it necessary to make schedule changes. The typical lack of intuitive controls, the often obscure instructions in manuals, and an installer's reluctance to spend time training the user exacerbate that problem.

[0005] Worse yet is the not uncommon situation where the 24V AC power fails when the back-up battery that retains data in memory during power failures has been allowed to wear out. In that case, all program information may be lost, and the user has to reprogram the whole system without the original installer's guidance.

[0006] As personal computers (PCs) have become more and more commonplace in homes, fairly complex irrigation control systems have been sold to homeowners and other users who are not very sophisticated in manually programming complex controllers, but who do own a PC. Such users are likely to be quite familiar with standard methods of interactively manipulating graphics. For example, most PC users intuitively know how to drag and drop icons by moving and clicking a mouse.

[0007] For such users, it is highly desirable to provide a user-friendly graphic interface which allows an operator to manipulate the settings of the field controller with a mouse, and visually observe the effect of his manipulations. In addition, it would be advantageous for users to have a means of allowing repair personnel in the field to perform diagnostic downloads and/or basic control functions, such as turning the water on and off at desired locations, without having to physically access the field controller or the PC. Also, it would be advantageous for users to see how different selections of watering settings would affect the cost of operating the irrigation system.

SUMMARY OF THE INVENTION

[0008] The present invention provides a centrally operated irrigation control system with an intuitive, interactive graphic operator interface by presenting to the operator a two-dimensional time-date chart on a PC screen. Color-coded icons representing the different zones of the system can be placed on the chart and manipulated so as to present to the operator a graphic picture of which zone will be watering how long, at what time and on which days. Clicking on other icons can shut off watering on selected days, start a manual watering cycle, or cause a selected setting to repeat at selected intervals or on selected days of the week or month.

[0009] Other screens, dialog boxes or icons provide more detailed information about individual zones, calculate the anticipated monthly or yearly cost of the water expended by the system as a result of the chosen settings, or selectively temporarily disable one or more malfunctioning zones.

[0010] The schedule and run time settings created by the operator on the PC screen are transmitted to a field controller when desired, and the PC polls the field controller to assure reliable communications by radio or other electronic means at frequent intervals, e.g. once per second, as long as the control program of this invention is running on the PC. The field controller's clock is synchronized with the PC's clock whenever a schedule is uploaded from, or downloaded to, the field controller. This prevents unintentional resetting of the field controller's clock e.g. between daylight saving and standard time. The field controller's transceiver acknowledges each transmission back to the PC. The transmitted schedules and settings for the field controller are stored in that controller and remain in effect until altered by the PC, even if the PC goes off line.

[0011] Thus, a significant aspect of the invention is that the field controller is a free-standing unit; i.e. it does not depend on the PC for its operation. Once it has been programmed by the PC, it continues to function on its own, with or without the PC, until its operation is purposely disabled or modified. This is important for several reasons. Firstly, the system of this invention does not tie up the PC unnecessarily. Secondly, a PC or radio link failure does not impede the scheduled functioning of the system. Thirdly, a landscape maintenance technician can (with an appropriate radio access code) download and/or modify the field controller's schedule and settings from his truck. This is useful for diagnostic purposes and for correcting inappropriately selected watering parameters without the homeowner having to be present. The homeowner receives the new schedule when he activates the inventive program or chooses, within the program, the menu option to upload the schedule from the field controller.

[0012] In one aspect of the invention, a handheld remote is provided to send water-off, manual-watering, and resume-operation radio signals to the field controller without changing its stored parameters. This is useful for maintenance personnel when checking the proper operation of the sprinkler heads.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] **FIG. 1** is a block diagram of the system of this invention;

[0014] **FIG. 2***a* is a front view of a typical field controller in the system of the invention;

[0015] **FIG. 2***b* is a block diagram of the field controller of **FIG. 2***a;*

[0016] **FIG. 3** is a block diagram of a handheld remote optionally used with the system of the invention;

[0017] **FIG. 4** shows the start-up screen of the control program;

[0018] **FIG. 5** shows the zones selection box;

[0019] **FIG. 6***a* shows the screen of **FIG. 5** with zone schedules inserted;

[0020] **FIG. 6***b* shows the label produced by positioning the cursor over a schedule box;

[0021] **FIG. 7** shows the schedule dialog box;

[0022] **FIG. 8** shows the screen of **FIG. 4** with alternate-days watering schedules entered thereon;

