US 20020189983A1

(19) **United States**

(12) **Patent Application Publication** (10) **Pub. No.: US 2002/0189983 A1**

Guess et al. (43) **Pub. Date: Dec. 19, 2002**

(54) **WATER FILTER MONITORING AND INDICATING SYSTEM**

(76) Inventors: **Ronald W. Guess**, Evansville, IN (US); **Dale A. Beard**, Dayton, OH (US); **Patrick J. Glotzbach**, St. Joseph, MI (US); **Keith A. Snyder**, Evansville, IN (US)

Correspondence Address:
MCGARRY BAIR LLP
171 MONROE AVENUE
SUITE 600
GRAND RAPIDS, MI 49503 (US)

(21) Appl. No.: **10/064,026**

(22) Filed: **Jun. 4, 2002**

Related U.S. Application Data

(60) Continuation of application No. 10/115,849, filed on Apr. 3, 2002, which is a division of application No. 09/605,776, filed on Jun. 28, 2000, now Pat. No. 6,375,834.

(60) Provisional application No. 60/141,693, filed on Jun. 30, 1999.

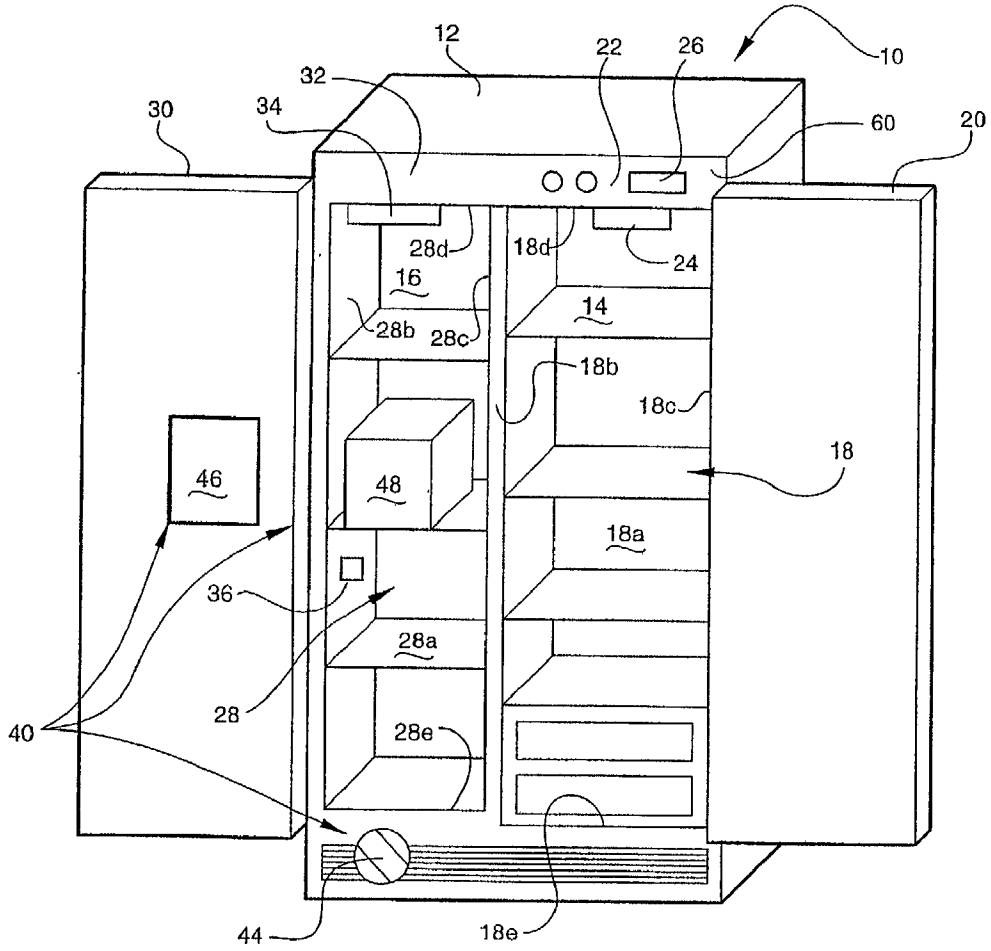
Publication Classification

(51) **Int. Cl.**[7] **B01D 35/14**

(52) **U.S. Cl.** **210/87**; 210/109; 210/134; 210/143; 210/175; 62/177; 62/389

(57) **ABSTRACT**

A method and apparatus for determining when a replaceable filter for a refrigerator needs replacing based on the volume of water passing through the water filter as determined by the product of the time that water has passed through the filter and the flow rate of an accessory being supplied the filtered water.



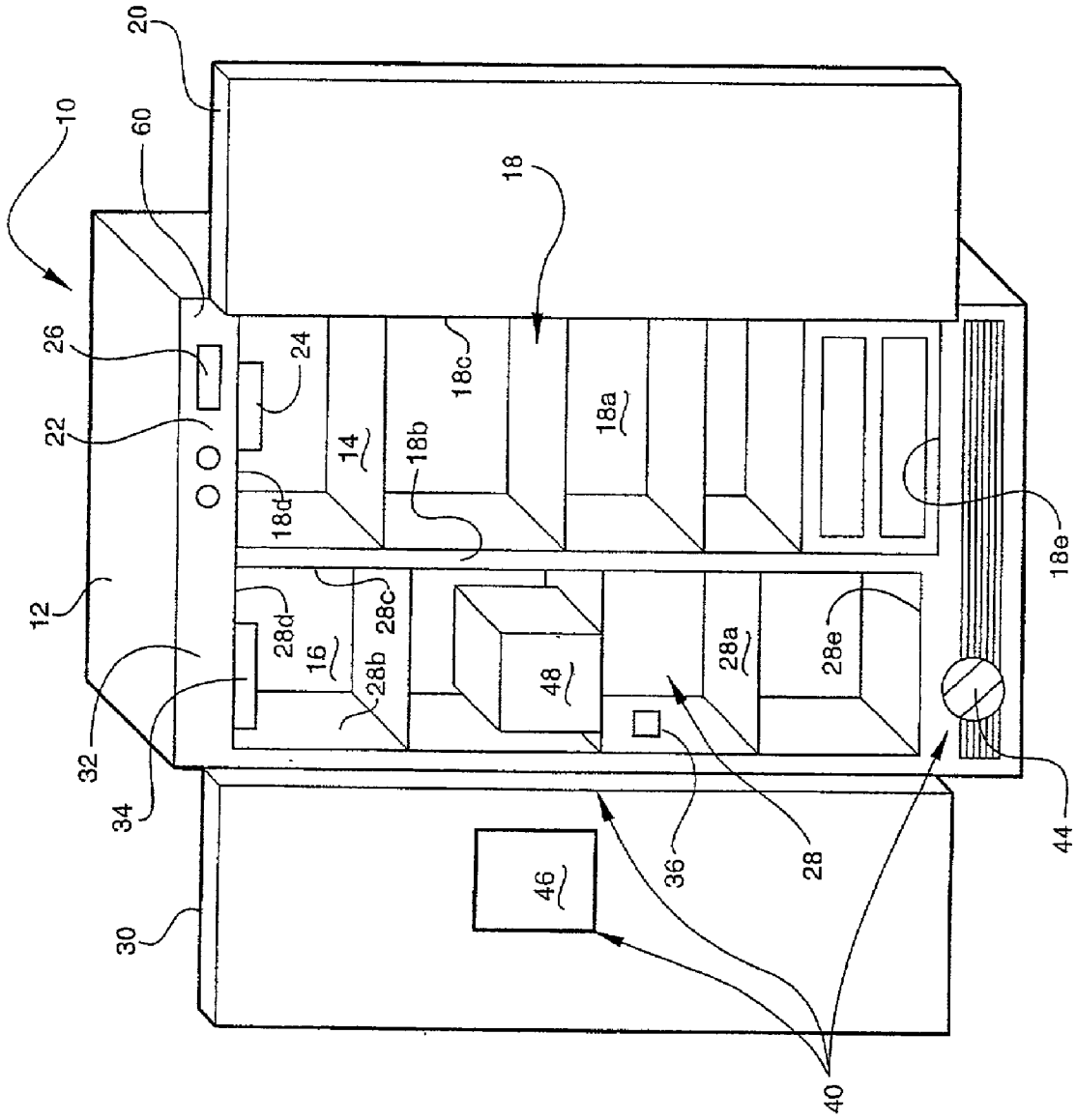

20
10
60
18
26
24
22
18c
14
18b
18a
18d
18e
12
28d
16
28c
28b
48
28a
28e
32
34
36
28
44
46
30
40

