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**Staton et al.**

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(54) **GRAPHICALLY ENCODED ICONS HAVING INTRINSIC ATTRIBUTES EMBEDDED THEREIN AND SYSTEMS AND METHODS FOR USING SAME**

(71) Applicant: **NEWTONOID TECHNOLOGIES, L.L.C.**, Liberty, MO (US)

(72) Inventors: **Fielding B. Staton**, Liberty, MO (US); **David Strumpf**, Columbia, MO (US)

(73) Assignee: **Newtonoid Technologies, L.L.C.**, Liberty, MO (US)

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(51) **Int. Cl.**
*G06K 19/06* (2006.01)

(52) **U.S. Cl.**
CPC .............................. *G06K 19/06037* (2013.01)

(58) **Field of Classification Search**
CPC ... G06K 19/06037; G06K 7/14; G06K 7/1417
USPC .......................................................... 235/494
See application file for complete search history.

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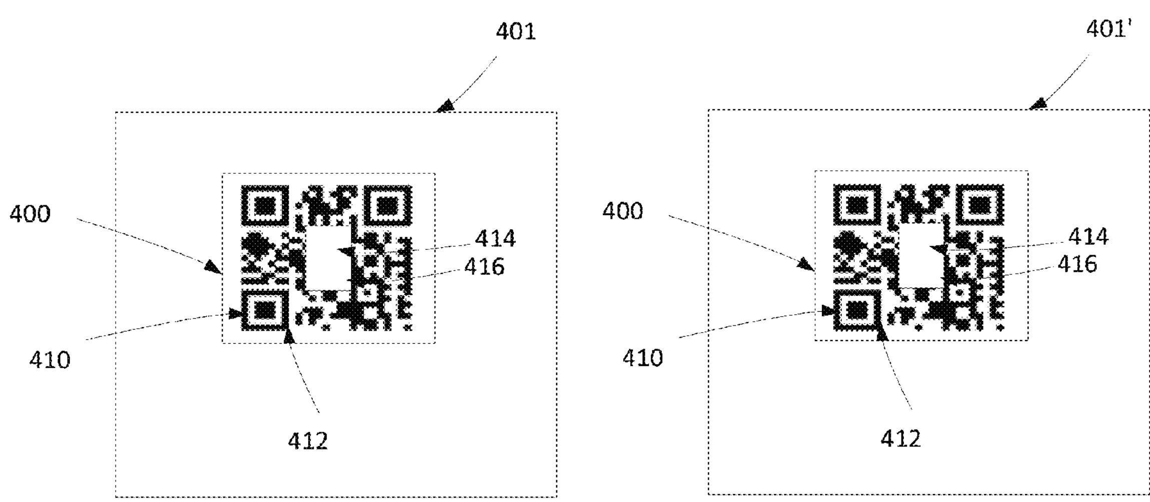
*Primary Examiner* — Ahshik Kim
(74) *Attorney, Agent, or Firm* — Lathrop Gage L.L.P.

(57) **ABSTRACT**

A graphically encoded icon comprises a label attached to an object. The label includes a static portion and an intrinsic portion. The static portion has an area of machine-readable indicia. The intrinsic portion includes at least one area comprising a stimuli-responsive material. The stimuli-responsive material is configured to change from a first state to a second state in response to a trigger, and the change in state is based on an attribute about the object.

**21 Claims, 17 Drawing Sheets**



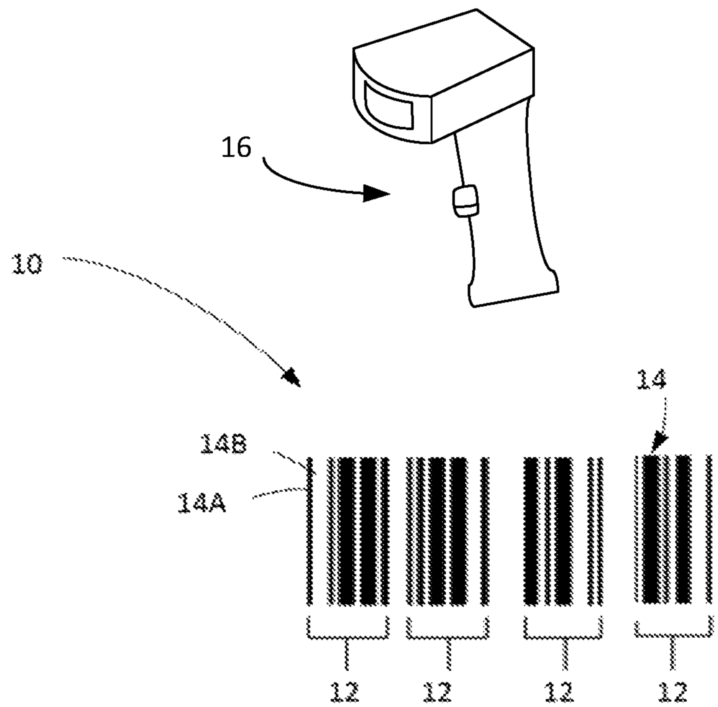



FIG. 1
(PRIOR ART)

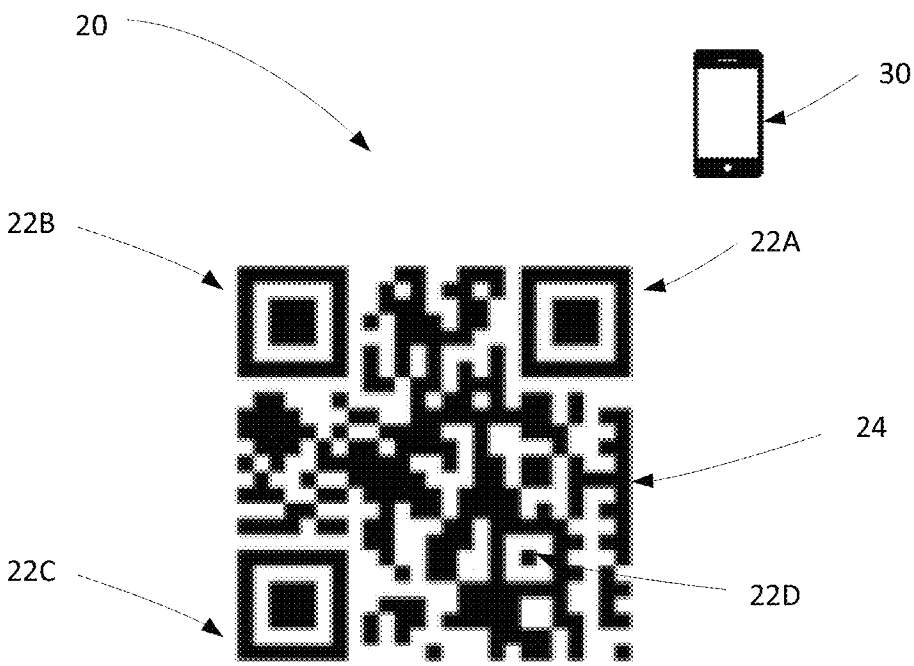



FIG. 2
(PRIOR ART)