[0023] **FIG. 9** shows a magnifying box on the screen of **FIG. 8**;

[0024] **FIG. 10** shows a magnified section of the screen of **FIG. 4** with a new-lawn schedule inserted;

[0025] **FIG. 11** shows an odd-days watering schedule;

[0026] **FIG. 12** shows an interval schedule screen;

[0027] **FIG. 13** shows an enlarged section of the screen of **FIG. 8** with a global adjustment of 100%;

[0028] **FIG. 14** shows the screen section of **FIG. 13** with a global adjustment of 150%;

[0029] **FIG. 15** shows the water cost calculator of the invention;

[0030] **FIG. 16** shows the Station On-Off subscreen of the manual operations screen;

[0031] **FIG. 17** shows the screen of **FIG. 16** with manual operations entered;

[0032] **FIG. 18** shows the Stations Enabled/Disabled subscreen of the manual operations screen; and

[0033] **FIG. 19** shows the Cycle and System subscreen of the manual operations screen.

DESCRIPTION OF THE PREFERRED EMBODIMENT

[0034] As shown in **FIG. 1**, the system **10** of this invention is composed of a PC **12**, a field controller **14**, zone valves or stations **16***a* through **16***h* (collectively referred to herein as stations **16**), and optionally a handheld remote **18**. Radio transceiver **20** connected to an appropriate USB or modem port of the PC **12**, and transceiver **22** at the field controller **14**, exchange schedule, setting and clock data between the PC **12** and the field controller **14**. A transceiver **24** in the remote **18** allows the remote **18** to access the field controller **14** for limited purposes. Each of the stations **16** turns the water from a main **26** on or off, under the control of the field controller **14**, to a set of sprinklers **28**.

[0035] The face plate of a typical field controller **14** in accordance with the invention is shown in **FIG. 2***a*. A communications monitor LED **36** indicates operation of the radio link between the field controller **14** and the PC **12** and/or the remote **18**. Zone Status LEDs **40***a* through **40***h* indicate the current status of the valves **16***a* through **16***h*, respectively, which control water flow to the sprinklers **28** in zones **1** through **8**, respectively. Manual Start pushbutton **42** is provided to start a manual watering sequence and to switch from one zone to the next. Enable/Disable button **44** toggles between inhibiting and restoring all watering. Water-Off LED **56** is connected to the power supply **46** (**FIG. 2***b*) in such a manner as to light steadily when watering is disabled, and to flash at intervals of e.g. four seconds under the power of a backup battery (not shown) in the power supply **46** to indicate an AC line power failure.

[0036] **FIG. 2***b* shows the details of the free-standing field controller **14**. Irrigation parameter and clock synchronization signals from the PC **12** of **FIG. 1** are received by the transceiver **22** and decoded by the encoder/decoder **30**. An access code may be embodied in the signals to assure that the field controller **14** responds only to its owner's PC. The received irrigation settings and schedules are stored in the non-volatile memory **32** by the microprocessor **34**. The microprocessor **34** acknowledges receipt and execution of the transmission from the PC **12** by transmitting a status signal back to the PC **12**. A status signal is also transmitted back to the PC **12** when the field controller **14** is polled by the PC **12** (typically about once per second while the PC program is running. The communications monitor LED **36** blinks whenever a good signal is received so that the proper operation of the communications link can be observed.

[0037] Under the control of its clock **38**, and solely in response to the scheduling and setting data stored in memory **32**, the microprocessor **34** turns power to the water valves or stations **16***a* through **16***h* on and off as the watering schedule stored in memory **32** dictates. Whenever power is on to one of the stations **16**, the microprocessor **34** illuminates the corresponding one of the station LEDs **40***a* through **40***h*. When no watering is in progress, the microprocessor **34** scrolls the station LEDs **40***a* through **40***h* to indicate that the system is functional and standing by. No intervention by the PC **12** is required for the free-standing field controller **14** to perform these operations.

[0038] The controller **14** has two controls which may be in the form of the Manual Start pushbutton **42** and the Enable/Disable pushbutton **44**. The Manual Start button **42** triggers the microprocessor **34** to energize station **16***a* for its run time as stored in the memory **32**. A second push turns off station **16***a* and starts station **16***b*. A third push turns station **16***b* off and starts station **16***c*. Finally, the ninth push turns off station **16***h* and returns the microprocessor **34** to its automatic operation. If button **42** is pushed only once, each station will water in numerical sequence for its designated run time, and then return to automatic operation.