Fig. 1

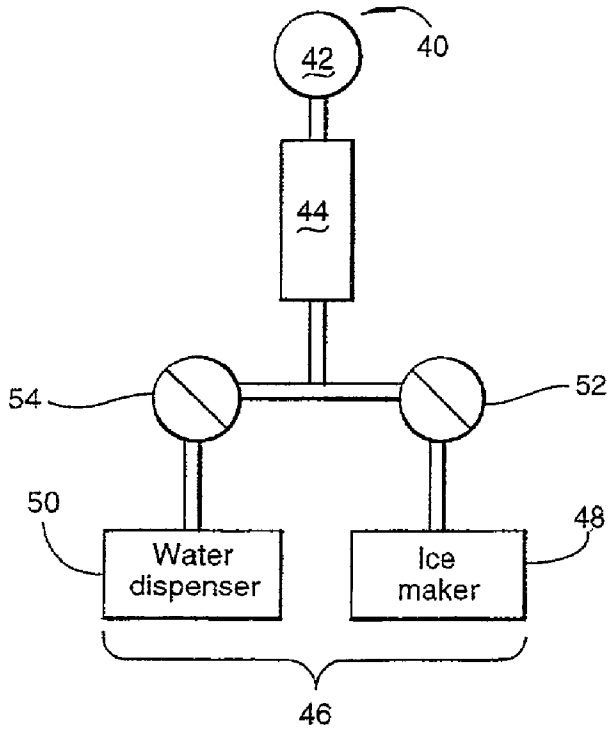

42
40
44
54
52
50
48
Water dispenser
Ice maker
46

Fig. 2

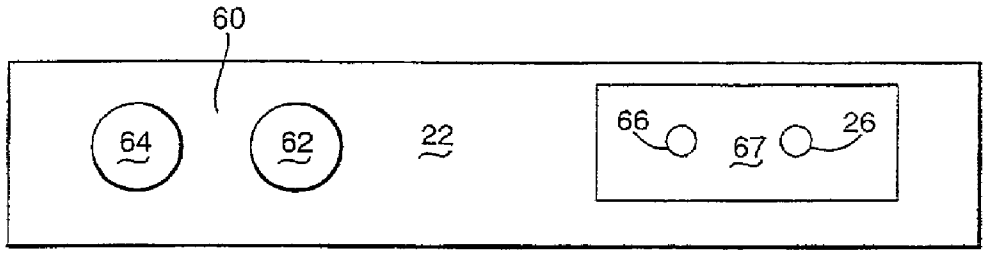

60
64
62
22
66
67
26

Fig. 3

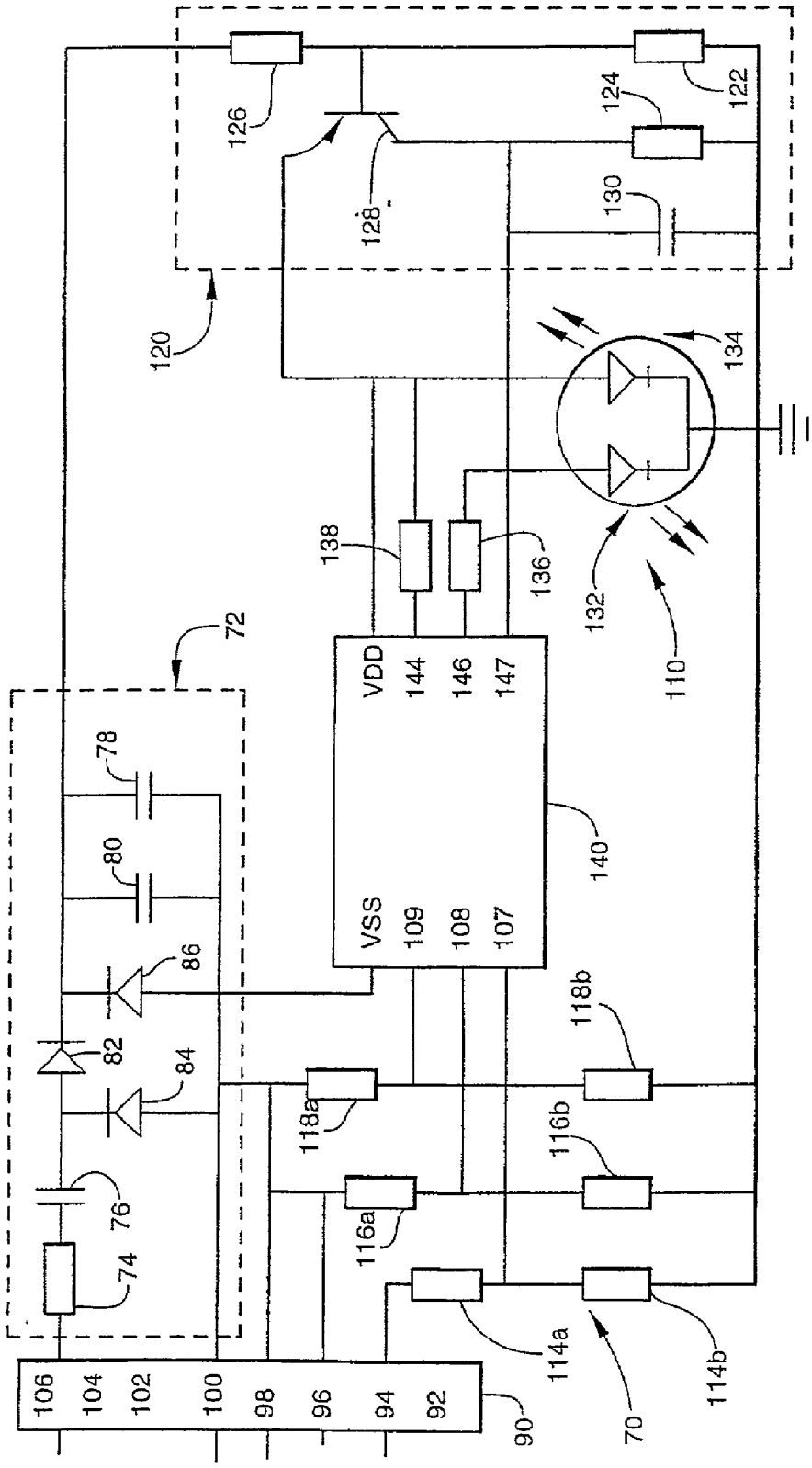

126
128
124
122
130
120
134
138
136
132
110
72
VDD
144
146
147
140
VSS
109
108
107
78
80
86
82
84
76
74
118b
118a
116b
116a
114a
114b
70
106
104
102
100
98
96
94
92
90