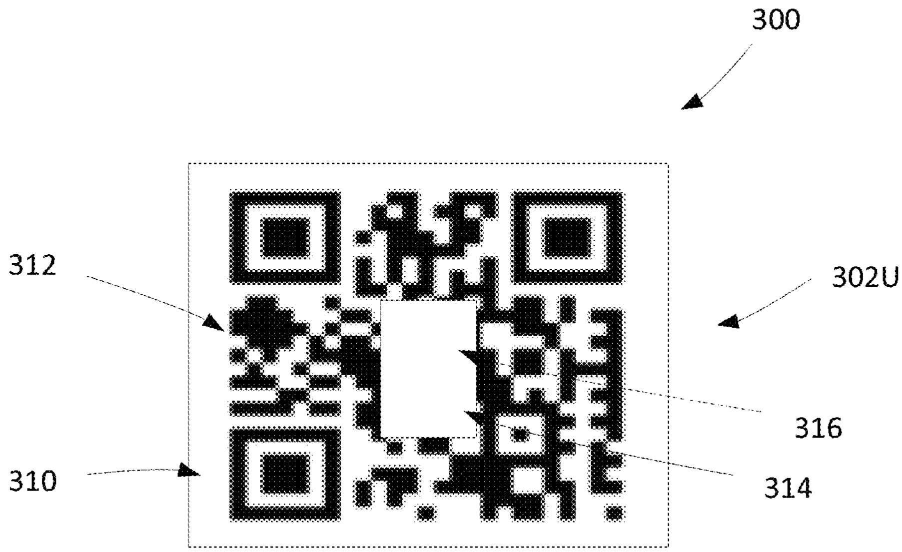



FIG. 3A

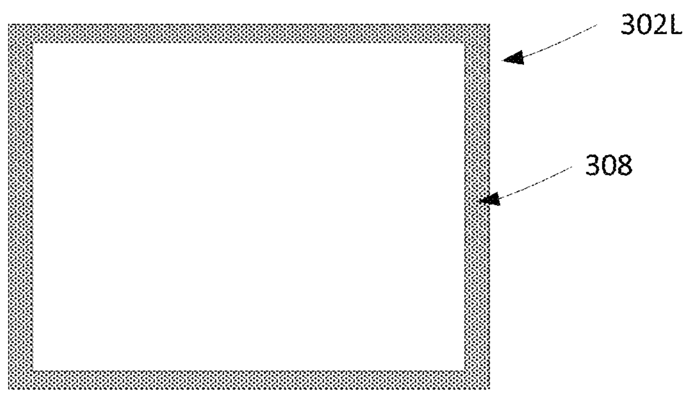



FIG. 3B

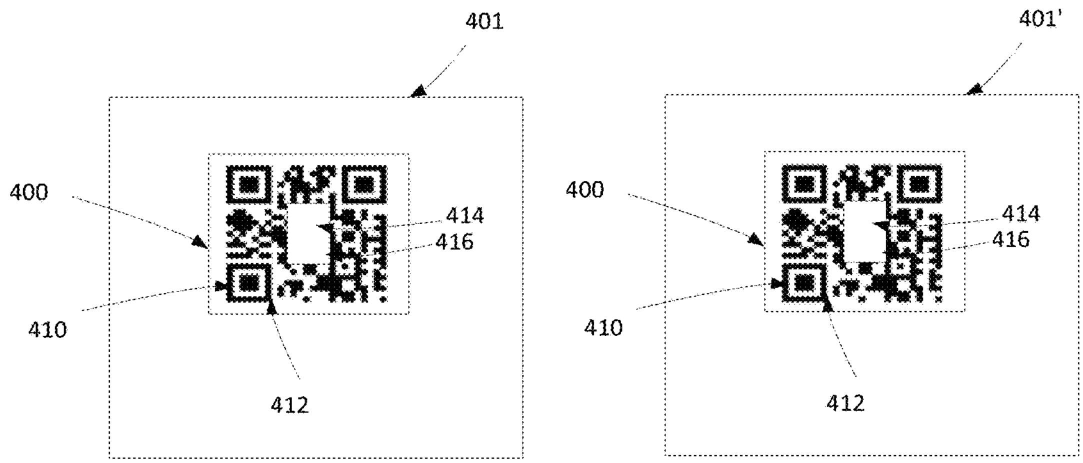

401
401'
400
414
416
410
412
400
414
416
410
412

FIG. 4A

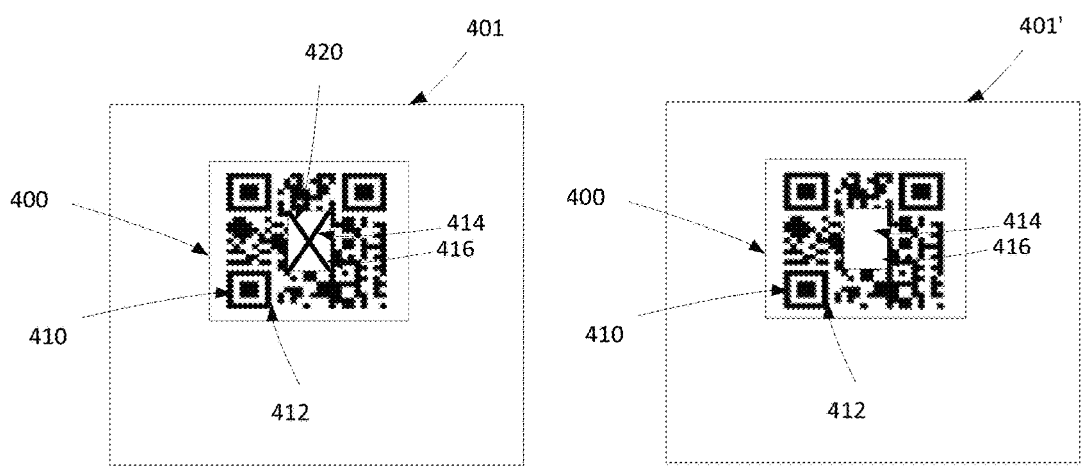

401
420
401'
400
414
416
410
412
400
414
416
410
412

FIG. 4B

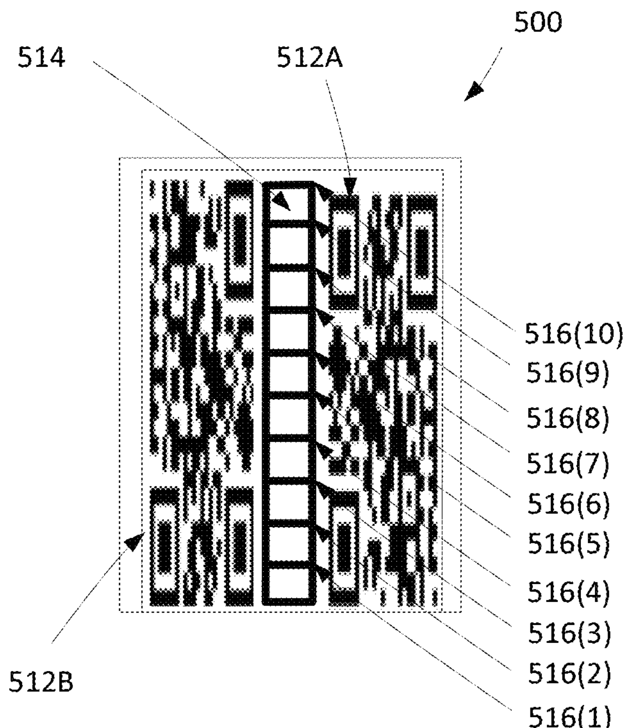

500
514
512A
516(10)
516(9)
516(8)
516(7)
516(6)
516(5)
516(4)
516(3)
516(2)
516(1)
512B

FIG. 5

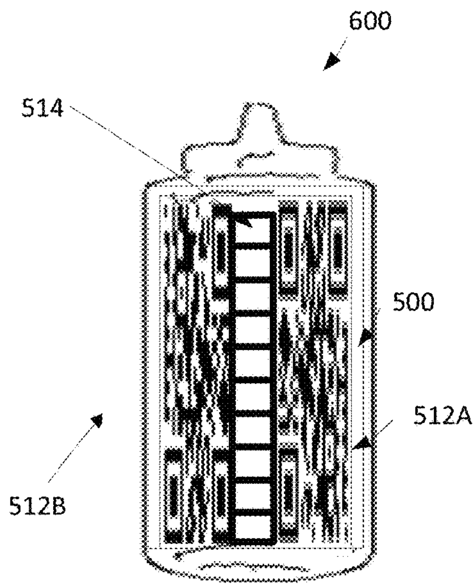



FIG. 6A

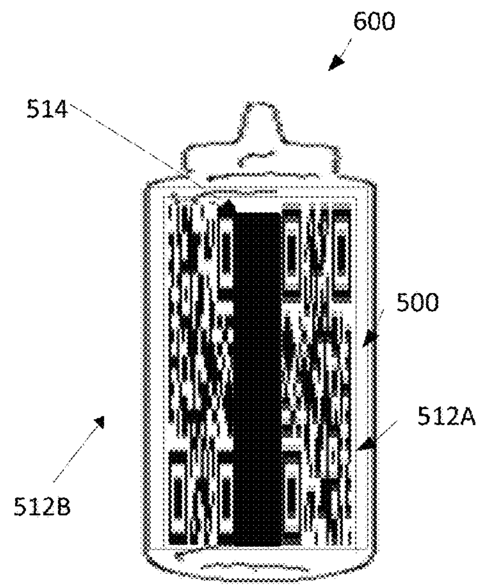



FIG. 6B

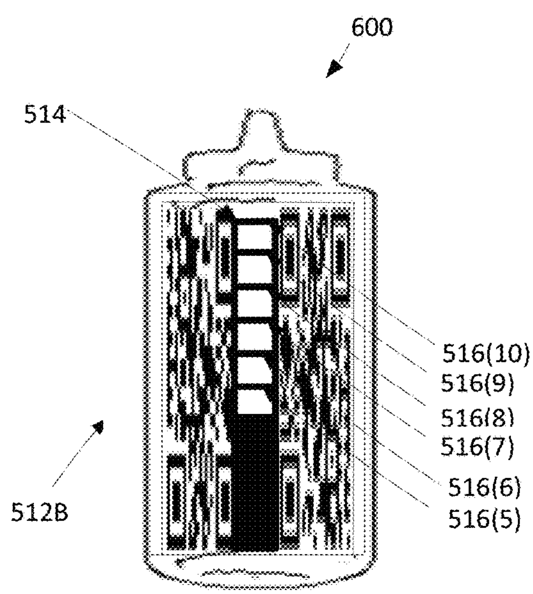



FIG. 6C

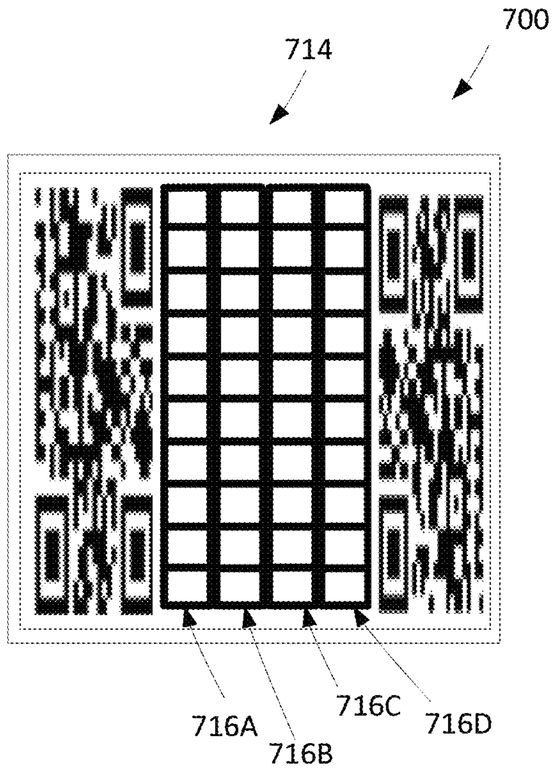



FIG. 7

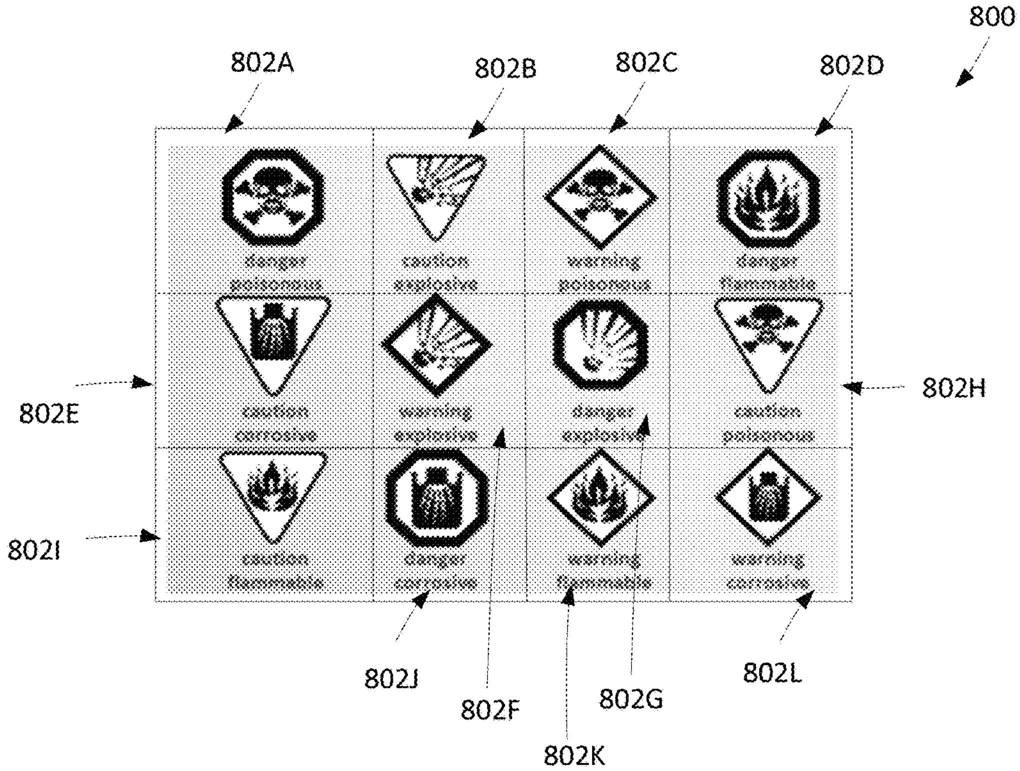

800
802A
802B
802C
802D
danger poisonous
caution explosive
warning poisonous
danger flammable
caution corrosive
warning explosive
danger explosive
caution poisonous
caution flammable
danger corrosive
warning flammable
warning corrosive
802E
802H
802I
802J
802F
802G
802K
802L

FIG. 8A

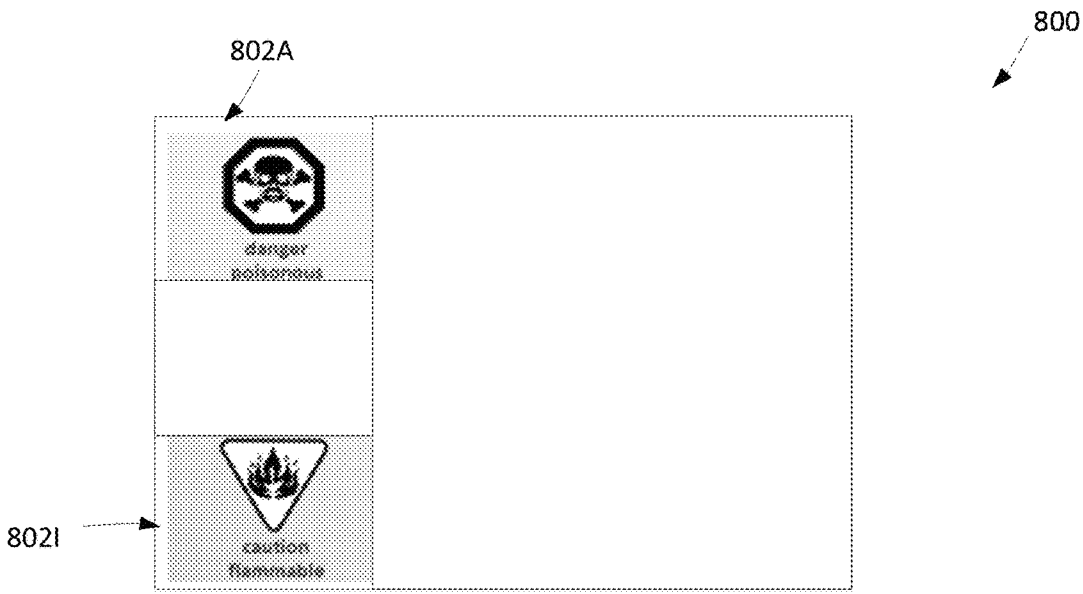

800
802A
danger poisonous
caution flammable
802I

FIG. 8B

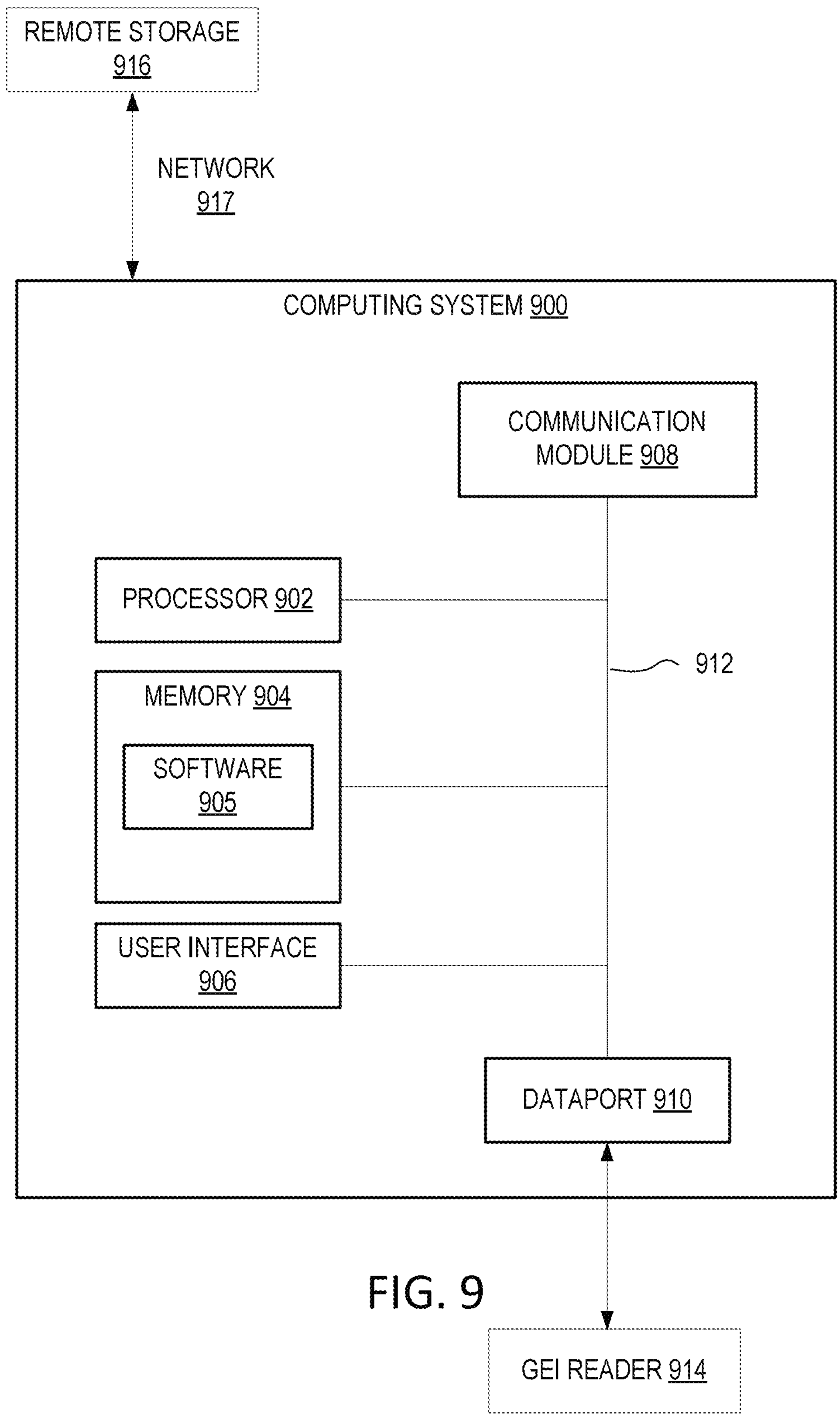

REMOTE STORAGE 916
NETWORK 917
COMPUTING SYSTEM 900
COMMUNICATION MODULE 908
PROCESSOR 902
912
MEMORY 904
SOFTWARE 905
USER INTERFACE 906
DATAPORT 910
GEI READER 914