[0039] The Enable/Disable button **44** shuts all watering off by removing the operating power from the stations **16**, while keeping the microprocessor **34** and radio transceiver **22** in operation. The Enable/Disable button can be physically pushed by an operator in the field, or actuated by a radio command signal from the PC **12** or the handheld remote **18**.

[0040] Referring now to **FIG. 3**, the optional remote **18** has a Manual Start button **70** and an Enable/Disable button **72**. An encoder **78** translates a button actuation into an appropriate code for transmission. The transceiver **24** is equipped with an LED **80** that lights when a signal is being transmitted or received. The LED **80** is programmed to blink twice if the addressed controller **14** is operational and acknowledges the transmission, once if the controller **14** is disabled, and not at all if the controller **14** is out of service and does not respond, or if a bad transmission is received.

[0041] **FIGS. 4 through 19** illustrate the establishment and manipulation of watering schedules and settings in the system of the invention. When the inventive control program is first opened on the PC **12**, the start-up or main graphic or screen **100** (**FIG. 4**) is initially presented to the user. The first two lines **102***a* and **102***b* of the menu bar **102** contain the standard operational icons of the Windows® operating system, adding only the Communications menu **104** and the Irrigation Tools menu **106**. The Communications menu **104** allows the selection of ports for the connection of the transceiver **20** and the initiation of a data transfer to or from the field controller **14**. The Irrigation Tools menu **106** allows the selection of the various types of screens discussed below.

[0042] The third line **102***c* of the menu bar **102** contains the special icons that activate the features of the inventive system. As described in more detail below, the Zone Display icon **108** brings up a Zones box or list **130** of all separately controllable zones. The No-Watering icon **109** toggles the field controller **14** of **FIG. 2***a* on/off in the same manner as the enable/disable buttons **44** and **72** described above. The Communications icon **110** monitors the functioning of the radio link by showing radiating green circles when transmissions to the field controller **14** are being acknowledged, and red ones when they are not. The Percent icon **111** brings up the global adjustment bar of **FIGS. 13 and 14** for globally increasing or decreasing all the watering times of all the zones in response to climatic changes or water conservation requirements. The Manual icon **112** brings up a set of screens which handle a variety of manual operations. The Plus and Minus icons **113**, **115** enlarge and reduce, respectively, selected portions of the screen as described below. Undo and Redo icons **114** and **116** carry out standard editing functions of the Windows® operating system. The "100%" notation **119** indicates that the global adjustment (discussed below in conjunction with **FIGS. 13 and 14**) is set to 100%.

[0043] The Send icon **118** is normally grayed out. When the program of this invention is opened on the PC **12**, the current schedule and settings stored in the field controller **14** are immediately uploaded for display on the PC **12**. When any change is made to the uploaded information, the Send icon **118** becomes active. When it is then clicked, the PC **12** begins sending the selected or modified watering schedule and settings to the field controller **14**. When the modified parameters have been successfully transmitted to the field controller **14**, the Send icon **118** will momentarily change to "OK", after which the Send icon **118** grays out, the PC **12** resumes its continual polling of the field controller **14**, and the screen again displays the status of the field controller **14**. Pop-up reminder boxes (not shown) warn the operator if a modification has been made but not sent to the field controller **14** within a reasonable time.

[0044] The body of the start-up screen **100** displays horizontal time bands **120** arranged in a vertical series of days. The first day **122** of the series is always the current day as determined by the computer's internal clock. The screen **100** preferably displays seven time bands to form a repeating one-week setup. Two-week or four-week setups (i.e. setups that repeat every two or four weeks) can be chosen from the Irrigation Tools menu **106**, in which case weeks preceding or following the displayed week can be accessed by clicking the up arrow **124** or the down arrow **126**. A vertical line **128** shows the current time, in accordance with the computer's clock, on the midnight-to-midnight scale of the time bands **120**.

[0045] In order to set up a watering schedule, the Zone Display icon **108** is clicked. This brings up the Zones box **130** (**FIG. 5**) which displays a valve icon **132** and an editable description box **134** for each of the separately programmable zones. A watering schedule is begun by dragging and dropping, in accordance with standard Windows® practice, a selected valve icon **132** onto a selected time band **120** at approximately the time position at which a watering cycle is selected to begin. (Note that in **FIG. 5**, the down arrow **126** has been clicked until the time bands **120** on the screen represent the sixth through twelfth days of a two-week setup).

