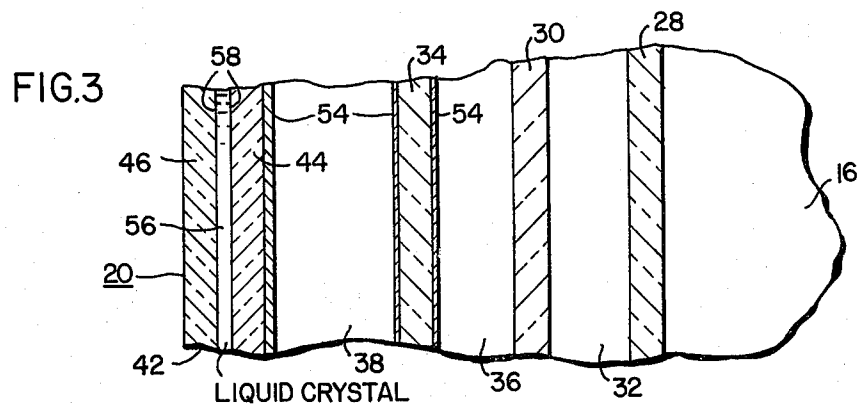
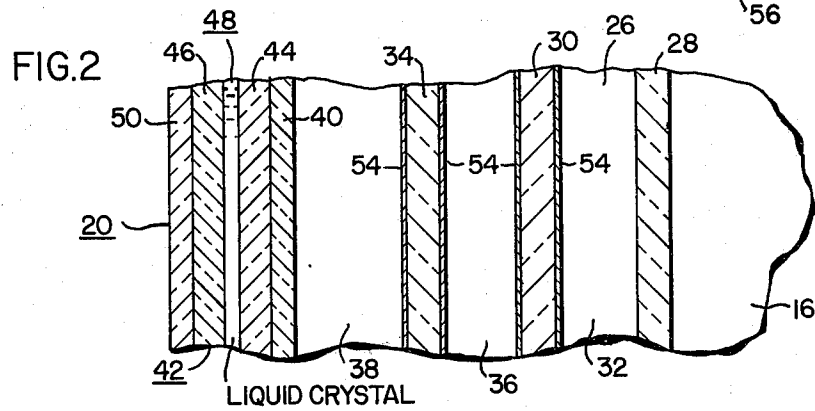
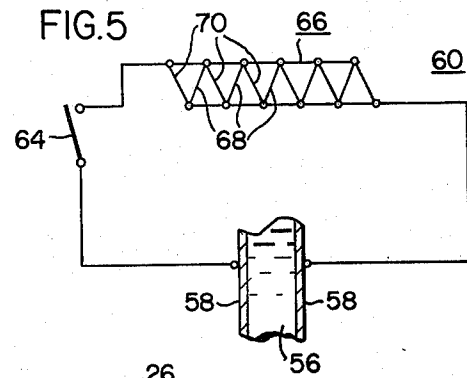
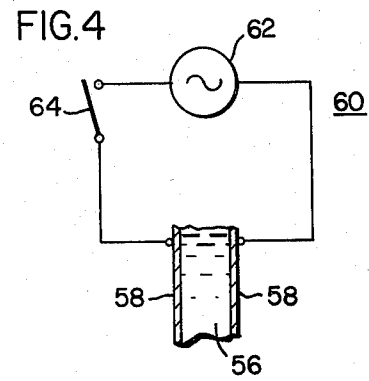
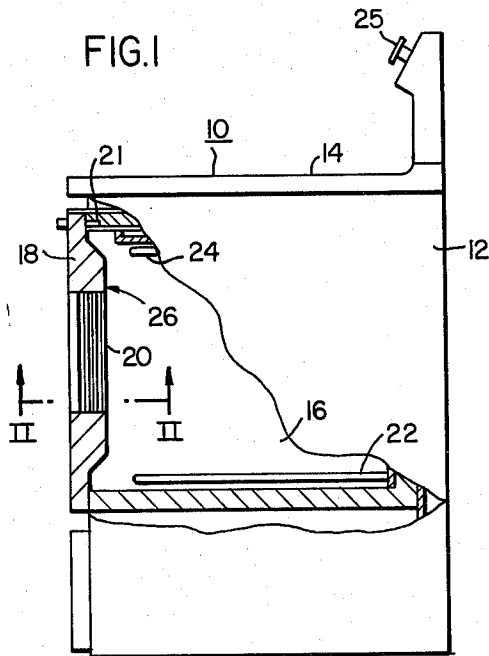




LIQUID CRYSTAL DOOR WINDOW SHUTTER ARRANGEMENT FOR SELF-CLEANING COOKING OVEN

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention pertains to the art of cooking ovens, and, particularly to the doors of pyrolytic self-cleaning ovens which have shuttered windows.