FIG. 9

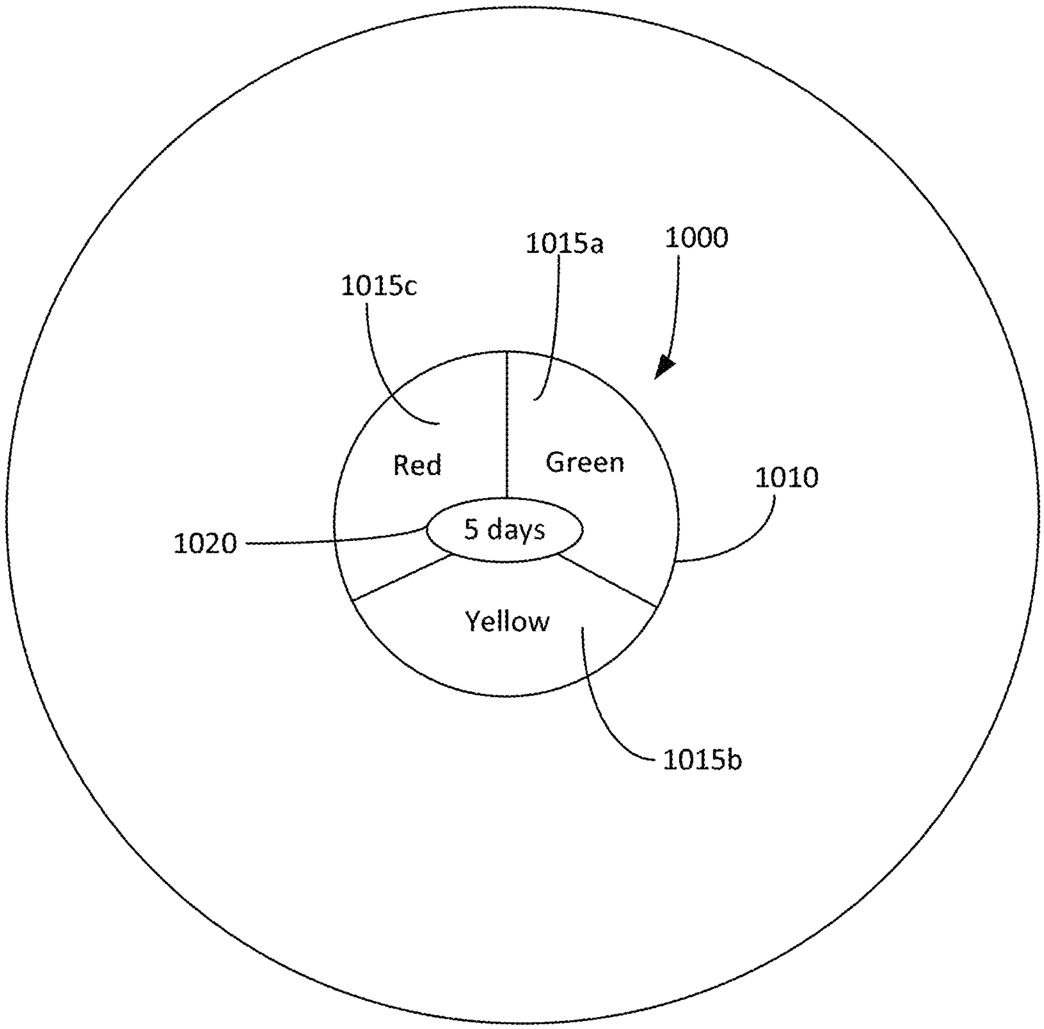



FIG. 10

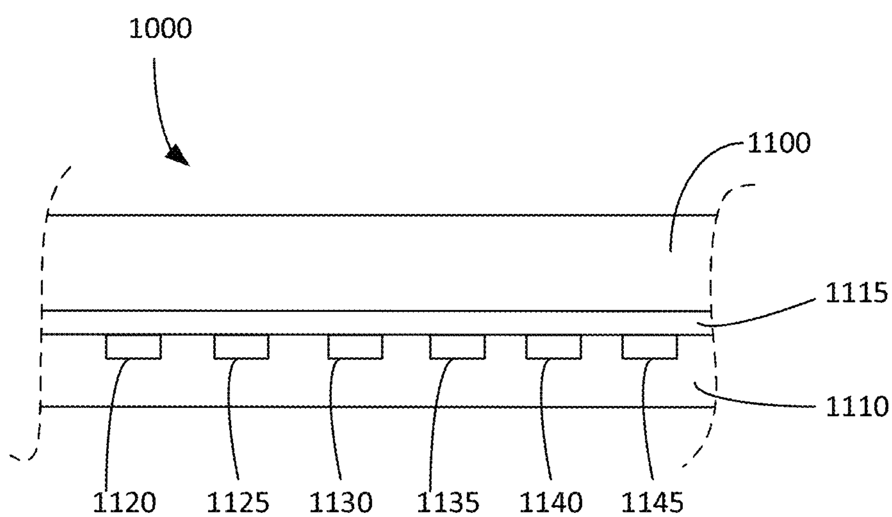



FIG. 11

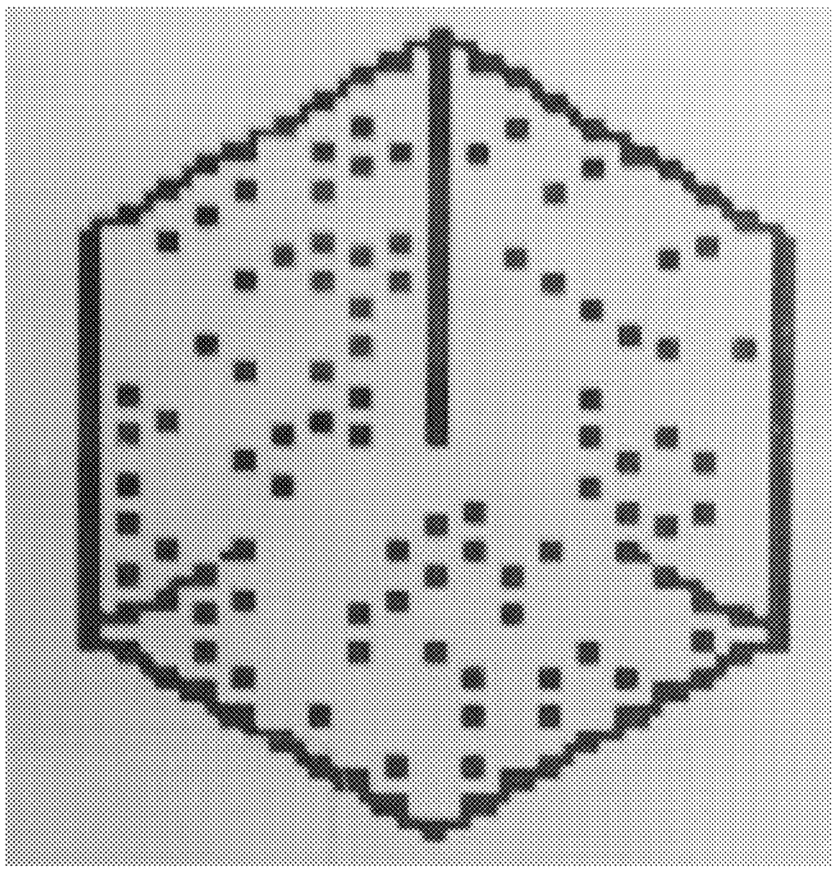


FIG. 12

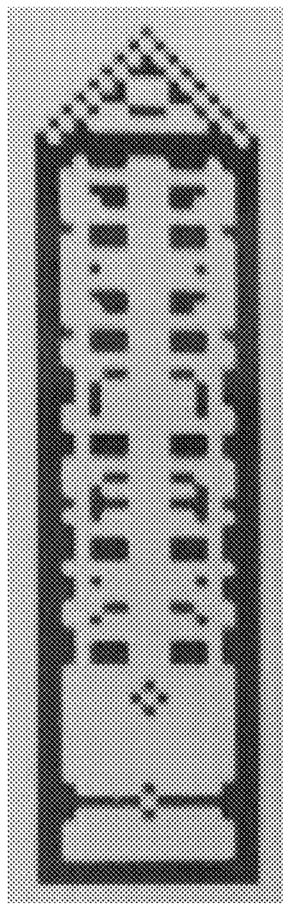


FIG. 13

FIG. 14

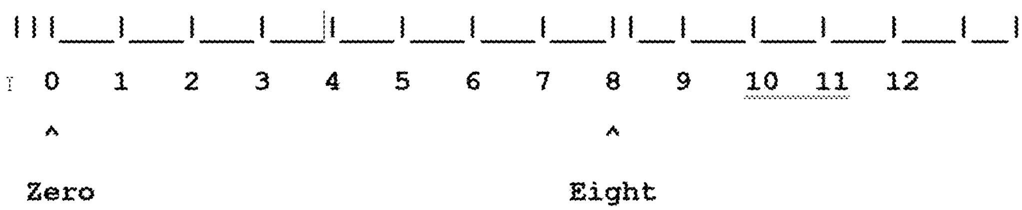

0 1 2 3 4 5 6 7 8 9 10 11 12
^ ^
Zero
Eight

FIG. 15

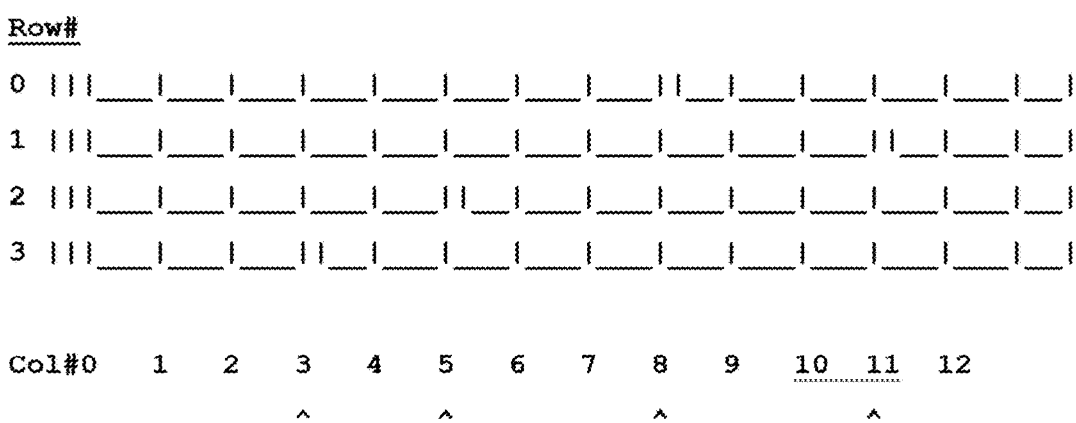

Row#
0
1
2
3
Col#0 1 2 3 4 5 6 7 8 9 10 11 12
^ ^ ^ ^

FIG. 16

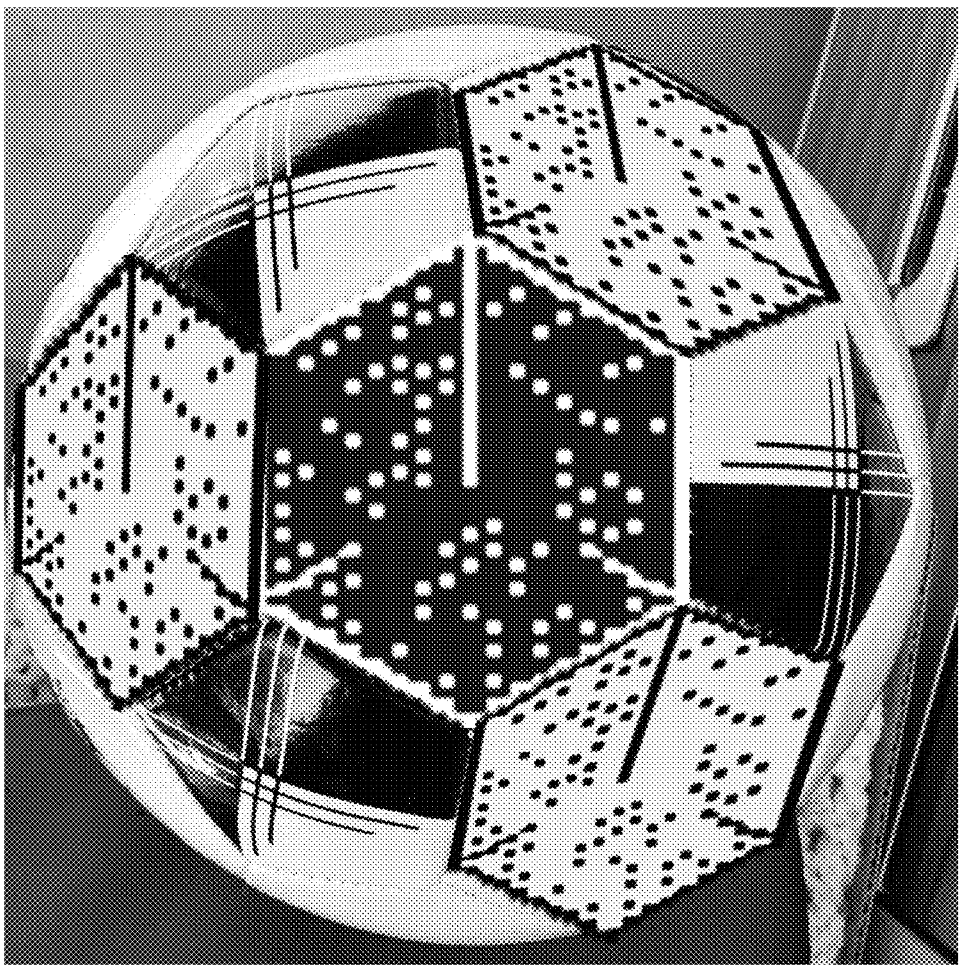


FIG. 17

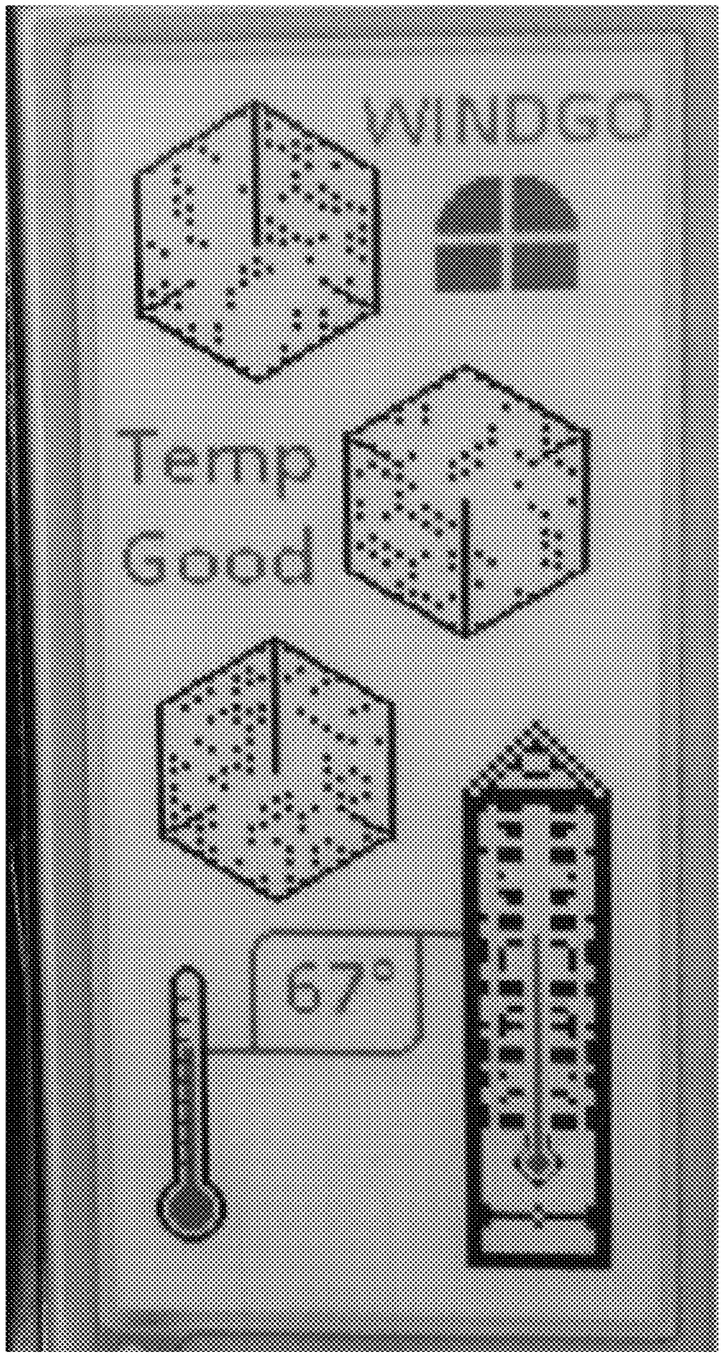



FIG. 18

# GRAPHICALLY ENCODED ICONS HAVING INTRINSIC ATTRIBUTES EMBEDDED THEREIN AND SYSTEMS AND METHODS FOR USING SAME

## CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims priority to U.S. Provisional Patent Application No. 62/590,117, filed Nov. 22, 2017, and U.S. Provisional Patent Application No. 62/640,142, filed Mar. 8, 2018, the disclosures of which are incorporated herein by reference in their entireties.