[0046] Repeated dragging and dropping produces the screen of **FIG. 6** (the up arrow **124** having been clicked to go back to a display of the first seven days of the two-week setup). Preferably, the valve or zone icons **132** are color-coded, and the schedule boxes **135** are correspondingly color-coded in addition to being numbered. It will thus be seen in **FIG. 6** that the flower beds and parkway lawn get watered on Tuesday at about 7:15 am and 8:15 am, respectively; the rear lawn, front lawn and front shrubs get watered on Wednesday at about 5:55 am, 7:05 am and 7:55, respectively; and the rose garden gets watered at 8:00 am on Thursday. The side yard and rear shrubs get watered, one immediately after the other, beginning at 9:00 am on Thursday.

[0047] Because only one zone can normally be on at any given time, an attempt to drag schedule box **136** onto schedule box **138** causes schedule box **136** to jump back to a position immediately adjacent schedule box **138**. Positioning the cursor **135** over a schedule box such as **133** brings up an information label **137** (**FIG. 6***b*) that identifies the zone and shows its start time, run time and end time. Right-clicking a schedule box such as **136** brings up a dialog box **139** (**FIG. 7**) in which the user can modify the start time and run time, or delete the schedule box entirely. Incompatible selections chosen in the dialog box, such as overlapping run times, are rejected with an advisory pop-up box (not shown) indicating the inappropriate choice. Alternatively, a schedule box can be dragged to a different start time, and its right edge can be dragged to increase or decrease its run time.

[0048] **FIG. 8** (with the Zones box **130** now hidden by clicking Zone Display icon **108**) illustrates a method of

building a one-week schedule that waters alternate sets of zones on alternate weekdays. In that figure, the Tuesday schedule of zones **3**, **7**, **4** and **8** and the Wednesday schedule of zones **6**, **5**, **1** and **2** are first established in the manner discussed above in connection with **FIG. 5**. Next, the Tuesday time band **140** is selected and highlighted by double-clicking on it. Positioning the cursor over the thus selected time band produces a 4-way arrow. The highlighted time band can now be dragged to the desired day with the left mouse button. A copy of the time band **140** will thus be produced on the desired day. In like manner, the Wednesday band **142** is copied to the Friday band. The Saturday and Sunday bands **144**, **146** are left blank. It will be noted that as the top band rotates to the bottom of the screen (with next week's date) at the end of the day, Monday's and Tuesday's schedules will not alternate but be the same. This can be avoided by setting up a two-week schedule.

[**0049**] To the right of each time band is a large X **148**. Clicking that X highlights the time band and the X, and disables watering for that day only. This would be useful if the forecast for that day calls for rain. If an error is made in scheduling a given day, the error can be corrected by a conventional Edit-delete or Undo and reentry operation.

[**0050**] **FIGS. 9 and 10** illustrate the magnification of any desired area of the screen so that settings may be observed and manipulated more exactly. Clicking the Plus icon **113** magnifies the whole screen. Because this may move a desired portion of the screen out of view, a portion of the screen can alternatively be selected for magnification by dragging the mouse with the left button. This places a shaded box **150** over the image on the screen. The box **150** can be moved and sized by its handles **152** in accordance with standard Windows® drawing practice. When it has been placed and sized as desired, clicking the Plus icon **113** enlarges the area encompassed by the box **150** to fill the screen (**FIG. 10**). This is convenient, for example, when it is desired to schedule, by copying and pasting, a number of short, spaced waterings **151** as would be beneficial on a new lawn. The process of clicking the Plus icon **113** and/or creating a box **150** can be repeated as desired for increasing the magnification of the screen image. Clicking the Minus icon **115** reverses the process step by step.

[**0051**] When local ordinances or other watering restrictions so provide, watering can be scheduled for odd or even days of the month by selecting, e.g., "Odd Days" from the Irrigation Tools menu **106**. This brings up the screen of **FIG. 11**, in which all even days are blocked out, but in which watering on odd days can be scheduled at will, as described above. It should be noted that if the last day of the month is odd, it is also blocked out so that watering cannot occur two days in a row. In the screen of **FIG. 11**, double-clicking the arrows **124**, **126** moves the display to the first seven or last seven days of the month, respectively. As in the other seven-day screens, single-clicking the arrows **124**, **126** moves the display up or down by one day.