2. Description of the Prior Art

The best prior art known to the applicant in this particular field generally discloses various shutter arrangements using mechanical or electromechanical means to interpose an opaque sheet between the inner and outer surfaces of the window in an oven door during heat cleaning operations. The arrangements also include provisions for withdrawal of the shutter from the line of sight into the oven during normal cooking operations of the range. A representation of this art is found in U.S. Pat. No. 3,720,196.

The various mechanisms for withdrawal of the shutter occupy space within the oven door. These mechanisms occupy space which would normally be filled with thermal insulation. This reduces the insulating capacity of the door, and further, the amount of space available in the door for use as a window is reduced by the space occupied by the mechanisms. As a result the windows in heat cleaning ovens are usually smaller than in ranges not including this feature. The present invention eliminates these objections to the prior art oven door window arrangements.

SUMMARY OF THE INVENTION

A pyrolytic self-cleaning cooking oven having an opening with the opening closed by a door having a window therein. The window includes a liquid crystal shutter arrangement comprising a layer of liquid crystal which serves as an optical shutter by affecting a change in the light transmission through the liquid crystal layer. The window transforms from an opaque to a transparent state when the temperature in the oven changes from a heat cleaning range to a temperature below a heat cleaning range.

DESCRIPTION OF THE DRAWINGS

FIG. 1 is a side elevational view of a cooking range, partly broken away and partly in cross-section, incorporating the invention;

FIG. 2 is an enlarged partial sectional view of the range door window taken along line II—II of FIG. 1;

FIG. 3 is a partial sectional view of a range door window, showing an alternate embodiment of the invention;

FIG. 4 is a simplified schematic circuit arrangement for use with the embodiment of FIG. 3; and

FIG. 5 is a simplified schematic of an alternate circuit arrangement for use with the embodiment of FIG. 3.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to FIG. 1, a self-cleaning range 10 is shown comprising a cabinet structure 12 and a top 14. The cabinet structure 12 supports a forwardly open oven structure 16. The opening of the oven 16 is closed by a door 18 having a window arrangement 20 therein. The oven 16 is heated for cooking and self-cleaning operations by a lower heating element 22 and an upper

heating element 24. A door lock 21 prevents opening of the door during heat cleaning. The door lock 21 is controlled by the setting of a control dial 25.

In FIG. 2 an enlarged cross-sectional view of the window arrangement 20 taken along line II—II, FIG. 1 is shown. The window arrangement 20 includes a perimetric frame 26 securing a plurality of glass panes. The window arrangement 20 comprises an innermost pane 28 and a first intermediate pane 30 disposed substantially parallel to the innermost pane 28. These two panes 28 and 30 are held together by the frame 26 and define an inner closed air cell 32. A second intermediate pane 34 is disposed to the left of and substantially parallel to the first intermediate pane 30 in FIG. 2. The first intermediate pane 30 and the second intermediate pane 34 define a middle closed air cell 36. An outer closed air cell 38 is disposed between the second intermediate pane 34 and an inner polarized light filter 40.

The inner polarized light filter 40 defines the interior face of a shutter laminate 42. The shutter laminate 42 is disposed within the frame 26 substantially parallel to the plurality of panes 28, 30 and 34 and is comprised of the inner polarized light filter 40, an inner structural glass 44 and an outer structural glass 46. Sandwiched between the inner structural glass 44 and the outer structural glass 46 is a thin layer, in the range of 5 mils in thickness, of a cholesteric liquid crystal 48. The exterior face of the shutter laminate 42 is an outer polarized light filter 50.

The layer of cholesteric liquid crystal 48 can be any of a number of cholesteric substances which are colorless and substantially in their liquid phase but when in a mesomorphic crystalline liquid state exhibit the capacity to pass through a series of bright colors. In addition to changes in color, the cholesteric liquid crystal material has the capacity to rotate linearly polarized light. All cholesteric liquid crystals do not respond in the same way to temperature changes. However, for the purpose of the present invention several of those commercially available will suffice. A general discussion of the properties of cholesteric liquid crystals can be found in U.S. Pat. No. 3,627,408.