## FIELD OF THE DISCLOSURE

The disclosure relates generally to the field of graphically encoded icons. More specifically, the disclosure relates to graphically encoded icons having intrinsic attributes embedded therein, and to systems and methods for using such graphically encoded icons.

## SUMMARY

The following presents a simplified summary of the invention in order to provide a basic understanding of some aspects of the invention. This summary is not an extensive overview of the invention. It is not intended to identify critical elements of the invention or to delineate the scope of the invention. Its sole purpose is to present some concepts of the invention in a simplified form as a prelude to the more detailed description that is presented elsewhere herein.

In one embodiment, a graphically encoded icon comprises a label attached to an object. The label includes a static portion and an intrinsic portion. The static portion has an area of machine-readable indicia. The intrinsic portion includes at least one area comprising a stimuli-responsive material. The stimuli-responsive material is configured to change from a first state to a second state in response to a trigger, and the change in state is based on an attribute about the object.

In another embodiment, a system for providing and responding to a visual indication of an attribute about an object includes a graphically encoded icon secured to an object and a computing device. The graphically encoded icon includes a static portion comprising static machine-readable indicia; and an intrinsic portion comprising at least one area comprising a stimuli-responsive material configured to change from a first state to a second state in response to a trigger. The change in state is based on an attribute of the object. The computing device includes a processor in data communication with an input device, an output device, and computer memory. The computer memory has a program having machine readable instructions that, when effected by the processor, performs the following steps: (a) determine the change in state of the stimuli-responsive material; (b) determine if the change in state has reached a predetermined threshold; and (c) if the change in state has reached the predetermined threshold, activate the output device to provide a controlled response to the change in state.

## BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

Illustrative embodiments of the present disclosure are described in detail below with reference to the attached drawing figures and wherein:



FIG. **1** shows a PRIOR ART one dimensional barcode together with a scanner therefor.

FIG. **2** shows a PRIOR ART two-dimensional barcode together with a scanner therefor.

FIG. **3**A shows a top side of a label having a graphically encoded icon according to an embodiment of the present disclosure.

FIG. **3**B shows a bottom side of the label of FIG. **3**A.

FIGS. **4**A-**4**B show a top side of labels having a graphically encoded icon of the type shown in FIG. **3**A.

FIG. **5** shows a top side of a label having a graphically encoded icon comprising a fuzzy field, according to an embodiment.

FIGS. **6**A-**6**C each show a container with the label of FIG. **5** disposed thereon.

FIG. **7** shows an alternate embodiment of the label of FIG. **5** comprising a two-dimensional fuzzy field.

FIG. **8**A-**8**B show a label having sections that are configured to be manually triggered.

FIG. **9** shows a computing system for reading and processing the various graphically encoded icons disclosed herein.

FIG. **10** shows an embodiment of a label disposed on a container.

FIG. **11** shows a side view of the label of FIG. **10**.

FIG. **12** shows a graphically encoded icon according to another embodiment of the invention.

FIG. **13** shows yet another graphically encoded icon according to an embodiment of the invention.

FIG. **14** shows a picture of an embodiment of a graphically encoded icon disposed on a salt shaker according to an embodiment of the invention.

FIG. **15** shows a one-dimensional graphically encoded icon according to still another embodiment of the invention.

FIG. **16** shows a two-dimensional graphically encoded icon according to still yet another embodiment of the invention.

FIG. **17** shows a plurality of graphically encoded icons disposed on a three-dimensional object according to a further embodiment of the invention.

FIG. **18** shows a plurality of graphically encoded icons incorporated into a label according to yet another embodiment of the invention.

## DETAILED DESCRIPTION

The history of scanning, surveilling, dissecting, categorizing, decoding, and resolving information has been evolving for decades. There are many surveillance systems available today that are used for monitoring movement and identification of people or objects. Systems exist today that utilize fixed position observation as well as moving points of perspective. System input sources can range from a single camera to multiple points of observation. One exemplary way that surveillance systems have been used is in the tracking of inventory.

Up until the late 1800s, commercial establishments tracked their inventory primarily by hand. Such manual tracking of inventory was laborious and time consuming. Manual entry of large amounts of data and tracking thereof was also prone to error. Efforts were therefore made to develop machine readable indicia that could be used in large scale applications.

Punch cards, which typically comprised pieces of paper with holes punched therein, were invented in 1890 and allowed for inventory to be tracked more efficiently. Customers identified the products they had selected by removing the corresponding punch cards from a punch card catalog. The punch cards were then handed to the checkout clerk who passed the punch cards through a reader. The reader comprised an optical light and an optical sensor, and the punch card was placed in the reader such that the optical light and the optical sensor were on opposing sides of the card. If the optical sensor detected light passing through the card, i.e., through a hole punched therein, the reader would output a one; alternately, where the optical sensor detected no light, the reader would output a zero to indicate the absence of a punched hole.

Barcode scanning systems, which are configured to identify and decode inanimate objects and markers, were then invented in the 1950s and revolutionized the way in which inventory was tracked. The planar perspective of these systems can be categorized into dimensional perspectives (e.g. one, two, three, and multi-dimensional). The more dimensions of planar perspective available, the greater the ability to resolve more reliable information and greater yields of meaningful intelligence. FIG. **1** shows an example of a one-dimensional barcode **10** as is known in the art. The prior art example barcode **10** includes a plurality of slots **12**. Each slot **12** contains a predefined number of stripes **14**, including both black stripes **14**A and white stripes **14**B. All slots **12** have the same width, and all stripes **14** have the same width. A unique pattern of black and white stripes is associated with each digit from zero to nine. For example, one digit may be represented by two white stripes, two black stripes, two white stripes, and one black stripe, whereas another digit may be represented by two white stripes, one black stripe, two white stripes, and two final black stripes, etc. The barcode **10** is readable by a barcode scanner **16**. The scanner **16** shines LED, laser, projector, photonic semiconductor or other light onto the barcode **10**. Light reflects back off barcode **10** into a light-detecting electronic component of the scanner **16**, e.g., a photoelectric cell thereof. White stripes **14**B reflect more light as compared to the black stripes **14**A, which allows the scanner **16** to quickly decode the code. As the scanner **16** moves past the barcode **10**, the cell generates a pattern of on-off pulses that correspond to the black and white stripes. An electronic circuit attached to the scanner **16** converts these on-off pulses into binary digits (zeros and ones) to decode the barcode **10**.

Barcode **10** is typically referred to as a one dimensional or linear barcode. This is because the information in the code is organized horizontally and is read from left to right. The data in a one dimensional barcode **10** is limited in practice because addition of data thereto requires an increase in the physical length of the barcode **10**. It is this limitation of the one dimensional barcode that in the late 1980s led to the advent of two dimensional barcodes.

Two dimensional barcodes, such as a Quick Response (QR) code, a Datamatrix code, a PDF417 code, an Aztec code, etc., are configured to hold information in both the vertical and horizontal directions. Data is encoded in such two dimensional barcodes in patterns, matrices, squares, hexagons, dots, and other shapes. Because the data is encoded in both the vertical and horizontal directions, a two dimensional barcode can store much more information (e.g., 200 times more information) as compared to a similarly sized one dimensional barcode.

FIG. **2** shows a QR code **20** as is known in the art. Each QR code includes modules that contain static information required to read the QR code **20**. For example, the illustrated QR code **20** includes three edge modules **22**A, **22**B, and **22**C (i.e., the three large squares) which tell the scanner where the edges of the QR code **20** are, and an alignment marker **22**D that acts as reference points for the scanner. The QR code **20** also contains other modules and zones, such as timing pattern markers to define the positioning of the rows and columns, formatting markers to outline whether the QR code **20** contains numbers, text, symbols, or some combination thereof, a quiet zone, etc. Data and error correction information is encoded in a data encoding portion **24** of the QR code **20**. As is known, QR code **20** can be read using a smart phone **30** or other device having an imager. To read the QR code **20**, the imager of the QR code reader **30** is used to capture an image of the QR code **20**. The processor of the QR code reader **30** then decodes the image and converts it into information meaningful to humans.

Machine readable indicia, such as the barcode **10** and the QR code **20**, can be read by computing systems quickly (as compared to Arabic numerals, for example). However, humans are typically unable to decipher such machine readable indicia using the naked eye. To this end, machine readable indicia may be accompanied with static information that can be readily comprehended by the naked eye. For example, the barcode **10** may include at the bottom (or elsewhere) a sequence of Arabic numerals, Greek numerals, Chinese numerals, etc. that corresponds to the machine readable indicia of the barcode **10** and allow the barcode **10** to be read both by humans and by machines. Or, for instance, where machine readable indicia on the QR code **20** translates to a product code containing letters of the English alphabet, these letters may be listed underneath the machine readable indicia to allow a human to comprehend the information stored in the QR code **20** with the naked eye.

Associating machine readable indicia with static human readable indicia has several benefits. For example, if the barcode **10** or QR code **20** is deformed or is otherwise rendered unreadable by a computing system, a user may read the static human readable information provided with the barcode **10** and the QR code **20**, respectively, and manually enter same into the computing system (e.g., a point of sale or other system). The static human readable information may also be used for error detection and correction, validation of the machine readable data, security, encryption, etc.

While the one dimensional barcodes represent a significant advance over the punch cards of old and the two dimensional barcodes represent a significant advance over one dimensional barcodes, the prior art one and two dimensional barcodes are limited in that the information represented thereby is static. That is, once the prior art barcode **10** and the prior art QR code **20** are printed, they become fixed in form and cannot be used to convey variable information. As discussed herein, machine readable indicia that includes both static and variable information can have wide ranging applicability. This is particularly so when the variable information conveyed by the machine readable indicia: (a) is tied to an intrinsic attribute, e.g., of an object associated with the machine readable indicia; and/or (b) can be readily comprehended both by the naked eye and by computing systems.

Focus is directed to FIGS. **3**A and **3**B, which respectively show an upper surface **302**U and a lower surface **302**L of a label **300** according to an embodiment of the present disclosure. The lower surface **302**L of the label **300** may include an adhesive **308**, e.g., at the edges there of or elsewhere, to allow the label **300** to be permanently or removably adhered to an object.

The upper surface **302**U of the label may contain a graphically encoded icon **310**. In an embodiment, the graphically encoded icon **310** is configured to be deciphered by a machine (e.g., a bar code scanner, an imager, etc.) in its entirety and portions thereof are further configured to readily convey meaningful information about an attribute of an object associated with the label **300** to the naked eye. In some embodiments, a portion of the graphically encoded icon **310** is configured to be deciphered by a machine, another portion of the graphically encoded icon **310** is configured to convey information to the naked eye, and yet another portion of the graphically encoded icon **310** is readable by a machine and is further configured to convey meaningful information about an attribute of an object associated with the label **300** to the naked eye.

In the illustrated example, the graphically encoded icon **310** includes a static portion **312** and an intrinsic attribute portion **314**. The static portion **302** comprises static machine readable indicia, such as a traditional one dimensional barcode, a traditional two dimensional barcode, a three dimensional barcode, etc. In embodiments, the static portion **302** may also include information readily decipherable by the naked eye; for example, where the static portion **302** is a two dimensional barcode, the static portion **302** may include a listing of numerals, alphabets, etc. that corresponds to the static machine readable indicia.

The intrinsic attribute portion **314** may, in embodiments, be fully or partially encapsulated by the static portion **312**. The intrinsic attribute portion **314** may be configured to convey information about an attribute of an object to which the label **300** is adhered. In embodiments, indicia in the intrinsic attribute portion **314** may be machine readable and may further be configured to convey meaningful information about the attribute of the object associated with the label **300** to the naked eye.

In embodiments, indicia in the intrinsic attribute portion **314** may change states based on a trigger. For example, in embodiments, indicia in the intrinsic attribute portion **314** may initially appear invisible to the naked eye and to the scanner (e.g., a computing system having an imager), and may thereafter change states based on a trigger to convey meaningful information about an attribute associated with an object to which the label **300** is adhered.

In embodiments, the intrinsic attribute portion **314** may include stimuli-responsive polymers **316** and/or other such materials that exhibit a change in a characteristic thereof in response to a known stimulus. The change effectuated by the trigger may be one that is discernible by the naked eye. For example, the intrinsic attribute portion **314** may, in embodiments, include thermochromic (i.e., temperature sensitive ink) that changes colors based on temperature. Or, for instance, the intrinsic attribute portion **314** may contain smart polymers and smart polymer solutions that exhibit a visible change based on factors such as humidity, pH, the wavelength and/or intensity of impinging light, an electrical field, a magnetic field, etc. The artisan understands that smart polymers, e.g., poly propyl (acrylic acid), poly (ethacrylic acid), PMMA-PEG copolymer, polysilamine, poly(4-vinylpyridine), poly(2-vinylpyridine), poly(2-diethylaminoethyl methacrylate), etc., which exhibit a visible change based on their environment are commercially available in the marketplace today and that much research is underway to develop additional stimuli-responsive materials. The stimuli-responsive polymers **316** used in the present disclosure may, in embodiments, respond to one or more such factors by altering their color, transparency, or other physical attributes.