Fig. 4

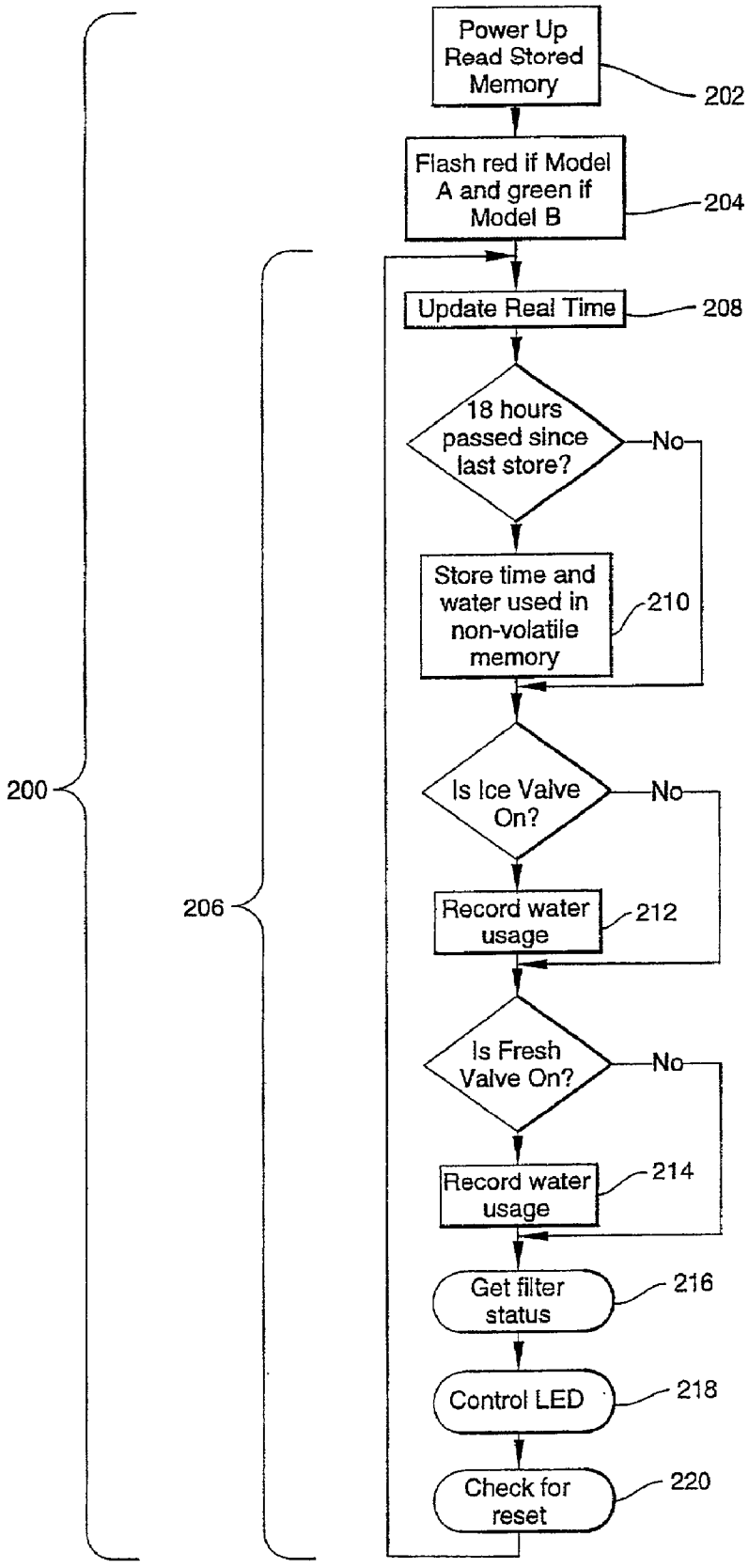

Power Up Read Stored Memory
202
Flash red if Model A and green if Model B
204
Update Real Time
208
18 hours passed since last store?
No
Store time and water used in non-volatile memory
210
Is Ice Valve On?
No
Record water usage
212
Is Fresh Valve On?
No
Record water usage
214
Get filter status
216
Control LED
218
Check for reset
220
200
206

Fig. 5

Fig. 6

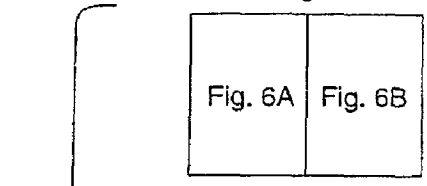
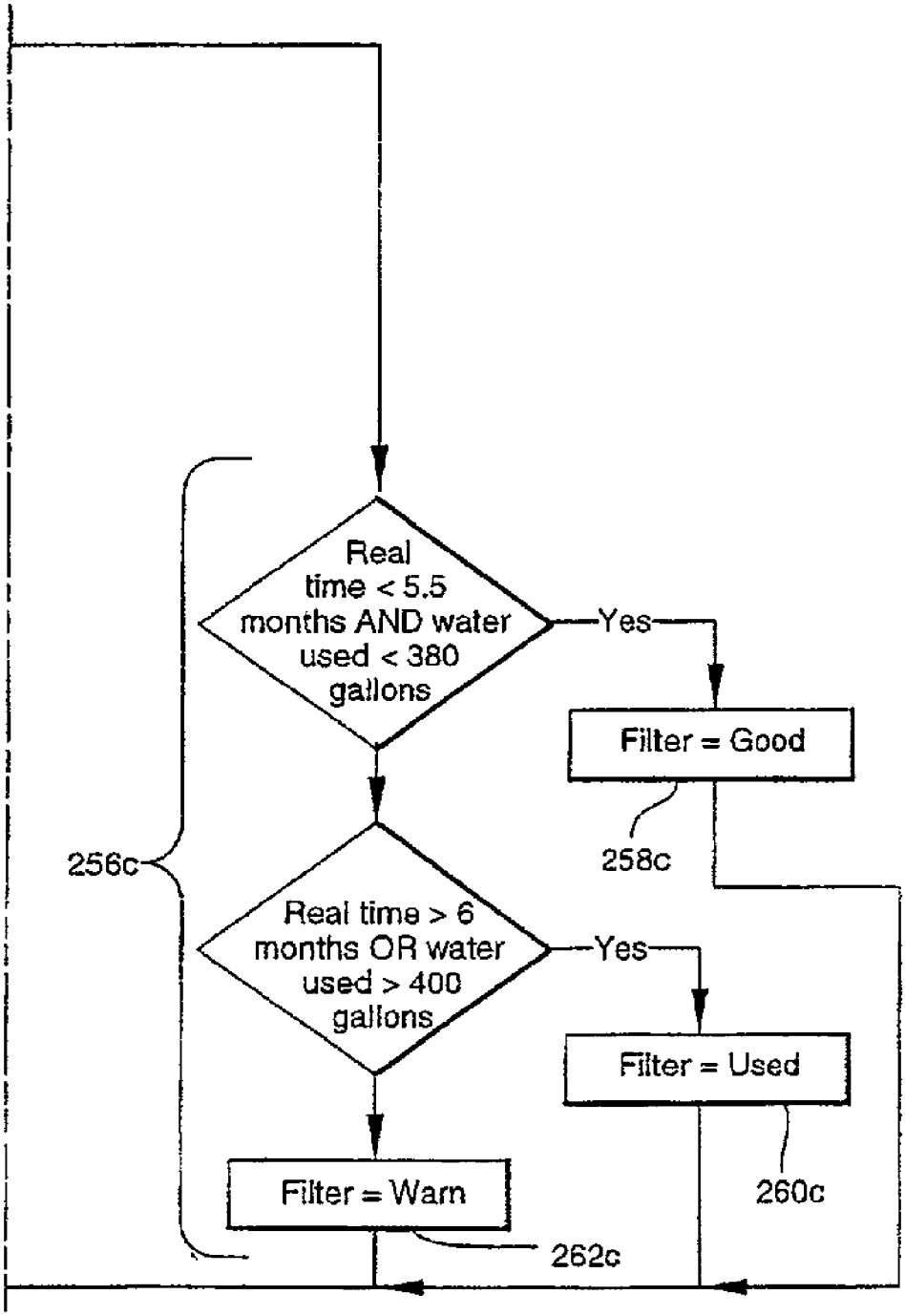


Fig. 6A
Fig. 6B

Fig. 6A

Get filter status
252
Is Control a Model C?
No
254
Is filter a Model A?
No
Real time < 11 months AND water used < 450 gallons
Yes
258a
Filter = Good
256a
256b
Real time > 12 months OR water used > 500 gallons
Yes
Filter = Used
Filter = Warn
260a
262a
Real time < 11 months AND water used < 380 gallons
Yes
Filter = Good
258b
Real time > 12 months OR water used > 400 gallons
Yes
Filter = Used
260b
Filter = Warn
262b
250
Current status = last status
Yes
269
Store time and water used in non-volatile memory
Done

Fig. 6B


Real time < 5.5 months AND water used < 380 gallons
Yes
Filter = Good
258c
256c
Real time > 6 months OR water used > 400 gallons
Yes
Filter = Used
260c
Filter = Warn
262c