[**0052**] **FIG. 12** shows an Interval Schedule screen **154** which can also be selected from the Irrigation Tools menu **106**. The screen **154** contains only one time band **120** for the current day. A schedule set up for that day will repeat at the intervals selected in the window **156**, starting on the day selected in window **158**. The selections in windows **156**, **158** cause a water drop icon **160** to appear on the selected days in the calendar **162**. Right-clicking on an icon **160** on the calendar **162** causes a Cancelled icon **164** to appear in its place, and watering will not take place on that day unless the Cancelled icon **164** is removed by right-clicking on it.

[**0053**] **FIGS. 13 and 14** illustrate the operation of the Percent icon **111**. Clicking that icon brings up the global adjustment screen **166** under the enlarged screen section **168**. In order to globally adjust all the run time settings of the watering schedules entered into the system (e.g. in order to cope with an unseasonal hot or cold spell), the user can move the slider **170** or click the bar **171** or the arrows **172**, **174** to vary the percentage of run time from the normal 100% to anywhere from 0% to 200%. Each click on the bar **171** on either side of the slider **170** increases or decreases the run time by 10%, while each click on one of the arrows **172**, **174** increases or reduces it by 1%.

[**0054**] The effect of a global adjustment to 150% of the original settings is shown in **FIG. 14**. Comparing the schedules of **FIG. 14** to those of **FIG. 13**, it will be seen that the width (i.e. run time) of each schedule box has been increased by 50%, but that the intervals **175** between the schedule boxes remain the same. It is conceivable, therefore, that for late-evening waterings, a 50% run time increase may push schedule boxes partly or wholly past midnight. If that is the case, any schedule portion past midnight is deleted. It is, however, stored in the PC's memory and is restored by the PC when the global adjustment is returned to 100%.

[**0055**] A water cost calculator, shown in **FIG. 15**, can be called up from the Irrigation Tools menu **106** (**FIG. 4**). In the screen of **FIG. 15**, which is essentially a dedicated spreadsheet, the white spaces such as **176** are selectable (as for example space **178**) and changeable, while the grey spaces such as **180** are automatically calculated. In using the calculator of **FIG. 15**, the flow rate in gallons per minute for each zone (known from the number of sprinklers in the zone and the manufacturer's specifications for the type of sprinkler involved) is first entered in the corresponding spaces **176**. Next, the user enters the number of gallons in a water company billing unit (usually a ccf, which equals about 750 gallons). Finally, the user consults his latest water bill and enters the number of billing units used and the charge for that amount of water. Based on the total run time, during the current month, of the schedules programmed into the system for each zone, the spreadsheet of **FIG. 15** continuously calculates the water cost per gallon, the total number of gallons scheduled to be consumed that month, and the total cost of that water. This is particularly useful in conjunction with the global adjustment feature of **FIGS. 13 and 14**, as it permits an instant assessment of the cost effectiveness of any particular adjustment.

[**0056**] Clicking the Manual icon **112** (**FIG. 4**) brings up the three-tab screen of **FIG. 16**. All of the indicators **182** through **196** are initially dark green. If the "Rose Garden" tag **197** is clicked, indicator **194** turns bright green, and the system sends out a signal to field controller **14** to turn zone **7** on for the twenty minutes currently entered into the Run Time box **198**. Subsequent clicking on "Rear Lawn" and "Front Shrubs" (**FIG. 17**) causes zones **2** and **5** to be run immediately following the run of zone **7**, in the order in which they were clicked, and each for the time entered in box **198**. The indicators **184**, **190** and **194** will turn bright green whenever their associated zone is running.

[0057] Clicking the "Stations Enable/Disable" tab **200** brings up the screen of **FIG. 18**. In this screen, all of the indicators **182** through **196** are originally bright green. If, for example, sprinkler heads break off in the rear lawn and the flower beds, those zones can be selectively shut off, pending repairs, by clicking on the labels "Flower Beds" and "Rear Lawn", and then clicking the "Stations Enable/Disable" tab **200**. This causes indicators **186** and **190** to turn red, and causes the PC to send out a signal to the field controller **14** to inhibit operation of zones **3** and **5**.

[0058] The "Cycle and System" tab **202** brings up the screen of **FIG. 19**. Each of the indicators **204** representing zones **1** through **8** is bright green when its zone is running, dark green when it is not, or red when it is disabled. A communication failure condition is indicated in box **205**. Clicking button **206** stops any manual cycle previously programmed in **FIG. 16**. Button **208** stops the currently running zone and advances the cycle to the next selected zone. Button **220** is provided to completely disable the field controller **14** as, e.g., for performing system maintenance. Button **220** has the same function as the No-Watering icon **109** on the menu bar **102**.