In embodiments, the response of the stimuli-responsive polymers in the intrinsic attribute portion **314**, once triggered by the triggering stimulus, may be permanent. Such stimuli-responsive polymers may be referred to herein as irreversible stimuli-responsive polymers. In other embodiments, the response of the stimuli-responsive polymers may be reversible. Such stimuli-responsive polymers may be referred to herein as reversible stimuli-responsive polymers. Consider, for example, a stimuli-responsive polymer that is initially transparent to the naked eye but changes color, e.g., changes from being transparent to appearing in a red hue, when the environment in which it is located reaches a temperature equal to or greater than a triggering temperature $T_{trigger}$. If this example polymer can respond to the stimulus more than once, e.g., turns red when the temperature reaches $T_{trigger}$ and turns transparent again after the temperature reaches below $T_{trigger}$, it may be referred to herein as a reversible stimuli-responsive polymer. Alternately, if this polymer maintains its changed state once the response is triggered notwithstanding any other changes in the environment, e.g., if the polymer turns red when the temperature reaches $T_{trigger}$ and remains red even when the temperature goes below $T_{trigger}$, it may be referred to herein as an irreversible stimuli-responsive polymer. It shall be understood that the stimuli-responsive polymer may be irreversible under normal operating conditions, yet be reversed in response to a controlled stimulus (e.g., to “reset” the polymer). Thus, the stimuli-responsive polymer may be semi-irreversible in certain embodiments. Depending on the application, embodiments of the present disclosure may employ a reversible stimuli-responsive polymer, an irreversible stimuli-responsive polymer, a semi-irreversible stimuli-responsive polymer, or any combination of the three.

The graphically encoded icons disclosed herein, e.g., the graphically encoded icon **310**, may have wide ranging applicability, and may be employed in any application where it is desirable to readily convey an intrinsic attribute of an object associated with the graphically encoded icon **310** to the naked eye and/or to a machine.

Assume, for example, that containers carrying seafood (e.g., shrimp) from various locations are shipped to another location (e.g., to a warehouse). As is known, shrimp is preferably stored at a temperature of −22 degree Fahrenheit. In the prior art, a one or two dimensional barcode may be adhered to each of the various containers. The prior art barcodes may outline, e.g., the shipping location, the location of the ultimate recipient, the product code associated with the shrimp, and other such information. The prior art barcodes, however, do not outline whether the shrimp container was maintained at a desirable storage temperature during transit.

FIG. **4**A shows example shrimp containers **401** and **401'** that are to be shipped form a shipping location to a recipient. The example containers **401** and **401'** are each shown as having a label **400** adhered thereto. Label **400** is an example of the label **300** and includes a graphically encoded icon **410** of the type shown in FIGS. **3**A and **3**B. The graphically encoded icon **410** includes a static portion **412** containing static machine readable indicia and an intrinsic attribute portion **414** encapsulated by the static portion **412**. In embodiments, care may be taken to ensure that the intrinsic attribute portion **414** is in the data encoding portion of the graphically encoded icon (e.g., in embodiments, the intrinsic attribute portion **414** does not cover the edge modules, the alignment markers, etc.). Such may ensure that the indicia in the static portion **412** and the intrinsic attribute portion **414** is readable by a machine.

In this example, the intrinsic attribute portion **414** contains an irreversible (or semi-irreversible) stimuli-responsive polymer **416** configured to change its state when the temperature of the environment exceeds −22 degree Fahrenheit (or another temperature). That is, the trigger in this example is a maximum temperature $T_{trigger(max)}$. As discussed herein, in other embodiments, the trigger may be a minimum temperature or another factor. The irreversible stimuli-responsive polymer **416** may initially appear transparent and may change to black, red or a different hue when the temperature of the environment exceeds −22 degree Fahrenheit.

FIG. **4**B shows the example shrimp containers **401** and **401'** as received by the recipient. The label **400** on the container **401**, and particularly the intrinsic attribute portion **414** thereof, now displays a trigger notification **420** (an X in this example). The trigger notification **420** apprises the recipient that the shrimp container **401**, during transit or at another time, was placed in an environment where the temperature exceeded −22 degree Fahrenheit. The recipient may therefore easily observe that the shrimp in the container **401** may be spoiled. Such may allow the recipient to discard the shrimp container **401** without having to open the container **401**. Conversely, the intrinsic attribute portion **414** of the container **401'** shown in FIG. **4**B does not display the trigger notification **420**. The recipient may therefore definitively observe that the shrimp container **401'** was maintained at a proper temperature during transit.

The trigger notification **420**, shown as an X in FIG. **4**B, may in embodiments be a different visible notification. For example, in embodiments, the trigger notification **420** may comprise the text "S" for spoiled. Or, for instance, the trigger notification **420** may be a square, circle, dashed line, or other shape or pattern that is visibly manifested when the trigger condition is met. As noted, the trigger notification **420** may, in embodiments, be machine readable. For example, in embodiments, a computing system having an imager may be configured to decode the trigger notification **420** to determine whether the shrimp in the various shrimp containers is spoiled. In these embodiments, a human may optionally verify the results using the naked eye. For instance, all shrimp containers flagged by the computing system as potentially containing spoiled shrimp may be routed to an inspection area, and personnel may visually inspect these containers to ensure that the trigger notification **420** has not been identified by the computing system in error. Such may allow for the verification of spoilage of goods with greater accuracy without having to inspect the goods themselves. FIG. **18** illustrates a label having a plurality of graphically encoded icons with machine readable and human readable information, including indicating that the temperature is within an acceptable range for the application. Thus, a user can easily verify that the temperature is acceptable, and this may be further confirmed by the machine readable indicia.

While the label **400** containing the graphically encoded icon **410** is illustrated above for a particular application (i.e., for shrimp containers), the artisan will understand from the present disclosure that labels having graphically encoded icons disclosed herein may be used in other applications where it is desirable to determine whether a trigger condition is met. For example, in an embodiment, a label having a graphically encoded icon of the type shown in FIGS. **3**A-**3**B may be configured such that the intrinsic attribute portion **314** displays a trigger notification when the temperature equals or exceeds a particular temperature $T_{trigger(max)}$. For instance, in an example application, the $T_{trigger(max)}$ may be 32 degrees Fahrenheit (or another temperature), and this label may be placed on paint containers. If the intrinsic attribute portion displays a trigger notification, such may indicate that the paint in the container has undergone at least one freezing cycle and is likely unfit for use. The label may therefore facilitate the discarding of unusable paint without having to open the container in which the paint is housed.

The graphically encoded icons **310** having an irreversible stimuli-responsive polymer may serve, in effect, as single use or permanent memory. The graphically encoded icons **310** having a semi-irreversible stimuli-responsive polymer may serve, in effect, as semi-permanent memory during normal operating conditions. These graphically encoded icons **310** may be used, e.g., in applications where the relevant question is whether the trigger condition was met at some point in time; the current state of the environment, conversely, is unimportant. For example, if the label **400** is placed on a shrimp container that has at one time (e.g., a day before, an hour before, etc.) been placed in an environment in which the temperature exceeds $T_{trigger(max)}$, it may not matter than the shrimp container is currently in a suitable environment. In other embodiments, the graphically encoded icon **310** may have a reversible stimuli-responsive polymer, and may serve, in effect, as volatile memory. In these applications, the focus may be on the current state of the environment and it may be unimportant to determine whether the trigger condition was previously met.

For example, in embodiments, the intrinsic attribute portion **314** of the graphically encoded icon **310** may comprise a reversible stimuli-responsive polymer, and this graphically encoded icon **310** may be placed, via a label or otherwise, on bottles of water or other such non-perishable drinks in a restaurant. The stimuli-responsive polymer may be configured to exhibit a visible change when the temperature of the environment goes above 50 degrees Fahrenheit (i.e., in this example, the trigger is a maximum temperature and the value of $T_{trigger(max)}$ is 50 degrees Fahrenheit (or a different temperature). For instance, the stimuli-responsive polymer may appear to be transparent until the temperature reaches $T_{trigger(max)}$, at which point its hue may change to red (or another color). When the bottle of water is to be served to a customer, the server at the restaurant may visibly inspect the graphically encoded icon **310**, and where the intrinsic attribute portion **314** thereof is transparent, the server may easily observe that the water is appropriately cold and may be served to the customer. Alternately, if the intrinsic attribute portion **314** appears red, the server may determine that the bottled water is not suitably cold and should not be served to the customer. The server may therefore place the bottle of water in a refrigerator or ice bucket and serve it to a customer when the reversible stimuli-responsive polymer in the intrinsic attribute portion **314** appears transparent. If the intrinsic attribute portion **314** of the graphically encoded icon turns transparent and subsequently turns red again, the server may place the bottle in the refrigerator once again. And so on.

Such graphically encoded icons **310** may likewise be used on bottles of water (or other drinks) being served in a vending machine. The vending machine may contain a computing system having an imager or other scanner, and the computing system may vend a bottle of water only if the graphically encoded icon **310** associated therewith appears transparent. Conversely, if the graphically encoded icon **310** associated with a bottle of water in the vending machine is red, the vending machine may vend a different bottle of water to a user; alternately, the vending machine may apprise the user that cold bottled water is currently unavailable for purchase.

In embodiments, the intrinsic attribute portion **314** of the graphically encoded icon **310** may comprise a reversible stimuli-responsive polymer configured to change its state when the temperature goes below a certain temperature

$T_{trigger(min)}$. Such a graphically encoded icon **310** may, for example, be associated with coffee, tea, or other drinks to ensure that these drinks, when served, are appropriately hot.

In some example embodiments discussed above, the graphically encoded icon **310**, and particularly the intrinsic attribute portion **314** thereof, may employ Boolean logic. That is, the intrinsic attribute portion **314** may have a binary value. For example, if the intrinsic attribute portion **314** contains an irreversible stimuli-responsive polymer that is configured to change its state when a trigger condition is met, the intrinsic attribute portion **314** will either: (a) appear in one (e.g., a changed) state if the trigger condition is met; or (b) appear in another (e.g., an original) state if the trigger condition is unmet. Similarly, if the intrinsic attribute portion **314** contains a reversible stimuli-responsive polymer, the intrinsic attribute portion **314** will either: (a) appear in one (e.g., a changed) state if the trigger condition is currently being met; or (b) appear in another (e.g., an original) state if the trigger condition is currently unmet. In some embodiments of the present disclosure, and as discussed in more detail herein, the intrinsic attribute portion **314** may employ many-valued logic (as opposed to Boolean logic). For example, in embodiments, the intrinsic attribute portion **314** may comprise a fuzzy field that may be in one state at one time, a second state at another time, a third state at yet another time, and so on. In other embodiments still, the intrinsic attribute portion **314** may comprise each of a binary field and a fuzzy field.

FIG. **5** shows a top side of a label **500**, which is an example of the label **300**. The label **500** includes a graphically encoded icon **510** comprising static portions **512**A and **512**B. The static portions **512**A and **512**A each include static machine readable indicia. The illustrated graphically encoded icon **510** includes an intrinsic attribute portion **514**, which may be situated between the static portions **512**A and **512**B or elsewhere. In embodiments, the graphically encoded icon **510** may include a solitary static portion **512** and a solitary intrinsic attribute portion **514**. In other embodiments, the graphically encoded icon **510** may include a plurality of intrinsic attribute portions **514** and a solitary static portion **512**.

The illustrated intrinsic attribute portion **514** may be a fuzzy field. The illustrated fuzzy field **514** has ten possible levels **516**(**1**) to **516**(**10**), although any number of levels may likewise be employed. The fuzzy field levels may but need not be visibly demarcated. As discussed herein, the fuzzy field **514** may, in embodiments, be configured to be "filled in" by a substance. That is, in some embodiments, the intrinsic attribute portion **514** may be configured to directly delineate a quantity of a substance in a container to which the label **500** is adhered. The substance may be a solid (e.g., candies, powdered salt, etc.), liquid (e.g., oil, coffee drinks, water, etc.), or gas (e.g., chlorine, nitrogen dioxide, etc.) that is visible to the naked eye. The fuzzy field **514** may (but need not) be transparent or generally transparent so as to allow the level of a substance to be ascertained as discussed herein.

FIGS. **6**A-**6**C show one example application of the label **500**. Assume, for example, that an entity (e.g., a commercial establishment such as a restaurant, a household, etc.) carries in a refrigerator or elsewhere a container **600** of salad dressing. Assume further that the entity wishes for additional salad dressing to be ordered when the level of salad dressing in the container **600** falls below a certain level (e.g., falls below the midway point). FIG. **6**A shows the container of salad dressing **600** with the label **500** adhered thereto. The container **600** shown in FIG. **6**A has no salad dressing therein. FIG. **6**B, conversely, shows the container **600** when it is generally full of salad dressing. And FIG. **6**C shows the container **600** that is only partially full.

The refrigerator (or the cupboard, kitchen, or other location) in which the container **600** is housed may contain or have associated therewith a computing system having an imager. The imager may be configured to capture an image of the container **600** periodically (e.g., once a day, once a week, etc.). The computing system may decode the graphically encoded icon **510** of the label **500**, and particularly the fuzzy field **514** thereof, to determine whether additional salad dressing is to be ordered. For example, when the imager captures an image of the container **600** in FIG. **6**C, the computing system may determine that the level of salad dressing in the container **600** has fallen below a midway point. The computing system may be in communication with a network and use same to order an additional salad dressing container (e.g., the computing system may be in communication with the world wide web and use same to automatically order another salad dressing from a grocery store). Or, for instance, the computing system may alert the user that a new salad dressing container is needed and/or add a salad dressing container to a grocery list communicated to the user. Alternately, when the imager captures an image of the container **600** in FIG. **6**B, the computing system may determine that ordering of an additional salad dressing container is not yet required. In this way, the label **500**, and specifically the fuzzy field **514** thereof configured to be filled in by a substance (salad dressing in this example), may ensure that the entity maintains the required supply of salad dressing. The artisan will appreciate that containers of salad dressing are but one example, and that the fuzzy field **514** may likewise be used to track the quantity of other substances (e.g., milk in a refrigerator, oil in an oil tank, salt in a salt shaker, ketchup in a bottle, lotion in a tube, lint in a dryer, toner in a printer, etc.).

From time to time, the fuzzy field output may be between two discrete levels, e.g., may be between level **516**(**5**) and **516**(**6**). In embodiments, the computing system may be configured to round the output up or down by ascertaining whether the output is closer to level **516**(**5**) or level **516**(**6**). In other embodiments, an output between two levels may always be rounded up or be rounded down.

The fuzzy field **514** of the label **500** illustrated in FIG. **5** is one dimensional. In other embodiments, the fuzzy field may be two dimensional, three dimensional, etc. FIG. **7** shows a label **700** that is an example of the label **300**. The label **700** has an intrinsic attribute area that contains a fuzzy field **714** arranged as a two dimensional matrix. The illustrated two dimensional matrix has ten rows and four columns **716**A-**716**D.

In embodiments, each column **716**A-**716**D may be adapted to convey the same information and thus provide a mechanism to verify the reading of one of the columns **716**A-**716**D. For example, the label **700** may be placed on the salad dressing container of FIGS. **6**A-**6**C and the computing system may order a new salad dressing container if at least three of the four columns **716**A-**716**D indicate that the salad dressing in the container has fallen below the midway point (or another level). Assume, for instance, that the salad dressing container is generally empty but that a portion of salad dressing is stuck to the container walls, e.g., at level **8** of column **716**A. If the fuzzy field **514** were one dimensional and contained only column **716**A, the computing system may have erroneously determined that the salad dressing in the container is at level **8**, and consequently, no salad dressing would have been ordered. The plurality of fuzzy field columns **716**A-**716**D may ensure that an accurate assessment of the quantity of salad dressing in the container is obtained notwithstanding the faulty reading of column **716**A.