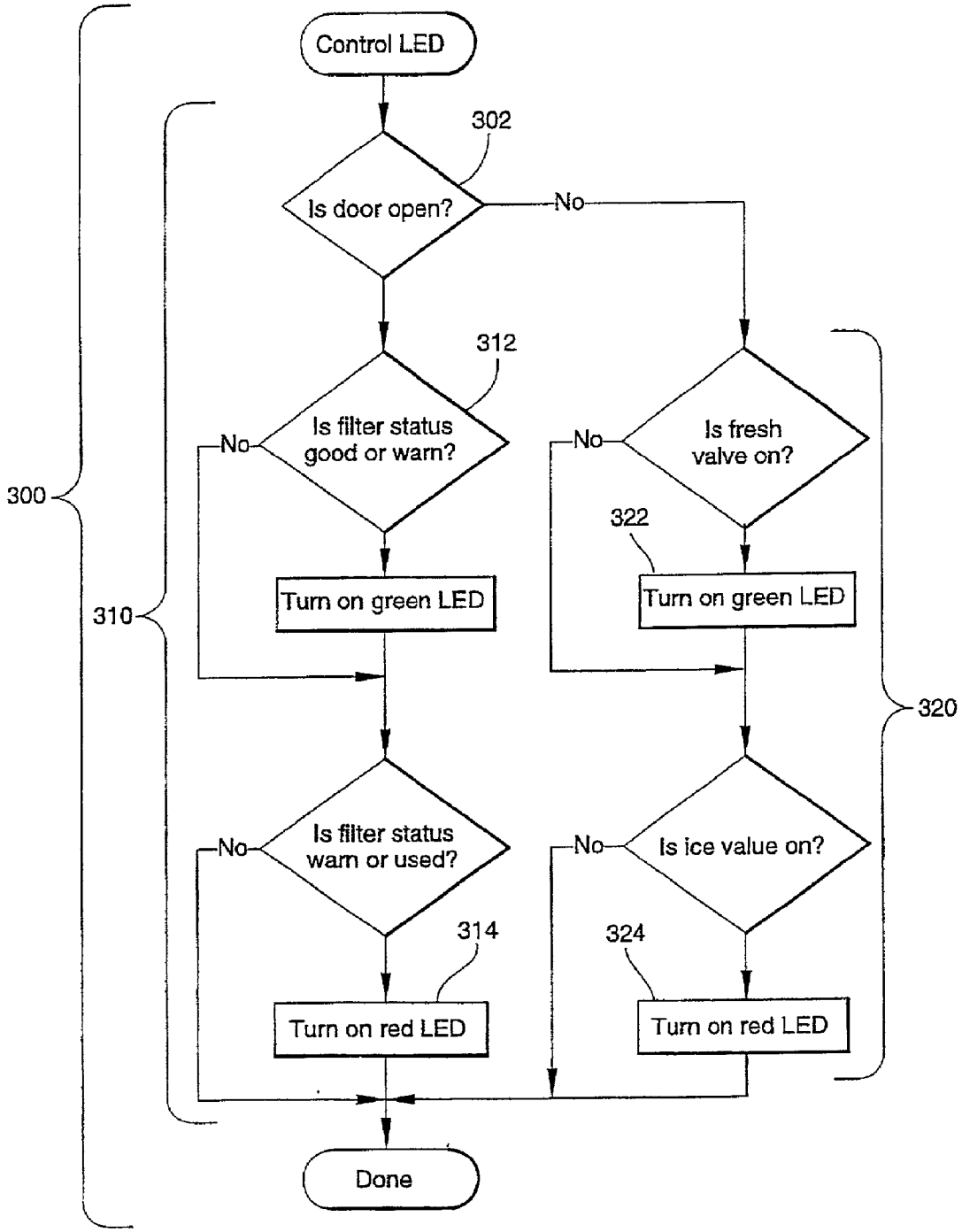

Control LED
302
Is door open?
No
312
Is filter status good or warn?
No
Turn on green LED
Is fresh valve on?
No
322
Turn on green LED
Is filter status warn or used?
No
314
Turn on red LED
Is ice value on?
No
324
Turn on red LED
Done
300
310
320

Fig. 7

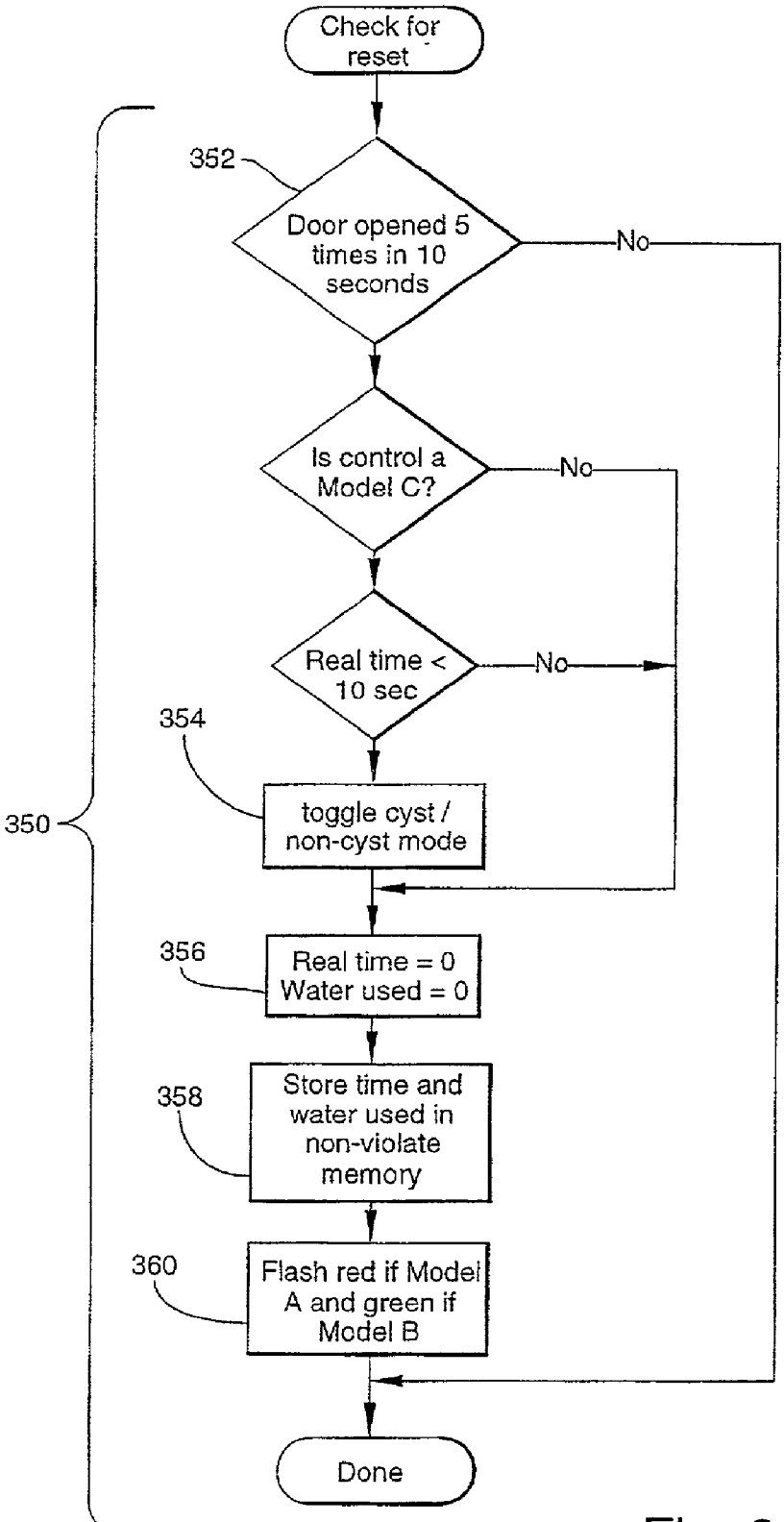

Check for reset
352
Door opened 5 times in 10 seconds
No
Is control a Model C?
No
Real time < 10 sec
No
354
toggle cyst / non-cyst mode
350
356
Real time = 0 Water used = 0
358
Store time and water used in non-violate memory
360
Flash red if Model A and green if Model B
Done

Fig. 8

WATER FILTER MONITORING AND INDICATING SYSTEM

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application is a continuation of U.S. patent application Ser. No. 10/115,849, filed Apr. 3, 2002, which claims priority from U.S. patent application Ser. No. 09/605,776 filed Jun. 28, 2000, now U.S. Pat. No. 6,375,834, issued Apr. 23, 2002, which is a non-provisional of provisional application No. 60/141,693 filed Jun. 28, 1999, now expired.

BACKGROUND OF INVENTION

[0002] 1. Field of the Invention

[0003] The invention relates to a refrigerator with a water filtration system having a replaceable filter. More specifically, the invention relates to a device for indicating when the replaceable filter is ready to be replaced.

[0004] 2. Description of the Related Art

[0005] Many refrigerators, and especially those using a side-by-side configuration wherein the fresh food compartment is to the side of the frozen food compartment, include integrated ice and water delivery systems. Typically, such systems deliver water and ice through the door of the frozen food compartment to a ice and water station recessed in the door.