[0059] It will be understood that the foregoing description is only one example of a system according to the invention, and that the described system may be modified to cover a variety of situations and requirements within the ambit of the following claims.

We claim:

1. An irrigation control system, comprising:

a) a computer;

b) a field controller linked to said computer for transfer of data therebetween; and

c) a set of water valves arranged to be selectively turned on and off by said field controller;

d) said field controller including a clock, a microprocessor and a memory, said memory being connected to store scheduling data and run time setting data for the operation of said water valves, and said microprocessor being arranged to operate said water valves in accordance with said clock and said data;

e) said computer being programmed to receive from an operator data representing desired watering schedules and run time settings for each water valve of said set, and to selectively transfer said data to said field controller; and

f) said computer being further programmed to present to said operator a graphic of the time of day for a plurality of days, said computer receiving said data from said operator by placing water valve identifying indicia into selected positions on said graphic.

2. The system of claim 1, in which said memory is non-volatile.

3. The system of claim 1, in which said graphic includes:

i) a plurality of time bands extending in a first direction, each time band representing hours of a day, said time bands being juxtaposed in a second direction to represent a series of days.

4. The system of claim 3, in which the current time is indicated by a line extending in said second direction across said time bands.

5. The system of claim 3, in which said graphic further incudes:

ii) a selectably displayable list of indicia representing the water valves of said set, watering schedules of said water valves being placed on said time bands by dragging and dropping indicia from said list onto said time bands in the form of schedule boxes having an edge representative of the start of watering and a width representative of run time.

6. The system of claim 5, in which said graphic includes directional arrows, and said displayed days are selected by clicking said arrows.

7. The system of claim 6, in which said schedule box can be expanded along its time band by dragging a trailing edge of said schedule box.

8. The system of claim 5, in which sets of schedule boxes in one time band can be copied to other time bands.

9. The system of claim 5, in which said graphic is arranged to display, whenever the cursor is placed over a scheduling box, a label showing the identity of the valve involved and its start and run time.

10. The system of claim 5, in which clicking on a schedule box displays a dialog box which allows the parameters of the schedule box to be changed.

11. The system of claim 5, in which said time bands each represent the 24 hours of a day, and said graphic shows seven time bands representing a repeating week.

12. The system of claim 5, in which said time bands are arranged in a series beginning with the current day and ending with the last day of a selectable repetition cycle, the displayed days of said repetition cycle being selectable.

13. The system of claim 12, in which said computer is adapted to send to said field controller scheduling data representing turn-on of a water valve at the time corresponding to a leading edge of a corresponding schedule box, and a turn-off of said water valve at the time corresponding to a trailing edge of said schedule box.

14. The system of claim 5, in which alternate ones of said time bands can be selectively blocked to allow watering only on odd or even days.

15. The system of claim 5, in which said graphic further includes:

iii) watering inhibition indicia which, when clicked, inhibit watering on a specific day with which they are associated.

16. The system of claim 1, in which selectable portions of said graphic can be repeatedly enlarged without affecting the effect of said indicia.

17. The system of claim 1, in which said graphic contains an icon which, if clicked, causes the watering schedule defined by said water valve indicia to be suspended.

18. The system of claim 1, in which said graphic contains an icon which monitors the data link between said computer and said field controller, and signals a failure to receive from said field controller a response to a polling or data transmission by said computer.

19. The system of claim 1, in which said data representing desired watering schedules and run time settings is selectably transmitted to said field controller by clicking a transmit icon on said graphic.

20. An irrigation control system, comprising:

a) a computer;

b) a field controller linked to said computer for transfer of data therebetween; and

c) a set of water valves arranged to be selectively turned on and off by said field controller;

d) said field controller including a clock, a microprocessor and a memory, said memory being connected to store scheduling data and run time setting data for the operation of said water valves, and said microprocessor being arranged to operate said water valves in accordance with said clock and said data;

e) said computer being programmed to receive from an operator data representing desired watering schedules and run time settings for each water valve of said set, and to selectively transfer said data to said field controller; and

f) said computer being further programmed to selectably present to said operator a graphic having a time band representing time in a day, any watering schedule established on said time band being repeated at a selectable interval of days beginning on a selectable day.