In embodiments, the computing system may be configured to average the readings from the multiple columns **716**A-**716**D, and the decision based thereon (e.g., the decision to order a new salad dressing container) may be based on this average. In other embodiments, integration and time stabilizing techniques may be used to normalize the fuzzy field outputs.

In embodiments, at least two of the columns **716**A-**716**D may be configured to convey different information. For example, column **716**A may be configured to convey an amount of a substance and another column **716**D may be configured to convey whether a trigger condition is met (e.g., whether the temperature is below a certain temperature $T_{trigger(min)}$. The multiple columns **716**A-**716**D may be provided with different colors that are printed using the same or different printing techniques.

FIG. **8**A shows a label **800** that is an alternate embodiment of the label **300**. The label **800** is substantially similar to the embodiment **200**, except as specifically noted and/or shown, or as would be inherent. Further, those skilled in the art will appreciate that the embodiment **300** (and thus the embodiment **800**) may be modified in various ways, such as through incorporating all or part of any of the various described embodiments, for example. For uniformity and brevity, corresponding reference numbers may be used to indicate corresponding parts, though with any noted deviations.

The example label **800** is shown as having a plurality of sections **802**A-**802**L. Each section **802**A-**802**L may be configured to convey distinct information. For example, in the illustrated example, section **802**A conveys that a substance is extremely poisonous, section **802**B conveys that a substance is relatively explosive, section **802**C conveys that a substance is fairly poisonous, and so on. The trigger for each section **802**A-**802**L may (but need not) be the same. In this embodiment, the trigger event may be one that is configured to be applied manually (i.e., the trigger event may be unlikely or impossible to occur on its own). For example, the trigger may be a temperature of 150 degrees Fahrenheit or another such trigger. Each section **802**A-**802**J may initially be transparent, but may become visible when the trigger is applied thereto. For example, FIG. **8**B shows the label **800** in which sections **802**A and **8021** are manually triggered whereas the remaining sections appear invisible to the naked eye.

The manually triggerable sections **802**A-**8021** may allow a user to use the label **800** to convey different information at different times. For example, the label **800** may be placed on a truck that typically carries hazardous materials. If the material currently being carried by the truck is highly poisonous and relatively flammable, only sections **802**A and **8021** may be triggered and the remaining sections may appear blank to the naked eye. Similarly, if a different material is being transported, the appropriate sections may be triggered and the remaining sections may remain deactivated. The warning indicia in each section **802**A-**8021** may be maintained in its changed state using electronics or other means. In order to maintain standards throughout the industry, the Department of Transportation has indicia (or labels) that are acceptable for each potential attribute of a hazardous material. Accordingly, the warning indicia revealed (or activated) for the material may be an approved Department of Transportation indicium (or label) for the particular attribute of the hazardous material in order to avoid confusion.

In embodiments, it may not be necessary for the label to carry machine readable indicia. Rather, the label may be singularly configured to provide meaningful information about an attribute of an object associated with the label to the naked eye. FIG. **10** shows a label **1000** according to an embodiment of the invention. The label **1000** is substantially similar to label **300** except as is shown and described. The label **1000** includes a graphically encoded icon **1010** having a one or more portions **1015***a*, **1015***b*, **1015***c* (generally **1015**), and each portion may include stimuli-responsive particles which may be embedded, for example, in a laminate or other transparent material. In one embodiment, each of the portions **1015** may have a plurality of static programmable electrochromic ("SPEC") non-volatile particles (hereinafter referred to as "SPECink") distributed within the portion **1015** configured to change a particular color upon a triggering event. In another embodiment, each portion **1015** has a SPECink distributed therein, wherein each portion is configured to change to a different color upon a triggering event.

In FIG. **10**, the label **1000** is configured for use on a container for holding leftover food (although the label **1000** may be used on other containers as well, and the container may hold items other than food). Here, the graphically encoded icon **1010** is divided into three portions **1015***a*, **1015***b*, and **1015***c*. Each of the portions **1015***a*, **1015***b*, and **1015***c* is coated (or partially coated, e.g., in a pattern) in stimuli-responsive SPECink particles **1100** (FIG. **11**) that changes a color based on a triggering event. Each of the portions **1015***a*, **1015***b*, and **1015***c* selectively change to a different color based on the triggering event. For example, portion **1015***a* may be selectively green. Portion **1015***b* may be selectively yellow. And portion **1015***c* may be selectively red. Optionally, a central portion **1020** is configured as a display (or user interface) for providing information to a user.

The SPEC particles **1100** may form a non-volatile, semi-permanent SPECink that responds to a stimulus (e.g., electrical, magnetic, etc.) causing the particles to switch between a first colored-state and a second colored-state (e.g., a white-state). The SPECink is considered semi-permanent because, once the SPEC particles have switched, e.g., from the colored-**2** state to the colored-**1** state (or vice versa), the SPEC particles remain in that state until a stimulus (e.g., electrical) causes the SPEC particles to switch to the other state (e.g., from the colored-**1** state to the colored-**2** state). The SPEC particles **1100** may be laminated between layers of film to form the top of the label **1000**. The composite layers contained within label **1000** may allow for scanning modes of operation based on reflective, transmissive, or emitted wavelengths of energy (e.g. reflected light, transmitted filtered light, emissivity of IR thermal energy wavelengths, black-light, electroluminescence, UV, etc.)

In an embodiment, the triggering event is dependent on a predetermined period of time, e.g., the time that the food in the container remains edible. A user may place the label **1000** on the container having the food therein. Pressure sensors disposed within the label **1000** may allow the user to interact with the user interface **1020** to toggle between numbers of days that the particular food may remain in the container (e.g., 2 days, 3 days, 4 days, 5 days, 10 days, 30 days, etc.). Once the user has selected the predetermined number of days that the food may remain in the container, the portion **1015***a* may turn green, and the container may be placed in the refrigerator or cupboard, as the case may be. A timer **1130** (FIG. **11**) disposed within the label **1000** may keep track of the elapsed number of days, and upon reaching the half-life (e.g., 5 days for a label set for 10 days), the portion **1015***a* may switch from the green-state to a white state (or a second colored state), and the portion **1015***b* may switch from a white-state (or a second colored state) to a yellow-state. This readily alerts the user that the food in the container is nearing the end of its edible life. The timer **1130** continues to monitor the elapsed number of days, and upon reaching the predetermined number of days, the portion **1015***b* may switch from the yellow state to the white state, and the portion **1015***c* may switch from the white state (or a second colored state) to a red-state. The user may then readily see that the food in the container is deemed no-longer safe to eat, and the food may be disposed accordingly. The label **1000** may be reusable by simply toggling through the options to reach a "0" day, which may reset the label **1000** for later use.

Optionally, the label **1000** may include a communications module **1125**. The communications module **1125** may be configured to communicate (e.g., via RFID, Bluetooth, near-field communication, or other data exchange function now known or later developed) with the user's phone, or with the refrigerator (e.g., where the refrigerator is configured with a display). For example, at the half-life of the food in the container, the portions **1015***a* and **1015***b* may change as described above, and an alert may additionally be sent to the user's phone to alert the user that the food item is nearing expiration.

In some embodiments, the label **1000** may include one or more sensors **1135** configured to determine the identity of the food in the container (or an attribute about the food in the container). Upon determining the food in the container, the sensors **1135** may transmit the information (e.g., via the communications module) to a processor **1140**, which may access a database **1145** having information regarding spoilage information for a variety of food items. Upon locating the correct food item, the processor may cause the user interface **1020** to display information about the food item (e.g., the number of recommended days for that food item to be stored before spoilage), and the timer **1130** may be automatically set accordingly. In embodiments, the user may be required to confirm the display information by, for example, touching the label **1000** (e.g., one tap indications confirmation, two taps causes the display to begin to toggle through the number of days).

Additional, or alternate, sensors may be incorporated into the label **1000**. For example, temperature sensors, bacteria sensors, humidity sensors, motion detectors, IR sensors, or any other sensor relevant to the environment of the label, whether now known or later developed, may be included as part of the label. The sensors may be configured to determine various attributes about the environment of the label. For example, in embodiments where the label is incorporated into food containers, a bacteria sensor may tell if harmful bacteria is present, or likely to be present (e.g., due to humidity conditions as measured by a humidity sensor). In other embodiments, such as where the label **1000** is placed, for example, on a wall in a bathroom, a bacteria sensor incorporated into the label may detect the presence of bacteria in the restroom. In embodiments, the connection with the communications module **1125** as described above may permit the label **1000** to be configured to provide a dynamic controlled response to eliminate or reduce the bacteria. In such embodiments, an output device, such as a UV-A, UV-B, and/or UV-C light (or other appropriate output device for a particular sensor), which may be configured as part of the label **1000**, or a separate device in communication with the label **1000**, may be activated. Activation of the UV-A, UV-B, and/or UV-C light (or other output device) may thus be triggered based on information received from a sensor. The UV-A, UV-B, and/or UV-C light (or other output device) may remain activated for a predetermined period of time (and thus may also be in communication with the timer). Additionally, or alternately, the UV-A, UV-B, and/or UV-C (or other output device) may be automatically activated after a particular time-lapse and may therefore not be reliant on information from a sensor. For example, in an embodiment where the label is placed in the UV-A, UV-B, and/or UV-C light may be activated at the half-life of a food item to ensure that the food remains healthy for a user to consume. In another embodiment, where the label is placed, for example, on a wall in the bathroom, the UV-A, UV-B, and/or UV-C light, in connection with the timer, may be programmed to activate for, e.g., 5 minutes every hour, 30 minutes between 12:00 a.m. and 1:00 a.m., etc. To prevent harmful ultraviolet rays from reaching humans, a motion detector in communication with the label **1000** may confirm that there are no humans in the room before the UV-A, UV-B, and/or UV-C lights are activated.

Because the power required to cause the particles to switch states is low, a lithium battery **1120** (or other type of battery such as an ultra-capacitor, supercapacitor, or batteries having energy-harvesting capabilities, for example) may be sufficient to cause the electrical stimulus needed to activate the particles. The battery **1120**, communication module **1125**, timer **1130**, other sensors **1135**, processor **1140**, and database **1145** may be (but need not be) embedded in a flexible circuit board **1110** which may be disposed at a backside of the label **1000**, as shown in FIG. **11**. In embodiments, the one or more sensors may be configured as an adhesive layer **1115**. Here, the adhesive may be configured to act as a pressure sensor to allow the user to set the timer as described herein. In an embodiment, the adhesive **1115** may further act as a heater or defroster. The heater or defroster may be configured to defrost a portion of the container to allow the user to see inside of the container. Exemplary adhesives are described in U.S. patent application Ser. Nos. 15/365,923 and 15/678,392, for example.

While the label **1000** is described as being adhered to a container for storing food, it shall be understood that the label **1000** may be configured for other purposes, including placement on freight packaging, shelf displays, etc. The label **1000** may, but need not include computer-readable information as described herein. As will be understood by those of skill in the art, the user interface (via the processor) may be configured to provide information relevant to the environment in which the label **1000** is deployed, and is not limited by the description provided herein.

It shall be further understood that the SPEC particles may be incorporated for use in many additional applications. It shall be clear from the above discussion that the SPEC particles have color changing attributes. The particles may be programmable, reprogrammable, transmissive, reflective, visible within the human visible range, and/or emissive within the infrared and/or ultraviolet spectrums. In embodiments, the particles may be virtually invisible to human viewers in one mode (e.g., an "off" mode) and in another mode (e.g., an "activated" mode) the particles may become visible. In further embodiment, the particles may be incorporated into liquid crystal displays (LCD), light emitting diode (LED) displays, electroluminescent (EL) displays, and/or organic light emitting diode (OLED) displays.

Among other reasons, the SPEC particles having color changing attributes may make the particles particularly useful in human-engaging applications where real-time information and/or safety is key. The SPEC particles may be deposited on virtually any surface. In embodiments, the SPEC particles may be laminated between layers of transparent substrate or film. The resultant substrate having the SPEC particles may be incorporated as, for example, a book cover, a page in a book, or may be inserted into a pocket formed into a folder or book. The SPEC particles may be uniformly deposited, deposited in a pattern, etc. In one embodiment, a plurality of SPEC particles having identical color-changing attributes may be deposited onto or within the substrate (e.g., all particles are a first color in a first mode (a "resting" mode) and a second color in a second mode (an "activated" mode)). In another embodiment, a plurality of a first type of SPEC particles having a first color changing attribute, and a plurality of a second type of SPEC particles having a second color changing attribute, may be deposited onto or within the substrate. The first and second types of particles may be deposited in a particular pattern. Additional types of SPEC particles may optionally be included. As described herein, power to the particles may be provided via a flexible circuit board which may be provided behind the particles, or embedded between layers of particles. The flexible circuit board may have a variety of components (e.g., batteries, memory, processors, communication modules, etc.) as is known in the art. The communication modules may allow the particles to react in response to a remote signal. Consider for example, an embodiment where a plurality of particles is deposited on a substrate that is incorporated into a folder or binder for students in a school. A first portion of the particles may be selectively activated by the student to display the student's favorite color. The substrate (e.g., via the communications module) may be in communication with an alert system at the school. In an emergency situation, the alert system may be activated, and the communications modules of each of the substrates may receive an alert. The alert may cause the first portion of the particles to selectively transition to the "resting" mode (e.g., a color-**2** mode, or a white mode). A second portion of the particles (e.g., being selectively red in an activated state) may then be activated to alert the students to the emergency situation. In embodiments, the particles, in communication with the alert system, may be programmed to provide an instruction message to the students (e.g., "Take cover in closet", "Remain in place", etc.). Optionally, the second portion of the particles may "flash" between the activated state and the resting state to provide the student with a visual, eye catching alert. Thus, emergency situations may be easily, quickly, and quietly communicated to students throughout a school.

Of course, the substrate may be incorporated into various devices within a home, workplace, public destination, outdoor environment, etc. Several further examples are provided below, which are intended to be exemplary in nature only and not intended to be limiting.

In one embodiment, the SPEC particles are incorporated into a paint, SPECink, or adhesive that may be used to provide color changing attributes to, for example, beverage or food containers. For example, consider a traditional Diet-Coke® can. The red ink on the can may be replaced by SPECink comprising the SPEC particles. In a "rest" state, the particles may appear as a red ink, similar to what is shown on a traditional can. Upon activation, however, the particles may "flash" between a colored-**1** state (e.g., red) and a colored-**2** state (e.g., white, or another color). Such flashing may cause attention to be drawn towards the can, providing increased branding recognition. In embodiments, sensors may optionally be distributed at or near the can (or within the ink itself) to measure, for example, the amount of liquid in the can. When the can is full, the particles may show the ink in a "rest" state. As the contents in the can are depleted, the particles may begin to flash, for example, slowly at first, and more quickly as the can approaches emptiness. Thus, in a retail environment, it may be possible for a waiter to quickly and easily tell whether a customer is in need of another drink (e.g., similar to the fuzzy field graphically encoded icons described above) while the user sees an aesthetically pleasing and intriguing can exterior.