[0006] Examples of such systems can be seen in U.S. Pat. No. 5,907,958 issued Jun. 1, 1999 to Coates , et al. and entitled "Refrigerator water filter"; U.S. Pat. No. 5,813,245 issued Sep. 29, 1998 to Coates , et al. and entitled "Pressure relief circuit for refrigerator contained water filter"; U.S. Pat. No. 5,715,699 issued Feb. 10, 1998 to Coates , et al. and entitled "Refrigerator water filter"; U.S. Pat. No. 5,707,518 issued Jan. 13, 1998 to Coates , et al. and entitled "Refrigerator water filter"; U.S. Pat. No. 5,135,645 issued Aug. 4, 1992 to Sklenak , et al. and entitled "Refrigerator water filter"; and U.S. Pat. No. 3,982,406 issued Sep. 28, 1976 to Hanson , et al. and entitled "Refrigerator water storage and dispensing system with water filter".

[0007] Increasingly such systems incorporate a filtration system with a replaceable filter element or cartridge so as to improve the quality of the ice and water delivered to the user of the refrigerator. Since the filters must be periodically replaced to maintain the quality of the water, various methods and apparatus could be used to notify the user of the need to change the filter. However, such many potential approaches would be costly, complex and inflexible as to substitution of different types of filters having different useful lives. Furthermore, in an effort to such reduce cost, many such approaches fail to give the user advance warning that the filter will soon need to replaced.

[0008] What is needed, therefore, is a filter monitoring and indicating system that is flexible enough to permit its use with different types of filters yet doesn't add the cost of requiring an additional switch or sensor for detecting the type of filter being used.

[0009] What is further needed is an inexpensive filter monitoring and indicating system that not only informs the user that filter needs to be replaced, but provides earlier warning that the filter will need to be replaced soon and therefore a new filter needs to purchased.

SUMMARY OF INVENTION

[0010] In one aspect, the invention relates to a water supply system in a refrigerator comprising an ice maker and a water dispenser for delivering filtered water from a water source to the ice maker and the water dispenser. The water supply system comprises a replaceable filter that is fluidly coupled to the ice maker and water dispenser by a filtered-water conduit and adapted to be coupled to a water source by a water source conduit. The replaceable filter has an inlet for receiving water from the water source through the water source conduit and an outlet for outputting filtered water to the ice maker and water dispenser through the filtered-water conduit. The water supply system further comprises a filter status unit that determines the status of the filter based on the volume of the filtered water demanded by the ice maker and water dispenser.

[0011] The filter status unit comprises a water volume meter for determining the volume of filtered water outputted by the water filter for each demand of water. A summing device is provided for maintaining an accumulated filtered-water volume based on the filtered-water volume determined by meter for each demand. An indicator signals when the accumulated filtered-water volume reaches a threshold value indicative of the need to replace the water filter.

[0012] The water supply system further includes a valve that that is fluidly connected to the filtered-water conduit to control the flow of water through the filtered-water conduit to one of the ice maker and water dispenser. A second valve can be provided that is fluidly connected to the filtered-water conduit to control the flow of water through the filtered-water conduit to the other of the ice maker and water dispenser.

[0013] The water volume meter preferably comprises a timer and a data processor. The timer determines the duration of each demand for water by either the water filter or the water dispenser. The data processors used for calculating the filtered-water volume for each demand are based on the duration of each demand. The data processor preferably includes a memory in which is stored a flow rate for least one of the ice maker and water dispenser. The water volume can be calculated by the data processor by determining the product of the duration and the flow rate. The memory can include a flow rate for each of the water filter and the water dispenser. The data processor selects the proper flow rate depending on which of the ice maker and the water dispenser is demanding water.

[0014] A sensor can be provided to determine when the water is flowing from the water filter to the one of the ice maker and water dispenser. The sensor preferably includes an electrically actuated valve for controlling the flow of water from the water filter to the one of the ice maker and water dispenser.

[0015] The timer preferably comprises a clock that is coupled to the data processor. The data processor uses the clock to determine the elapsed time that water flows from the water filter to the one of the ice maker and water dispenser as sensed by the sensor.

[0016] The summing device preferably comprises a portion of the memory of a microprocessor in which is stored an accumulated filtered water value.

[0017] The indicator comprises at least one of a visual and audible indicator. The indicator also preferably comprises a portion of the processor memory in which is stored a threshold value for the filter. The data processor compares the accumulated filtered water value to the threshold value to determine the status of the filter and activates the at least one of the visual and audible indicators when the filtered-water volume reaches the threshold value.

[0018] In another aspect, the invention relates to a refrigerator comprising a cabinet having a fresh food compartment with an open face and a freezer compartment with an open face. A first door is mounted to the cabinet for selectively closing the open face of the fresh food compartment. Similarly, a second door is mounted to the cabinet for selectively closing the open face of the freezer compartment. At least one water-using accessory is provided with the refrigerator. The replaceable water filter having an inlet adapted to be fluidly connected to a supply of household water and an outlet fluidly connected to the at least one water-using accessory provides for the supply of filtered water from the household supply to the at least one water-using accessory. A filter status unit is provided and indicates the replacement status of the replaceable water filter based on the accumulated volume of filtered water supplied by the replaceable water filter.

[0019] The water-using accessory is preferably one of a water dispenser or an ice maker. The at least one water-using accessory can include both the water dispenser and ice maker. A valve can be provided for fluidly connecting at least one of the water dispenser and ice maker to the replaceable filter. Similarly, a second valve can be provided for fluidly connecting the other of the at least one of the water dispenser and ice maker to the replaceable filter.

[0020] The filter status unit further comprises a timer that determines the duration of elapsed time that filtered water is supplied from the replaceable filter. A filter-water volume calculator is also provided and calculates the filter-water volume based on the determined duration and the flow rate of the filtered water to the at least one water-using accessory. The timer preferably determines a duration for each supply of the filtered water to the at least one water-using accessory. The filter-water volume calculator calculates a corresponding filter-water volume for each supply. The filter status unit can further comprise a filtered-water volume summing device that sums the calculated filter-water volumes for each supply to determine the accumulated volume of filtered water.

[0021] The filter status unit can further comprise a microprocessor having a memory and a clock that is coupled to the microprocessor. The microprocessor and the clock form the timer to determine the duration of each supply. The microprocessor forms the filter-water volume calculator by multiplying the duration by a flow rate stored in the memory. The microprocessor also forms the summing device by calculating and storing the memory of the value corresponding to the accumulated volume of filtered water. If the refrigerator has multiple water-using accessories, a flow rate for each of the accessories can be stored in the memory and the microprocessor selects the appropriate flow rate to calculate the water volume supplied by the replaceable filter.

[0022] In yet another aspect, the invention relates to a filter status unit for use in a refrigerator comprising at least one water-using accessory with a replaceable filter coupled to a water supply and a water supply system for delivering filtered water from the replaceable filter to the at least one water-using accessory.

[0023] The filter status unit comprises a timer, filter-water volume calculator, and a filtered-water volume summing device. The timer determines the duration of time that filtered water is supplied from the replaceable filter to the at least one water-using appliance. The filter-water volume calculator calculates the filtered-water volume based on the determined duration and the flow rate of the filtered water to the at least one water-using accessory. The summing device maintains an accumulated filtered-water volume based on the calculated filtered-water volume.

[0024] These and other advantages of the present invention will become apparent to those skilled in the art when the following detailed description of the preferred embodiment is read in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF DRAWINGS

[0025] **FIG. 1** is a front perspective view of a refrigerator apparatus having a water filtration and filter control and indicator system embodying the present invention.

[0026] **FIG. 2** is a schematic diagram of the ice and water assembly of the refrigerator apparatus of **FIG. 1**.

[0027] **FIG. 3** is a fragmentary enlarged front view of the refrigerator control console of the refrigerator of **FIG. 1**.

[0028] **FIG. 4** is a schematic electrical diagram illustrating the electrical circuitry of the filter control and indicator system of **FIG. 1**.

[0029] **FIG. 5** is a flow chart illustrating the programming and logic of the filter control and indicator system of **FIGS. 1 and 4** and more particularly illustrates the power-up and main subroutines of the filter control and indicator system.

[0030] **FIG. 6** is a flow chart illustrating the filter status subroutine of the main subroutine of **FIG. 5**.

[0031] **FIG. 7** is a flow chart illustrating the indicator subroutine of the main subroutine of **FIG. 5**, including the indicator subroutine and the diagnostics subroutine.

[0032] **FIG. 8** is a flow chart illustrating the reset subroutine of the main subroutine of **FIG. 5**.