When the oven 16, FIG. 2, is operating at temperatures in a normal cooking range, the window structure 20 is substantially transparent permitting observation from without of foods cooking within the oven. The transparent effect is obtained when light rays pass through the exterior filter 50 becoming linearly polarized. For explanation purposes, the direction of polarization will be referred to as vertical. These vertically oriented light rays then pass through the thin layer of cholesteric crystal 48. In passing through the liquid crystal at the temperature range obtained during normal cooking operations, the light rays are in effect rotated so that upon exiting from the cholesteric crystal layer 48 the light rays are no longer vertically oriented. The light rays being reoriented in directions other than vertical pass through the inner polarized filter 40 and upon exiting are polarized in a substantially horizontal direction which is perpendicular to the polarizing direction of the outer polarized filter 50 in this embodiment. The process of manipulating the orientation of the light rays as just discussed similarly affects light passing either into or out of the oven.

The window structure 20 includes a plurality of closed air cells designated as 32, 36 and 38 which serve as heat barriers assuring sufficient heat dissipation be-

tween the oven 16 and the layer of cholesteric liquid crystal 48. The temperature range of the liquid crystal responds to the temperature range within the oven 16 although always remaining proportionately lower. During normal cooking operations the temperature of the oven 16, is from ambient to about 550° to 600°F. Because of the heat barriers the liquid crystal 48 remains at temperatures in the mesomorphic, liquid crystal state and retains the capacity to rotate linearly polarized light throughout the oven cooking temperature range.

However, when the oven 16 passes into the heat cleaning temperature range (considered in the current state of the art to be in the range of about 750°F to about 1,050°F), the cholesteric liquid crystal 48 is heated to temperatures above the liquid crystal state into an isotropic liquid state. In the liquid state the liquid crystal 48 no longer has the capacity to reorient or rotate the light rays and it becomes transparent in appearance. Without the interposed rotation of the light the inner polarized light filter 40 and the outer polarized light filter 50 serve as a light shutter. One filter is oriented to polarize light rays perpendicularly to the other filter so that light passing through one cannot subsequently pass through the other. As a result viewing through the window 20 into the oven 16 at self-cleaning temperatures is obstructed because the window becomes opaque at self-cleaning temperatures.

The infrared rays produced during the self-cleaning operation of the oven 16 are reflected back into the oven by a coating of tin oxide 54 on the inner and outer surface of the first intermediate pane 30 and the second intermediate pane 34 in FIG. 2. The thickness of the tin oxide coating is in the range of 100 angstroms so that viewing into the range during normal operation will not be substantially impeded.

Another embodiment of the invention is shown in FIG. 3. It should be noted that elements common to alternate embodiments will have the same character reference in each embodiment. In this embodiment the window structure 20 is comprised of a perimetric frame 26 securing a plurality of panes including an innermost pane 28, a first intermediate pane 30 and a second intermediate pane 34 all disposed substantially parallel to each other. Enclosed between these panes are an inner closed air cell 32 and a middle closed air cell 36. Spaced from and disposed substantially parallel to the second intermediate pane 34 is a shutter laminate 42 defining an outer closed air cell 38 therebetween. The interior surface of the shutter laminate 42 as well as the exterior and interior surface of the second intermediate pane 34 are coated with a thin layer of tin oxide 54 which reflects infrared rays produced during the operation of the range 16.

In this embodiment the shutter laminate 42 includes an inner structural pane 44 and an outer structural pane 46 disposed substantially parallel thereto. The space between the inner structural pane 44 and the outer structural pane 42 has a thickness in the order of 5 mils and this space is filled with a nematic type liquid crystal 56. The opposed faces of the inner structural pane 44 and the outer structural pane 46 are uniformly coated with a thin layer of tin oxide 58.

Nematic type liquid crystals generally have the capacity to scatter light when an electric voltage is applied across the crystal. The voltage transforms the appearance of the crystal from transparent to turbid. The

electrical and optical properties of nematic liquid crystals are discussed in an article "Liquid Crystals Matrix Display" by Lachner, Marlowe, Nester and Tufts found in Proceedings of the IEEE, Vol. 59, No. 11 page 1,566 dated November, 1971. A general discussion can also be found in U.S. Pat. No. 3,322,485. The properties of nematic crystalline liquids vary considerably according to chemical composition but for the purposes of the present invention several of those commercially available are satisfactory.