Similarly, the particles may be distributed, for example, on the outside surface of a flower pot (e.g., as a paint). Moisture sensors may also be distributed at or near the flower pot. As the water evaporates leaving the plant dry (as measured by the sensors), the particles may begin to flash between a colored-**1** state and a colored-**2** state. In embodiments, the sensors may be distributed along a vertical line in or on the pot. As the water evaporates, the sensors may cause the particles to switch from a colored-**1** state to a colored-**2** state. The sensors may be pre-programmed to cause the particles to switch at a predetermined moisture content (e.g., at or below 10% moisture) Therefore, a viewer may be able to readily tell the moisture content of the soil in the pot, and may thus provide water. In certain embodiments, a plurality of particles having different colored-**1** and colored-**2** states may be deposited on the pot (e.g., different shades of green). When the moisture content is at 100%, a first particle may be activated to show the pot as, for example, Kelly green. As the moisture content decreases, the first type of particles may be deactivated (e.g., flip to a colored-**2** state, such as white or black) and a second-type of particle may be activated, thereby changing the apparent color of the pot.

In another embodiment, the SPEC particles may be utilized as a paint, SPECink, distributed within a film, or laminated within a substrate for use on displays such as road signs or traffic cones. Of course, other displays (e.g., store displays) may additionally utilize such particles to draw attention to a particular product, sale, etc. Here, portions of a display, such as a road sign, may have particles distributed in a pattern known to drivers. For example, consider object markers used on the road today (road signs having a yellow background with black diagonal stripes). Here, particles may be programmed such that in a first state, the particles distributed in the traditionally yellow section are viewable to the user as "yellow" and the particles distributed in the traditionally black section are viewable to the user as "black." When the particles are activated (e.g., via a temporal sensors, light sensors, etc.), the particles in the traditionally yellow section may flash to black, and the particles in the traditionally yellow section may flash to yellow. The flashing may occur in succession for a predetermined period of time. Similarly, a stop sign may be configured to flash between white and red. In embodiments, it may be particularly useful if the particles have a reflective attributes. Thus, attention is drawn to traffic signals such that drivers may be made increasingly aware of the hazard or instruction.

In still another embodiment, the particles may be utilized as a paint, ink, distributed within a film, or laminated within a substrate for use with tiles (e.g., floor tiles, tiles for a counter top, etc.). This may be particularly useful in retail environments (e.g., grocery stores) where hazards may occur that are not readily identifiable by shoppers. For example, a substrate having the particles dispersed therein may be a layer of a tile. The tile may include one or more of a variety of sensors (e.g., moisture, bacteria, temperature, etc.). In an embodiment, the tile is configured for use on a floor. Moisture sensors disposed on or within the substrate may detect when a spill is affecting a particular tile. If the sensor detects that there is moisture on the tile, the particles in the substrate may change from a colored-**1** state to a colored-**2** state to alert customers that the tile is not safe and that an alternate route should be taken. In another embodiment, the tile is configured for use on a countertop. Here, bacteria sensors disposed on or within the substrate may detect the presence of harmful bacteria. If the sensor detects that there is harmful bacteria, the particles in the substrate may change from a colored-**1** state to a colored-**2** state to alert the user that the tile is not safe and that the tile should be thoroughly cleaned. Optionally, when the bacteria sensor identifies the presence of harmful bacteria, a bacteria-killing light (e.g., UV-A, UV-B, and/or UV-C, which may be a part of the substrate or remotely positioned such that the light contacts the substrate, for example, under the upper cabinets) may be activated to remedy the situation.

The floor tiles may include sections of sidewalks at intersections (e.g., the corner sections). The particles may be distributed to provide information to a user such as to flash red if it is not safe to cross the road, or to provide direction indicators (e.g., arrows). In some embodiments, the sidewalks may include additional programmable smart material particles, such as particles configured to heat up (e.g., so as to melt snow at busy cross-sections).

It shall thus be understood that the particles may be utilized in a variety of different applications, and further non-limiting applications include use with fishing lures, as an additive to nail polish, on shoes, purses, sunglasses, sportswear, military gear, and other fashion forward items, in building materials such as wall-paint, on baseboards, on doors, shingles, etc. The particles may additionally be utilized to program machine readable indicia on the graphically encoded icons described herein.

For example, consider again FIGS. **3**A, **4**A, **4**B, **5**, **6**A-C, **7**, as well as FIGS. **12** and **13**. FIGS. **12** and **13** represent exemplary configurations of graphically encoded icons **600** having a non-rectangular shape. Within the graphically encoded icons **600** are machine readable sections **610** having areas of programmability. Here, the dark-colored dots are arranged in a pattern so as to provide information about an object to which the graphically encoded icon **600** is attached. The dots are areas of SPEC particles that are "activated" (i.e., turned to a color state), and the white areas likewise correspond to areas of SPEC particles that are "deactivated" (i.e., turned to a white state). The black dots can be "deactivated" and one or more portions of the white area can be "activated" from time to time in order to convey updated information about the object. For example, on a shipping pallet the information may be updated to provide each location where the pallet was loaded or unloaded onto a carrier, the length of time spent at each location, the parties involved in the transaction, etc. Accordingly, the graphically encoded icons can dynamically provide information to a user.

Thus it is clear that graphically encoded icons can be encoded in several modes, including passive, proactive, and dynamic. The graphically encoded icons allow for readings of attributes about an object (e.g., container, surface, or system) which can be presented as geometrically predictable and decodable icons, images, or patterns in order to express qualitative and/or quantitative data. The SPEC particles may be configured to form lattice or lattice-work structures that can be formed into the geometric shapes forming the graphically encoded icons. In embodiments, the lattice-work can be programmed to form a structural array of elements (or node particles) that can be formed in one-, two-, or three-dimensional groupings.

While prior art systems provide means by which information can be presented to, and encoded by, humans and machine, such information is limited to numerical strings. However, in certain applications, it may be important for the information to convey not a number, but an actual attribute of the product or item that one is attempting to encode for scanning purposes by an observer. For example, and similar to the dressing container described above, a salt shaker (FIG. **14**) on the table may contain a label that has a vertical gradient pattern that resembles industry standard bar code patterns. There may be a desire to scan intrinsic attributes related to the contents of the salt shaker container. The fields of information (e.g., the area in which the black dots occur) may be structured and encoded in such a manner that the level and contents of the salt shaker can be qualitatively examined by a scanning and decoding system without digitally acquiring the content level of the container. In this example, the white salt may contrast against a darker printing of a graphically encoded icon "frame" that is strategically placed onto the container. The mixed-mode of quantified data fields, along with qualified fuzzy fields (or analog data—the area in which one can see through the container and into the contents of the container) may be advantageous when the goal is to read naturally occurring physical attributes. The patterns and placement of the graphically encoded icon frame may increase the probability of decoding a reliable reading of the fuzzy fields.

In embodiments, a scanning voting system such as a simple 3-of-5 reading and scoring system may be employed to improve reliability of the scanned data. If the fuzzy fields yield varying results over time via multiple scans, in embodiments, a computing system may average and/or accept the more prevalent result of the fields that are scanned. These techniques may assist in reliability for qualitative fuzzy fields and increase reliability of scanned quantitative fields. A quantitative field may be one that is fixed (e.g., is in one of two states). In embodiments, reliability may be enhanced by a mathematical cross-checking system such as checksums, CRC, etc.

Qualitative fields may be enhanced in reliability by comparing sets of analog data in adjoining contiguous fuzzy fields such as a gray-scale reading of the salt shaker in a vertical range of the graphically encoded icon overall frame. The relative readings of analog grayscale (and/or, in embodiments, colors in RGB) may assist in finding the specific granularity of reading the content layer of salt. This may allow anomalies such as dirt or other data-noise to prevent false readings. In embodiments, it may be desirable to exclude the fuzzy fields from the mathematical calculations that are used to validate the quantitative fields.

Multiple versions of the encoded data set may be made available to the observer during scanning and decoding. One version of information (e.g., passive) may be a strictly digital and quantitative perspective that excludes the fuzzy bits entirely. Another version (e.g., proactive) may include all bits and fields but the fuzzy bits are triggered by a 50% (or other level) decision of logic for their data result for each fuzzy field. A more advanced mode (e.g., dynamic) may incorporate one or more of the techniques above such as multiple scan, voting, and CRC error detection and correction. In an embodiment, the computing system in a RAW mode stores an image of the overall icon for further processing; this data may be sent to the cloud for processing and system level analysis.

A passive mode graphically encoded icon may be as simple as a line that has markings at measurable points along a line. The quantified data represented by the graphically encoded may be a wider marking at a certain location along the line as compared to the other unit markings along the line. FIGS. **15** and **16** below provide examples of a one dimensional and a two dimensional graphically encoded icon, respectively. In FIG. **15**, the graphically encoded icon can be read as number 8. In FIG. **16**, the graphically encoded icon can be read as a series of numbers 3, 5, 8, 11.

In embodiments, multiple dimensions may exist with different colors or varied printing techniques that reflect based on excitation wavelengths of light or energy waveforms (such as radio frequencies (RF)). Focal lengths may be used to increase the perceivable and recognizable dimensions of graphically encoded icon recognition.

Quantitative data encoding may yield specific information in the form of numerical values that can be mathematically validated. This may be in the form of checksums, CRC algorithms, or other techniques such as redundant bit stuffing relying on statistical probability to yield a resulting probable error percentage in GEI data decoding. These techniques are generally used for error detection or data field validation. However, one of the major benefits beyond Error Detection when encoding quantitative (or digital) data may be the potential ability to provide Error Correction to fields of data (rows, columns, shapes, lines, dashes, etc.) where a questionable reading has occurred.

In embodiments, qualitative or fuzzy logic data may be encoded intentionally or naturally based on material properties. An example of qualitative data (or fuzzy bits) may be an observer examining the scratched part of the CD and reporting the "best guess" of whether the scratched portion should be replaced by a one or a zero. Another example would be a sequence of encoded numbers for 1, 2, 3, 4, and 5, but the observer reads 1, 2, 3, ?, 5. If the observer takes several readings and the questionable data field is close to "4" then four is likely the correct answer. This would be a case of a qualitative review for consideration as a resolution to the fuzzy field of data.

As described above, smart materials such as SPECink, may be utilized to exist on or within a substance (or structure) in such a way that can create a grid or pattern of graphically encoded icon fields. Each area of SPECink may be switchable to be dark or light based on a desired state of information for a graphically encoded icon field. In an embodiment, a graphically encoded icon field or group of fields may change color based on vibration, exposure to bacteria, moisture, aging, etc. These fields may generally be envisioned as fuzzy fields. However, in some cases the natural function and reliability of programmable matter may be deterministic and viewed as pseudo-digital (i.e., it can be reliably read as "on" or "off" with minimal unknown status). In these cases, the encoding system may treat such fields as qualitative but highly reliable. Or, in advanced systems, the error detection and correction calculations may have an active mode that changes a checksum field state based on intrinsic field fuzzy readings or trigger levels. In embodiments, integration and time stabilizing techniques may be used to normalize the fuzzy field trigger decisions.

One of the limitations of data acquisition and collection is the limited number of access points throughout the universe and on planet Earth today. Current methods strive to apply blanket coverage of ubiquitous access points of data collection opportunity to allow an overlapping mesh grid for SCADA and IoT communication globally. However, it is important to note that graphically encoded icons (or encoded patterns) can be utilized in nearly any environment to provide information to a user. In embodiments, roadways may have surface patterns that include or resemble a QR code that contains some fixed quantitative graphically encoded icon fields, while other fields may comprise programmable particles within the asphalt or concrete itself.

One goal of graphically encoded icon usage in the mass deployment and intrinsic mode is to allow many mobile collection nodes (e.g., cameras, phones, cars safety systems, roadway traffic scanners, energy management systems, self-driving highway systems, etc.) to scan at will through opportunistic free-will. This concept may be encoded beyond just the structure of the graphically encoded icon field shapes and purposes. In an embodiment, one goal is to setup fields on the graphically encoded icon patterns in such a way as to attract an observer to scan many graphically encoded icon images into a device that is at a known physical location, at a known time, from a known entity (e.g., machine, person, system, etc.). The scan may encode an end-node identifier for itself and a routing target destination (i.e. www.ioTwebpaae.com) but append with supplemental fields of information such as sensor readings, trending data alerts, and requests to the higher level system.

Data resulting from the user's scan may include post critical and intrinsically available data along with location, time, and locally important data/alerts. The user may then receive a resulting webpage including information about the area he is visiting or a coupon for the closest restaurant. The combination of multi-purpose media and network usage along with redundant network scanning reinforcement may provide hundreds of readings each day to the same end-nodes for data collection purposes. Additionally, there may be a back-channel such as localized Bluetooth or WiFi that provides a limited link for data to be returned to the end-node while the user is nearby in the scanning session. This may all occur in real-time as a user's car drives by a specific mile marker on the highway.

Mass scanning of end-nodes from multiple opportunistic network taps may enhance security and provide a more stable access path to millions of end nodes. Furthermore, the fuzzy intrinsic fields may be resolved more reliably with multiple devices and network access methods being utilized in real-time. The concept of "data analytics in the cloud" may be realized more easily with such a mass collection system as opposed to a massive web-mesh system. All of these techniques may be used interchangeably.

Security may be enhanced by providing fragments of data that have limited perspective and may be encrypted in a rolling system over time and contain different encryption keys, methods, and data stuffing techniques per end-node. By positioning hundreds of data fragments on varying networks and having obscure purpose for each node, the data itself can become very benign. Furthermore, the output for the user can evolve to be socially appealing and the data backchannels may become essentially seamless, and extremely low-cost to operate.

In embodiments, groupings and distribution of multiple graphically encoded icon patterns as an array or composite set may be useful to create patterns that are duplicating and replicated based on the scale (or zoom level) of the observer. Techniques such as fractal encoding may be used to create repeating patterns over scale zoom levels that can help with broad phase alignment, authentication, and decoding synchronization.