21. The system of claim 20, in wich said graphic further includes a calendar for a selectable month, with interval-selected watering days being marked by a watering icon.

22. The system of claim 21, in which watering days can be selectively inhibited, and in which a no-watering icon is substituted for said watering icon on inhibited days.

23. An irrigation control system, comprising:

a) a computer;

b) a field controller linked to said computer for transfer of data therebetween; and

c) a set of water valves arranged to be selectively turned on and off by said field controller;

d) said field controller including a clock, a microprocessor and a memory, said memory being connected to store scheduling data and run time setting data for the operation of said water valves, and said microprocessor being arranged to operate said water valves in accordance with said clock and said data;

e) said computer being programmed to receive from an operator data representing desired watering schedules and run time settings for each water valve of said set, and to selectively transfer said data to said field controller; and

f) said computer being further programmed to selectably present to said operator a graphic representing a selectable global adjustment of the run times of all said water valves programmed into said computer.

24. An irrigation control system, comprising:

a) a computer;

b) a field controller linked to said computer for transfer of data therebetween; and

c) a set of water valves arranged to be selectively turned on and off by said field controller;

d) said field controller including a clock, a microprocessor and a memory, said memory being connected to store scheduling data and run time setting data for the operation of said water valves, and said microprocessor being arranged to operate said water valves in accordance with said clock and said data;

e) said computer being programmed to receive from an operator data representing desired watering schedules and run time settings for each water valve of said set, and to selectively transfer said data to said field controller; and

f) said computer being further programmed to present to said operator a graphic in the form of a dedicated spreadsheet which, upon entry of the flow rate of each said water valve and the cost data of a known water consumption, calculates and displays the water use and cost of the irrigation schedule using said desired watering schedules.

25. An irrigation control system, comprising:

a) a computer;

b) a field controller linked to said computer for transfer of data therebetween; and

c) a set of water valves arranged to be selectively turned on and off by said field controller;

d) said field controller including a clock, a microprocessor and a memory, said memory being connected to store scheduling data and run time setting data for the operation of said water valves, and said microprocessor being arranged to operate said water valves in accordance with said clock and said data;

e) said computer being programmed to selectively transfer run time data to said field controller; and

f) said computer being further programmed to present to said operator a selectable set of graphics presenting indicia which, when clicked, manually disable or run selectable ones of said water valves.

26. An irrigation control system, comprising:

a) a computer;

b) a field controller linked to said computer for transfer of data therebetween;

c) a set of water valves arranged to be selectively turned on and off by said field controller;

d) said field controller including a clock, a microprocessor and a memory, said memory being connected to store scheduling data and run time setting data for the operation of said water valves, and said microprocessor being arranged to operate said water valves in accordance with said clock and said data;

e) said computer being programmed to receive from an operator data representing desired watering schedules and run time settings for each water valve of said set, and to selectively transfer said data to said field controller; and

f) said computer being further programmed to present to said operator a graphic of the time of day for a plurality of days, said computer receiving said data from said

operator by placing water valve identifying indicia into selected positions on said graphic; and

g) a remote linked to said field controller for transmitting commands thereto;

h) said remote including means for transmitting to said field controller only manual operation and disabling commands.

27. An irrigation control system, comprising:

a) a computer;

b) a field controller releasably linkable to said computer for transfer of data therebetween; and

c) a set of water valves arranged to be selectively turned on and off by said field controller;

d) said field controller being a free-standing unit including a clock, a microprocessor and a memory, said memory being connected to store scheduling data and run time setting data for the operation of said water valves, and said microprocessor being arranged to operate said water valves in accordance with said clock and said data regardless of whether said field controller is linked to said computer;

e) said computer being programmed to receive from an operator data representing desired watering schedules and run time settings for each water valve of said set, and to selectively transfer said data to said field controller memory when said field controller and computer are linked.

28. The system of claim 27, wherein said computer is linked to said field controller by a radio link.

29. The system of claim 28, wherein said data being transferred to said field controller includes an access code for allowing said field controller to accept said transferred data from any computer cognizant of said access code.

30. The system of claim 27, wherein said field controller is polled continually by said computer while linked thereto to inform said computer of the status of said field controller, and said clock is synchronized with the clock of said computer only as part of a schedule data transmission to or from said field controller.

31. The system of claim 30, wherein said computer displays said status of said field controller unless said data has been modified on said computer but has not yet been transmitted to said field controller.

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