In this embodiment the nematic crystal 56 remains in its transparent state during normal cooking operations of the oven 16. However, during heat cleaning operations of the oven 16, a voltage is applied to the nematic crystal 56 transforming it into its light scattering or turbid mode. This is accomplished by a circuit 60 such as shown in FIG. 4. The circuit 60 includes a voltage source 62 which establishes an electromotive field between layers of tin oxide 58 which serve as electrodes. The nematic crystal 56 is disposed between the tin oxide electrodes 58. The circuit is completed by a switch 64. The switch 64 is operated in this embodiment by the door lock 21 which must be engaged before the oven 16 can be put into its heat cleaning operation by the control 25. The switch 64 could also be operated by a thermostatic switch responsive to temperatures in the heat cleaning range in the oven 16.

When the oven 16 is in its heat-cleaning operation the switch 64 is closed completing the circuit and applying an electric potential across the nematic crystal 56 which transforms the crystal into its turbid mode. In the turbid mode, the nematic crystal 56 serves as an optical shutter obstructing viewing into the oven during heat cleaning operations.

When the oven 16 is operating in its normal cooking temperature range, the circuit in FIG. 4 is open and the liquid crystal 56 remains in its transparent mode and permits viewing through the window 20 into the oven.

The voltage source for the circuit 60 could be a thermopile 66 as shown in FIG. 5. The thermopile 66 is a series of junctions between lengths, of two dissimilar metals; a first metal is designated as 68 and a second as 70 in FIG. 5. The junctions are arranged in the range 10 so that half of the junctions are at or near the internal temperature of the oven 16 and the other half of the junctions are at or near the temperature at the external surface of the range 10. This arrangement provides an electric potential which at heat-cleaning temperatures is sufficient to transform the nematic crystal 56 into its turbid mode.

From the foregoing description, taken with the drawings, it is seen that this invention has provided a new and improved optical shutter for use in a self-cleaning oven door window.

I claim:

1. In a pyrolytic self-cleaning cooking oven, said oven having an opening therein;
 - a door for closing said opening, said door having a window therein;
 - means including a liquid crystal material associated with said window for providing an optical shutter operative at elevated temperatures in said oven corresponding to a heat-cleaning temperature range; and
 - said means permitting transmission of light sufficient for viewing through said window when the temperature of said oven is below the heat cleaning range

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and excluding transmission of light sufficient for viewing through said window when the temperature of said oven is in a heat-cleaning range.

2. In the oven of claim 1 wherein:

said liquid crystal material comprises a cholesteric liquid crystal; and

said means includes two mutually opposed linearly polarizing light filters with the polarity of each being generally perpendicular with respect to the other, and wherein said liquid crystal material is disposed therebetween.

3. In the oven of claim 2 wherein:

said liquid crystal material is of a character that it responds to temperatures transmitted to it during normal cooking in said oven to rotate light passing therethrough;

and to temperatures transmitted to it during pyrolytic cleaning operations of said oven, to provide substantially negligible rotation of said light therethrough.

4. In the oven of claim 1 wherein:

said liquid crystal material comprises a nematic liquid crystal material confined between spaced apart electrode layers.

5. In the oven of claim 4 wherein:

said means for providing an optical shutter further includes:

a circuit having a voltage source for serially connect-

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ing said layers of said conducting material with said nematic liquid crystal material and switch means for completing said circuit, and means for moving said switch means to a closed position in response to said oven being in a heat-cleaning operation whereby said liquid crystal transforms into a turbid state preventing transmission of sufficient light for viewing therethrough.

6. In the oven of claim 5 wherein:

said voltage source comprises a thermopile, a portion of which is substantially exposed to the elevated temperature of said oven to generate said voltage means.

7. In an improved open door for a pyrolytic self-cleaning oven having a window for normally viewing the interior of an oven and means for obstructing viewing therethrough during a heat-cleaning cycle and wherein the improvement comprises:

said means for obstructing viewing includes a pair of opposed parallel spaced panes associated with said window and said space between said panes contains a conditionally responsive liquid crystal material of a character that responds to said oven being at heat-cleaning temperatures to alter the transmission of light through said panes in a manner to prevent viewing through said window.

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