DETAILED DESCRIPTION

[0033] The Refrigerator

[0034] In the illustrative embodiment of the invention as shown in **FIG. 1 a** refrigerator **10**, comprising a side-by-side fresh food/freezer configuration, is provided having a cabinet **12** forming fresh food compartment **14** and freezer compartment **16**.

[0035] The fresh food compartment **14** is provided with an access opening **18** and a fresh food door **20** hingedly mounted to the cabinet **12** for selectively closing the access opening **18**. The access opening **18** has a back wall **18***a*, side walls **18***b* and **18***c*, top wall **18***d*, and a bottom wall **18***e*. The refrigerator **10** also has a partial front wall **22** disposed around the perimeter of the access opening **18** parallel to and selectively engageable with the fresh food door **20** for sealing the access opening **18**.

[0036] The fresh food compartment **14** is further provided with a light **24** which is connected in series with a light switch **26**. The light switch **26** is a reciprocable switch actuated to selectively connect the light **24** with a source of electrical power, not shown, when the door **20** is in an open position and to disconnect the light **24** from the source of electrical power when the fresh food door **20** is in the closed position. In the preferred embodiment, the light switch is located in portion of the partial front wall **22** above the top wall **18***d* of the access opening.

[0037] Similarly, the freezer compartment **16** is provided with an access opening **28** and a freezer door **30** hingedly mounted to the cabinet **12** for selectively closing the access opening **28**. The access opening **28** has a back wall **28***a*, side walls **28***b* and **28***c*, top wall **28***d*, and a bottom wall **28***e*. The refrigerator **10** also has a partial front wall **32** disposed around the perimeter of the access opening **28** parallel to and selectively engageable with the freezer door **30** for sealing the access opening **28**. The freezer compartment **14** is further provided with a rocker-type light **34** which is connected in series with a light switch **36** functionally similar to the light **24** and light switch **36** in the fresh food compartment **14**.

[0038] As is further well known in the art, the refrigerator **10** is provided with a water and ice supply system **40**, shown schematically in **FIG. 2** for delivering water from an external source **42** through a filter **44** to an ice and water delivery system **46**.

[0039] The filter **44** may be mounted to the refrigerator below the bottom wall **28***e* of the access opening **28** and accessed for servicing by selective removal through an opening through the lowermost portion of the partial front wall **32**, as shown in **FIG. 1**.

[0040] The ice and water delivery system **46** includes an ice making assembly **48** mounted within the freezer compartment **16** and an ice and water dispensing system **50** mounted in the freezer door **30**.

[0041] The ice making assembly **48** is mounted to the inside surface of the back wall **28***a* of the freezer compartment **16**. The ice and water dispensing system **50** is provided below the ice making assembly **48** for receiving ice pieces therefrom as well as for receiving cool water from a water supply system **40**. As shown in **FIG. 2**, the water and ice supply system **40** includes electrically operable water valves **52** and **54** for supplying water, respectively, to the ice making assembly **48** and the ice and water dispensing system **50**.

[0042] The ice and water dispensing system **50** includes an ice storage receptacle or bin **56**. When operated, the ice and water dispensing system **50** transfers ice pieces from the ice storage receptacle or bin **56** through the freezer door **30** whereby ice pieces may be dispensed through a conventional, forwardly exposed ice dispenser station or external ice service area **58**.

[0043] In the preferred embodiment of the present invention, a refrigerator control console **60** is defined on an upper portion of the partial front wall **22** of the fresh food compartment **16** in the vicinity of the light switch **26**. The refrigerator control console **60**, which is shown integral with the front wall **22**, includes a fresh food compartment temperature control switch **62**, a freezer compartment temperature control switch **64**, the light switch **26**. In the vicinity of the light switch **26**, the refrigerator control console also includes a filtration system status indicator **66**, described later in detail. The refrigerator control console **60** further incorporates a consumer label **67** surrounding the switch **26** and the indicator **66** on which is printed the following written matter describing the operation of the filter **44** and the meaning of the status indicator **66**:

"EZ-CHANGE SIGNAL	FILTER INDICATOR RESET
Green = Good Filter Yellow = Order Filter Red = Change Filter	Push the light switch 5 times in 10 seconds to reset filter indicator to green."

[0044] Components of the Water Filter Status Monitoring & Indicating System

[0045] Referring now to the **FIG. 4**, the Refrigerator **10** includes a water filter status monitoring and indicating system **70**. The water filter status monitoring and indicating system **70** includes a power supply **72** comprising resistor **74**, capacitors **76**, **78** and **80** and diodes **82**, **84**, and **86** in a conventional capacitive drop design with capacitor **76** as the charge pump device, diode **82** as the rectifier. Diode **84** provides noise suppression and functions as a clamping diode. Diode **86** (5.1V, 500 mW) is a zener diode used as a simple voltage regulator. Capacitor **80** functions as the reservoir capacitor and capacitor **78** provides high frequency bypass. Resistor **74** is critical to line surge performance of the overall circuit since it absorbs most of the pulse energy.

[0046] The water filter status monitoring and indicating system **70** has an input connector **90** with three identical discrete digital inputs **94**, **96** and **98**, respectively, for monitoring the light switch **26** and the water valve electrical input of water valve **54** associated with the water dispenser of the ice and water dispensing system **50**, and the water valve electrical input of water valve **52** associated with the ice making apparatus **48**. These inputs are designed for 120V (RMS) signals directly from the monitored loads. Each of these inputs has an identical input resistive divider network respectively comprised of pairs of resistors **114***a*, **114***b*, **116***a*, **116***b*, **118***a* and **118***b*. Each resistor pair, **107**, **108** and **109**, can also be viewed as a series device to limit current into the microprocessor input pin, respectively, to the microprocessor device **140** described later, and a shunt device to provide input pull-down to a known state when the associated load is not activated.

[0047] The input connector **90** further has inputs **100** and **106** respectively connected to the neutral and the hot lines of the AC power supplied to the refrigerator **10**. Inputs **92**, **102** and **104** of the input connector **90** are not used.

[0048] The water filter status monitoring and indicating system **70** also has a power-on reset circuit **120** comprised of resistors **122**, **124** and **126**, transistor **128**, and capacitor **130**. Resistors **122** and **126** set the reset threshold voltage and provide base drive for the transistor **128**, and, in turn provides a pull-up voltage to master clear input **147**. Resistor **124** is a passive pull-down to the master clear input **147** of the microprocessor device **140** when VDD is low which establishes a valid logic low when VDD is below the threshold. Capacitor **130** provides filtering for high frequency noise and transients.

[0049] The water filter status monitoring and indicating system **70** further includes the filtration system status indicator **66**, which in the preferred embodiment consists of a bi-color device **110** containing a red LED die **132** and a green LED die **134**.

[0050] The microprocessor device **140** provides all logic functionality and memory. In addition to red and green, the color amber can be achieved by alternating resistors **136** and **138** by providing alternating signals from microprocessor output pins **144** and **146**.

[0051] Microprocessor device **140** is preferably a Microchip PIC12CE518 device, which contains 512 words of program ROM (implemented as OTP EPROM) and includes a 16 by 16 EEPROM.

[0052] The specifications of the preferred components of the water filter status monitoring and indicating system **70** are as follows:

Component	Reference numeral	Specifications
	72	
	74	
	76	
	78	
	80	
	82	
	84	
	86	
	88	
	90	
	92	
	94	
Resistor	114a	
Resistor	114b	
Resistor	116a	
Resistor	116b	
Resistor	118a	
Resistor	118b	
	110	
	112	
	114	
	116	
	118	
	120	
	122	
	124	
	126	
	128	
	130	
	132	
	134	
	136	
	138	

[0053] Programming Logic of the Water Filter Status Monitoring & Indicating System

[0054] **FIG. 5** through **FIG. 8** illustrate the programming and logic of the water filter status monitoring and indicating system **70** which is programmed into the microprocessor device **140**. The Logic is intended to provide programming for alternative models, such as an A model refrigerator a B model refrigerator or a C model refrigerator, each having different functionality. The various models may have different replacement criteria for the filters depending on the gallon rating and the useful life of the filter.

[0055] Referring to **FIG. 5**, when the power is first supplied to the microprocessor device **140**, a Power-up Subroutine **200** is initiated. At step **202**, the microprocessor device reads the stored memory. At Step **204**, the microprocessor device **140** sends a signal to the indicator **66** to flash red if the refrigerator is a Model A and green if it is a model B.

[0056] The microprocessor device **140** then enters a continuously repeated main subroutine **206**. Within each repetition of main subroutine **206**, microprocessor device **140** updates its clock at step **208** and, once every 18 hours, stores the time and water used in the non-volatile memory at step **210**. At steps **214** and **216**, respectively, the amount of water used is incremented if the ice valve **52** is open or if the fresh water valve **54** is open. The open time for each valve **52** and **54** is weighted for the normal water flow rate associated with the valve. At steps **216**, **218** and **220**, respectively, the microprocessor calls the filter status subroutine **250**, the control subroutine **300** and the reset subroutine **350**, after which the main subroutine **206** repeats.

[0057] Referring to **FIG. 6**, the filter status subroutine **250** determines at steps **252** and **254** whether refrigerator **10** is a model A, B or C and directs the program to one of water usage comparison subroutines **256***a*, **256***b* and **256***c*, respectively for the appropriate model. In each respective water usage comparison subroutine **256***a*, **256***b*, and **256***c*, at respective steps **258***a*, **258***b* and **258***c*, the status of the filter is designated as "good" if less than a first predetermined time period has passed and less than a first predetermined quantity of water has been consumed, as indicated by the information stored in memory since the last reset. In each respective water usage comparison subroutine **256***a*, **256***b*, and **256***c*, at respective steps **260***a*, **260***b* and **260***c*, the status of the filter is designated as "used" if more than a second predetermined time period of usage or more than a second predetermined quantity of water has been consumed since the last reset. In each respective water usage comparison subroutine **256***a*, **256***b*, and **256***c*, at respective steps **262***a*, **262***b* and **262***c*, the status of the filter is designated as "warn" if the status has been set as neither "good" or "used".

[0058] Finally, at step **270**, the time and water used is stored in non-volatile memory if the status of the filter has not been changed by the water usage comparison subroutine **256***a*, **256***b* or **256***c*. The status is not restored if it hasn't changed so as to maximize the useful life of the EEPROM non-volatile memory.

[0059] Referring to **FIG. 7**, the control subroutine **300** determines at step **302** if the fresh food door **20** is open by monitoring the voltage across the fresh food light **24**.

[0060] If the fresh food door **20** is detected as open, then indicator subroutine **310** is run. At step **312**, the green LED die **134** is illuminated if the status of the filter has been saved as "warn" or as "good". At step **314**, the red LED die **132** is illuminated if the status of the filter has been saved as "warn" or as "used". Thus, if the status has been saved as "warn", both LED die are alternatingly illuminated and the status indicator **66** appears amber in color.

[0061] The alternating signal of red and green is created by step **312** always turning off the green die, off if it is on, and, after a built-in time delay by having step **314** always turn off the red die, if it is on. After a subsequent time delay, the programming again returns to step **312**, turning off the red LED and turning on the green LED.

[0062] If the fresh food door **20** is detected as closed, then diagnostic subroutine **320** is run. At step **312**, the green LED die is illuminated if the water dispenser valve **54** is open . At step **324**, the red LED die is illuminated if the water valve **52** to the ice making apparatus **48** is open. If both valves **52** and **54** are open, both LED die are illuminated and the status indicator **66** appears amber. The diagnostic subroutine **320** permits detection of malfunctions of the water valves **52** and **54** or the water filter status monitoring and indicating system **70** by a service technician manually by depressing the light switch **26** and selectively operating the valves **52** or **54**, the service technician can isolate faults in the system.

[0063] Referring to **FIG. 8**, the reset subroutine **350** determines at step **352** if the light switch **26** has been depressed 5 times in less than ten seconds, indicating the user is sending a reset instruction to the microprocessor device **140**. The user should do this when the filter is replaced. If a reset instruction has been detected at step **352**, then the time and water usage counters are reset to zero at step **356** and stored to non-volatile memory at step **358**. However, if the system has already been reset, within the last 10 seconds, that is, a reset instruction has been sent twice, then, at step **354**, the microprocessor device reads the input as an instruction that a different type of filter is being used and changes the model setting from a model A to a model B. Finally, at step **360**, the indicator is illuminated red or green to indicate the model setting.

[0064] Operation of the Water Filter Status Monitoring & Indicating System Components

[0065] The purpose of the water filter indicator is to provide the consumer with a reliable measure of the filter cartridge end of life condition. There are two criteria for end of life, namely a prescribed number of gallons or a fixed period of real time. In order to monitor the water flow, the electrical inputs to both the ice maker valve and the dispenser valve are monitored by the WFI. Since the processor "knows" that the valves have flow rates of 0.3 and 0.5 gallons per minute, the flow can be computed from the amount of time which each is energized. It is in this fashion that the usage in gallons is accumulated.

[0066] Real time is simply accumulated by a divider from the processors clock. Since the clock used in this case is the internal RC oscillator, it is subject to more inaccuracy than would be experienced with a crystal controlled or 60 Hz based time keeping scheme. The Microchip literature guarantees this tolerance to be about 7.0% over voltage and temperature **4** variations. Also included in the microprocessor is an EEPROM device, which provides non-volatile retention of flow as well as real time.

[0067] The state of the water filter is indicated on a bi-color LED incorporating a red and a green die in the same package. By activating both die at a 50% duty cycle an amber color is obtained. Up to 90% life the indicator is green, from 90% to just less than 100% it is amber, and at end of life it shows red. User reset of the accumulated flow and time variables is effected by activating the door switch five times within 5 seconds.

[0068] In order to facilitate factory test as well as servicing in the field, the LED displays usage status only when the door is open. When the door is closed, the LED is off unless one or both of the valve inputs is active. The LED indicates red for the ice maker valve, green for the dispenser valve and amber if both valves are active.

[0069] The above constitutes a detailed description of the best mode of the present invention as contemplated by the inventors at the time of filing. It is further contemplated that changes and modifications may be made from the best mode described herein within without departing from the spirit of the present invention or the intended scope of the claims below.

1. in a refrigerator comprising an ice maker and a water dispenser, a water supply system for delivering filtered water from a water source to the ice maker and water dispenser, the water supply system comprising:

a replaceable water filter having an inlet for receiving water and an outlet for outputting water such that water passing through the water filter from the inlet to the outlet is filtered;

a water source conduit for connecting the water source to the filter inlet to supply the water filter with water;

a filtered-water conduit for connecting the filter outlet to the ice maker and the water dispenser to supply the ice maker and water dispenser with filtered water; and

a filter status unit for determining the status of the filter based on the filtered water demanded by the ice maker and water dispenser and comprising a water volume meter for determining the volume of filtered water outputted by the water filter for each demand of water, a filtered-water volume summing device for maintaining an accumulated filtered-water volume based on the filtered-water volume determined by the filtered-water volume meter for each demand, and an indicator for signaling when the accumulated filtered-water volume reaches a threshold value indicative of the need to replace the water filter.

2. The water supply system according to claim 1 and further comprising a valve fluidly connected to the filtered-water conduit for controlling the flow of filtered water through the filtered-water conduit from the filter to one of the ice maker and water dispenser.

3. The water supply system according to claim 2 and further comprising a second valve fluidly connected to the filtered-water conduit for controlling the flow of filtered water through the filtered-water conduit from the filter to the other of the ice maker and water dispenser.

4. The water supply system according to claim 3 wherein the filtered-water conduit comprises a first branch for connecting to the ice maker and a second branch for connecting to the water dispenser, and the valve is located in the first branch and the second valve is located in the second branch.

5. The water supply system according to claim 1 wherein the water volume meter comprises a timer for determining the duration of each demand for water by either the ice maker or water dispenser and a data processor for calculating the filtered-water volume for each demand based on the duration of each demand.

6. The water supply system according to claim 5 wherein the data processor comprises a memory in which is stored a flow rate for at least one of the ice maker and water dispenser and the water volume for each demand is determined by the data processor calculating the product of the duration and the flow rate.

7. The water supply system according to claim 6 wherein the memory of the data processor stores a flow rate for each of the ice maker and the water dispenser and the data processor selects the flow rate corresponding to which of the ice maker and water dispenser is demanding filtered water when calculating the filtered-water volume.

8. The water supply system according to claim 7 and further comprising a valve fluidly connected to the filtered-water conduit for controlling the flow of filtered water through the filtered-water conduit from the filter to one of the ice maker and water dispenser.

9. The water supply system according to claim 8 and further comprising a sensor for determining the opened/closed status of the valve and coupled to the filter status unit for use in determining the duration of each demand for water.

10. The water supply system according to claim 9 wherein the timer comprises a clock coupled to the data processor, the sensor is coupled to the data processor, and the timer determines the duration of each demand of water by using the clock to measure the elapsed time that the valve is opened.

11. The water supply system according to claim 10 and further comprising a second valve fluidly connected to the filtered-water conduit for controlling the flow of filtered water through the filtered-water conduit from the filter to the other of the ice maker and water dispenser.

12. The water supply system according to claim 11 and further comprising a second sensor for determining the opened/closed status of the second valve and coupled to the filter status unit for use in determining the duration of each demand for water.

13. The water supply system according to claim 12 wherein the summing device comprises a portion of the memory in which is stored an accumulated filtered water value.

14. The water supply system according to claim 13 wherein the indicator comprises at least one of a visual and an audible indicator.

15. The water supply system according to claim 14 wherein the indicator comprises a portion of the memory in which is stored a threshold value for the filter and the data processor for comparing the accumulated filtered water value to the threshold value to determine the status of the filter and activating the one of the visual and audible indicators when the filtered-water volume value reaches the threshold value.

16. The water supply system according to claim 1 wherein the water volume meter comprises a sensor for detecting the flow of filtered water from the filter, a timer for determining the duration of filtered water flow detected by the sensor, and a data processor for calculating the volume of filtered water output from the filter for the duration of the detected flow of filtered water.

17. The water supply system according to claim 16 wherein the sensor comprises an electrically actuated valve fluidly connected to the filtered-water conduit for controlling the flow of filtered water through the filtered-water conduit from the filter to one of the ice maker and water dispenser and electrically coupled to the data processor and sending a signal to the data processor indicating the open/closed status of the valve.

18. The water supply system according to claim 17 wherein the timer comprises a clock coupled to the data processor and determines the duration of the time that the valve is open.

19. The water supply system according to claim 18 wherein the sensor further comprises a second electrically actuated valve fluidly connected to the filtered-water conduit for controlling the flow of filtered water through the filtered-water conduit from the filter to the other of the ice maker and water dispenser and electrically coupled to the data processor and sending a signal to the data processor indicating the open/closed status of the second valve.

20. A refrigerator comprising:

a cabinet having a fresh food compartment with an open face and a freezer compartment with an open face;

a first door mounted to the cabinet for selectively closing the open face of fresh food compartment;

a second door mounted to the cabinet for selectively closing the open face of the freezer compartment;

at least one water-using accessory;

a replaceable water filter having an inlet adapted to fluidly connect to a supply of household water and an outlet fluidly connected to the at least one water-using accessory; and;

a filter status unit indicating the replacement status for the replaceable water filter based on the accumulated volume of filtered water supplied by the replaceable water filter.

21. The refrigerator according to claim 20 wherein the at least one water-using accessory is one of a water dispenser or an ice maker.

22. The refrigerator according to claim 21 wherein the at least one of a water-using accessory is both the water dispenser and the ice maker.

23. The refrigerator according to claim 22 and further comprising a valve fluidly connecting at least one of the water dispenser and ice maker to the replaceable filter.

24. The refrigerator according to claim 23 and further comprising a second valve fluidly connecting the other of the at least one of the water dispenser and ice maker to the replaceable filter.

25. The refrigerator according to claim 20 wherein the filter status unit further comprises a timer that determines the duration of time that filtered water is supplied from the replaceable filter and a filtered-water volume calculator that calculates the filtered-water volume based on the determined duration and the flow rate of the filtered water to the at least one water-using accessory.

26. The refrigerator according to claim 25 wherein the timer determines a duration for each supply of filtered water to the at least one water-using accessory, the filtered-water volume calculator calculates a corresponding filtered-water volume for each supply, and the filter status unit further comprises a filtered-water volume summing device that sums the calculated filtered-water volumes for each supply to determine the accumulated volume of filtered water.

27. The refrigerator according to claim 26 wherein the filter status unit further comprises a microprocessor having a memory and a clock coupled to the microprocessor and supplying timing data thereto, the microprocessor and the clock form the timer to determine the duration of each

supply, the microprocessor forms the filtered-water volume calculator by multiplying the duration by a flow rate stored in the memory, the microprocessor also forms the summing device by calculating and storing in memory a value corresponding to the accumulated volume of filtered water.

28. The refrigerator according to claim 27 wherein the at least one water-using accessory comprises first and second water-using accessories.

29. The refrigerator according to claim 28 wherein the first water-using accessory has a first water flow rate, the second water-using accessory has a second flow rate, which is different than the first flow rate, and the first and second flow rates are stored in the microprocessor memory and the microprocessor selects the flow rate corresponding to which of the first and second accessories is supplied filtered water by the filter when calculating the water volume supplied by the replaceable filter

30. The refrigerator according to claim 29 and the filter status unit further comprises a sensor for determining which of the first and second accessories is being supplied water from the water filter.

31. The refrigerator according to claim 30 wherein the sensor comprises at least one valve fluidly connecting one of the first and second accessories to the replaceable filter and the at least one valve is coupled to the microprocessor and provides a signal to the microprocessor indicative of when the at least one valve is open.

32. The refrigerator according to claim 31 wherein the sensor comprises a second valve fluidly connecting the other of the first and second accessories to the replaceable filter and the second valve is coupled to the microprocessor and provides a signal to the microprocessor indicative of when the second valve is open.

33. In a refrigerator comprising at least one water-using accessory with a replaceable filter coupled to a water supply and a water supply system for delivering filtered water from the replaceable filter to the at least one water-using accessory, a filter status unit for determining whether the replaceable filter should be replaced, the filter status unit comprising:

a timer that determines the duration of time that filtered water is supplied from the replaceable filter to the at least one water-using appliance;

a filtered-water volume calculator that calculates the filtered-water volume based on the determined duration and the flow rate of the filtered water to the at least one water-using accessory; and

a filtered-water volume summing device for maintaining an accumulated filtered-water volume based on the calculated filtered-water volume.

34. The filter status unit according to claim 33 wherein the timer determines a duration for each supply of filtered water to the at least one water-using accessory, the filtered-water volume calculator calculates a corresponding filtered-water volume for each supply.

35. The filter status unit according to claim 34 wherein the filtered-water volume summing device sums the calculated filtered-water volumes for each supply to determine the accumulated volume of filtered-water.

36. The filter status unit according to claim 35 and further comprises a microprocessor having a memory and a clock coupled to the microprocessor and supplying timing data thereto, the microprocessor and the clock form the timer to determine the duration of each supply, the microprocessor forms the filtered-water volume calculator by multiplying the duration by a flow rate stored in the memory, the microprocessor also forms the summing device by calculating and storing in memory a value corresponding to the accumulated volume of filtered water.

37. The filter status unit according to claim 36 wherein the flow rate is approximately equal to the rate at which the at least one water-using appliance draws the filtered water.

38. The filter status unit according to claim 36 wherein the at least one water-using accessory comprises first and second water-using accessories.

39. The filter status unit according to claim 28 wherein the first water-using accessory has a first water flow rate, the second water-using accessory has a second flow rate, which is different than the first flow rate, and the first and second flow rates are stored in the microprocessor memory and the microprocessor selects the flow rate corresponding to which of the first and second accessories is supplied filtered water by the filter when calculating the water volume supplied by the replaceable filter.

40. The filter status unit according to claim 39 wherein the filter status unit further comprises a sensor for determining which of the first and second accessories is being supplied water from the water filter.

41. The filter status unit according to claim 40 wherein the sensor comprises at least one valve for fluidly connecting one of the first and second accessories to the replaceable filter and the at least one valve is coupled to the microprocessor and provides a signal to the microprocessor indicative of when the at least one valve is open for use by the microprocessor in determining the duration of the supply.

42. The filter status unit according to claim 41 wherein the sensor further comprises a second valve fluidly connecting the other of the first and second accessories to the replaceable filter and the second valve is coupled to the microprocessor and provides a signal to the microprocessor indicative of when the second valve is open for use by the microprocessor in determining the duration of the supply.

43. The filter status unit according to claim 36 and further comprising an indicator that sends a signal observable by a user that the replaceable filter needs replacing.

44. The filter status unit according to claim 43 wherein the indicator comprises at least one of a visual and an audible indicator.

45. The filter status unit according to claim 44 wherein the indicator comprises a portion of the memory in which is stored a threshold value for the filter and the microprocessor compares the accumulated filtered water value to the threshold value to determine the status of the filter and activates the at least one of the visual and audible indicators when the filtered-water volume value reaches the threshold value.

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