Patterns of graphically encoded icons may be planar or 3D geometrically shaped such as a sphere or buckyball polygon with three-dimensional distribution of fields (e.g., FIG. **17**). Distribution of planar fields on a three-dimensional multi-planar surface such as a sphere (or geodesic dome) may create a concave or convex distribution of planar fields. The embedded and encoded geometric patterns may be used to enhance the planar integrity of the graphically encoded icon, or graphically encoded icons within the three-dimensional space. Mathematical techniques may be used to adjust and correct the perspective of planar distortion and implied or inferred geometric patterning. Individual data fields may also contain geometric patterns or shapes within one-dimensional, two-dimensional, or three-dimensional perspective, and may not need to be a specific dot in space. Thus, a data field may actually be a subset of a fractal encoded environment.

Data field elements within the graphically encoded icon may be passive such as reflective or transmissive of a particular color or pattern. Each data field may also contain a geometric shape or pattern of motion or attribute that changes over time. An example of this could be a specific data field that is a resonant molecule or cluster of molecules that is vibrating or rotating at a specific vibration or resonant frequency pattern (including harmonics).

Graphically encoded icons can be utilized with systems within the macro-, micro-, and/or nano-scale. An example of a nanoscale implementation may include an outer definition of the graphically encoded icon geometry made up of carbon nanotubes that could contain a distribution or lattice of C-60 (i.e., Buckyballs) that could encode a specific pattern of data wherein the Buckyballs create the individual data fields and a three-dimensional perspective may be represented through the resonance or vibration of regionally positioned carbon molecules.

A macroscale implementation may have galactic applications. Imagine a distribution within a galaxy of pulsars where the pulsars are the encoded data field positions within the graphically encoded icon pattern. Each pulsar may be transmitting a series of information beacons by varying their magnetic rotation or position including color or radiation pattern. The combination of static fields such as star positions of particular color temperature may be used to identify orientation and position of the graphically encoded icon while the individual data fields may be encoded as a composite of the information intended to be decoded by the viewer. A simple example would be multiple pulsars that are transmitting different bits of information such as the one's place is transmitted by Pulsar A, the two's place is transmitted by Pulsar B, and the four's place is transmitted by pulsar C. The synchronicity of the informational asynchronous composite of graphically encoded icon(s) may provide complex information transmission that can be sampled over time by the viewer.

A more micro perspective could be a segment of magnetic tape that contains a two-dimensional grid of magnetic particles such as ferric oxide that contain a gradient of electromagnetic poles similar to a magnetic strip or magnetic audio tape. But in the graphically application, there may be a fixed position of two-dimensional geometric patterns that can be scanned without requiring a sequential swiping of the tape itself. Each magnetic particle can become a graphically encoded icon data field, while the composite of the magnetic pattern can make up the graphically encoded icon geometric definition or shape.

Moving on, FIG. **9** is a functional block diagram of a computing system **900** which may be used to implement the various graphically encoded icon embodiments according to the different aspects of the disclosure. The computing system **900** may be, for example, a smartphone, a laptop computer, a desktop computer, a flexible circuit board, or other computing device whether now known or subsequently developed.

The computing system **900** includes a processor **902**, a memory **904**, a user interface **906**, a communication module **908**, and a dataport **910**. These components are communicatively coupled together by an interconnect bus **912**. The processor **902** may include any processor used in smartphones and/or other computing devices, including an analog processor (e.g., a Nano carbon-based processor, magnetic, photonic, pneumatic, hydraulic, thermal, convection, biochemical, gravimetric, etc.). In certain embodiments, the processor **902** includes one or more other processors, such as one or more microprocessors, and/or one or more supplementary co-processors, such as math co-processors.

The memory **904** may include both operating memory, such as random access memory (RAM), as well as data storage, such as read-only memory (ROM), hard drives, optical, flash memory, or any other suitable memory/storage element. The memory **904** may include removable memory elements, such as a CompactFlash card, a MultiMediaCard (MMC), and/or a Secure Digital (SD) card. In certain embodiments, the memory **904** includes a combination of magnetic, optical, and/or semiconductor memory, and may include, for example, RAM, ROM, flash drive, and/or a hard disk or drive. In embodiments incorporating SPEC particles, memory may include the visual aspects of the color change itself (e.g., the particles remain in a colored-**1** or colored-**2** state until stimulated into another state). The processor **902** and the memory **904** each may be located entirely within a single device, or may be connected to each other by a communication medium, such as a USB port, a serial port cable, a coaxial cable, an Ethernet-type cable, a telephone line, a radio frequency transceiver, or other similar wireless or wired medium or combination of the foregoing. For example, the processor **902** may be connected to the memory **904** via the dataport **910**.

The user interface **906** may include any user interface or presentation elements suitable for a smartphone and/or other computing device, such as a keypad, a display screen, a touchscreen, a microphone, and a speaker. The communication module **908** is configured to handle communication links between the computing system **900** and other, external devices or receivers, and to route incoming/outgoing data appropriately. For example, inbound data from the dataport **910** may be routed through the communication module **908** before being directed to the processor **902**, and outbound data from the processor **902** may be routed through the communication module **908** before being directed to the dataport **910**. The communication module **908** may include one or more transceiver modules configured for transmitting and receiving data, and using, for example, one or more protocols and/or technologies, such as GSM, UMTS (3GSM), IS-95 (CDMA one), IS-2000 (CDMA 2000), LTE, FDMA, TDMA, W-CDMA, CDMA, OFDMA, Wi-Fi, WiMAX, BLE, 5G-IoT, or any other protocol and/or technology.

The dataport **910** may be any type of connector used for physically interfacing with a smartphone, GEI (graphically encoded icon) reader **914**, and/or other device, such as a mini-USB port or an IPHONE®/IPOD® 30-pin connector or LIGHTNING® connector. In other embodiments, the dataport **910** may include multiple communication channels for simultaneous communication with, for example, other processors, servers, and/or client terminals.

The GEI reader **914** may be in data communication with the computing system **900**. The GEI reader **914** may be a scanner, such as one-dimensional barcode scanner, an imager, or other reader that allows for the various graphically encoded icons discussed herein to be read by the computing system **900** for decoding.

The memory **904** may store instructions for communicating with other systems, such as a computer. The memory **904** may store, for example, a program (e.g., computer program code) adapted to direct the processor **902** in accordance with the present embodiments. The instructions also may include program elements, such as an operating system. While execution of sequences of instructions in the program causes the processor **902** to perform the process steps described herein, hard-wired circuitry may be used in place of, or in combination with, software/firmware instructions for implementation of the processes of the present embodiments. Thus, unless expressly noted, the present embodiments are not limited to any specific combination of hardware and software.

In embodiments, the memory **904** may include software **905**. The software **905** may contain machine readable instructions configured to be executed by the processor **902**. The software **905** may, e.g., process data obtained from the GEI reader **914**. In embodiments, the software **905** may cause the computing system **900** to dynamically respond to a reading obtained by the GEI reader **914**. For example, the software **905** may order an item based on a reading obtained by the GEI reader **914**. Alternately or in addition, the software **905** may round up, round down, integrate, stabilize, average, and/or otherwise mathematically manipulate the outputs of the various fuzzy fields. The software **905**, e.g., one or more modules thereof, may also be used for error correction.

The computing system **900** may be in data communication with a remote storage **916** over a network **917**. The network **917** may be a wired network, a wireless network, or comprise elements of both. The remote storage **916** may be, e.g., the "cloud" or other remote storage in communication with other computing systems. In embodiments, data (e.g., readings obtained by the GEI reader **914** and the dynamic responses of the computing system **900** thereto) may be stored in the remote storage **916** for analytics.

While graphically encoded icons are described above as a separate physical embodiment such as a label, coating, paint, etc., it shall be understood that a graphically encoded icon is more broadly a collection of visually identifiable matter (or energy fields) that can be used to observe meaningful information about an object, an assembly of objects, etc. Graphically encoded icons may therefore also be naturally occurring (e.g., patterns that occur naturally on/in an object, waveform patterns, anomalous biological cells, traffic patterns, antenna arrays, thermal scans, etc.) and may occur in clusters that are identifiable at a smaller scale but provide information about a larger scale assembly of objects.

Accordingly, graphically encoded icons may be incorporated into a broader scanning and surveillance system that gathers information directly from an object itself acting as the graphically encoded icon, or from the object in conjunction with a physically separate graphically encoded icon, such as the labels described herein. The graphically encoded icons may be recognizable and readable via video surveillance systems. Video surveillance systems are known in the art. Over time, video surveillance has evolved from the use of low-resolution, fixed focus, fixed focal-length cameras to fully adaptive intelligent pan-tilt-zoom 360 degree domes. The flexibility of multidimensional scanning systems (e.g. advanced surveilling equipment) can be utilized to perform visual identification of people, animals, vehicles, inanimate fixed position objects, and complex moving objects that are moving in unpredictable manners.

Combining surveillance and scanning technologies may provide a universal scanning system that can operate in multiple dimensions and identify subjects including individuals (and attributes of the individual), animals, and objects in a location (e.g., building materials in a particular location). Scanning of uniquely identifiable shapes (e.g., GEIs) and movement trending data (e.g., movement of individuals and/or animals) can yield a complete spectrum of indicators the can be used to identify the presence, location, and meaning of all subjects being scanned.

In scanning for information, varying abilities to focus, zoom, and planar alignment can yield unreliable and unpredictable image information on a single scan which can be improved by providing clearly identifiable graphical indicators of a coarse nature as well as redundant repetitive image icons that occur at varying scale-levels. For example, the repeating pattern of a specific shape within other smaller scale shapes (e.g., fractal geometry) can be a trigger for recognizing a pattern that is out of frame from the observer's view to provide particular (e.g., redundant, preemphasis, forward error correction, cyclical error detection, encrypted, cross-media data striping, etc.) information about a subject. These techniques, as well as mathematical predictive techniques, can be used to provide rapid and reliable recognition of image intelligence. The net result of stacked and scaled patterns can yield localized quantified results that contain the same statistical character as the whole graphically encoded icon at varying zoom levels as well as partial field view graphically encoded icon observation. For example, when observing a full-frame image of the whole graphically encoded icon, the observer may identify a pattern of apparent black and white dots. However, if the observer where to zoom-in (or angularly align) on a particular dot pattern within the graphically encoded icon, it may become clear that there is finer granularity (e.g., resolution) imagery contained within the dot itself. Furthermore, it is possible that the dot image may contain a micro-scaled (or macro-scaled, subset, superset) version of the entire content imagery of the graphically encoded icon itself. These scaled and optionally redundant patterns may repeat in scale to many levels that grow into macro, micro, and nano-scale. These techniques of encoding may be utilized to provide ease of identification, authentication, security validation, encryption, and minimized re-scanning of the graphically encoded icon. It is important to note that strategic encoding techniques within a dot pattern (e.g., internal content(s) within a graphically encoded icon image or dot) can be utilized to encode intentional averaging of gray-scale, color, or thermal imagery as an integrated view by a coarse wide-angle (e.g., low resolution) observation. This means that the dots or apparent image attributes may appear as simple resolvable dots but may contain multiple layers (e.g. multiple dimensioned arrays) of complex composite information within each apparent dot.

By utilizing and exploiting natural and unnatural patterns in a recursive pattern of shapes the encoded information can be packed in such a way as to provide scalable decoding at various zoom levels, angular planar views, and focus levels. Information encoded in geometric patterns that are fractal encoded (or other recursive patterns) can exploit shapes that either are naturally occurring in nature or are not naturally occurring in nature to encode and modulate recognizable patterns related to the intelligence of information encoded within the composite shapes (e.g. GEIs). Shapes and geometric patterns may be enhanced or accentuated utilizing reinforcing waveform and media types such as varying colors, wavelengths of transmissive and/or reflective materials, magnetic, radioactive, thermal, electrical, and physically oscillating materials (e.g. quartz crystals), fluorescing materials (biological films, bacteria, etc.), position changing actuators, magnetic tape, laser reflection (CD-ROM/DVD like surfaces), etc. Geometric shaped encoding methods may be used to allow a GEI to become mathematically resolvable in order to correct for non-ideal focal lengths, planar alignment, and non-ideal image framing.

In embodiments, the full implementation of a scanning system could thus provide the ability to provide scanning, surveilling, dissecting, categorizing, decoding, and resolving of all subjects (or selected category of subjects) within an observer's (or scanning device's) field of view in the system. Optionally, the observed subjects can be superimposed with unique identifying markers known as 3D spatial markers. The marking content can be graphical in the form of iconic encoded information that is identifiable by scanning algorithm methods.

Thus, as has been described, the graphically encoded icons disclosed herein may represent a significant advance over the traditional machine readable indicia embedded in one dimensional, two dimensional, multi-dimensional and other such barcodes. Many different arrangements of the various components depicted, as well as components not shown, are possible without departing from the spirit and scope of the present invention. Embodiments of the present invention have been described with the intent to be illustrative rather than restrictive. Alternative embodiments will become apparent to those skilled in the art that do not depart from its scope. A skilled artisan may develop alternative means of implementing the aforementioned improvements without departing from the scope of the present invention. Not all steps listed in the various figures need be carried out in the specific order described.

The invention claimed is:

**1**. A graphically encoded icon, comprising:

a label attached to an object, the label comprising a static portion and an intrinsic portion;

wherein:

the static portion comprises static machine-readable indicia;

the intrinsic portion comprises a first area comprising a stimuli-responsive material, and a second area comprising stimuli-responsive material;

the stimuli-responsive material is configured to change from a first state to a second state in response to a trigger, the change in state being based on an attribute about the object;

the change in state of the stimuli-responsive material in the first area is semi-irreversible; and

the change of state of the stimuli-responsive material in the second area is reversible.

**2**. The graphically encoded icon of claim **1**, wherein the change in state of the stimuli-responsive material of at least one of the first area and the second area results in machine-readable indicia.

**3**. The graphically encoded icon of claim **1**, wherein the change in state of the stimuli-responsive material of at least one of the first area and the second area results in human readable indicia.

**4**. The graphically encoded icon of claim **1**, wherein the change in state of the stimuli-responsive material of at least one of the first area and the second area is a change in reflection of the stimuli-responsive material.

**5**. The graphically encoded icon of claim **1**, wherein the change of the stimuli-responsive material of at least one of the first area and the second area is state is a change in the transparency of the stimuli-responsive material.

**6**. The graphically encoded icon of claim **1**, wherein the trigger is a change in temperature, wherein the trigger occurs when the change in temperature is above a predetermined threshold.

**7**. The graphically encoded icon of claim **6**, wherein the label is placed on a container for a food item, and wherein the predetermined threshold is based on a safe handling temperature of the food item.

**8**. The graphically encoded icon of claim **7**, wherein the change in state of the stimuli-responsive material of at least one of the first area and the second area results in human readable indicia, wherein the human readable indicia indicates that the food item is one of safe for consumption or unsafe for consumption.

**9**. The graphically encoded icon of claim **1**, wherein the trigger occurs automatically based on a predetermined condition.

**10**. The graphically encoded icon of claim **1**, wherein the trigger is manual.

**11**. The graphically encoded icon of claim **10**, wherein:

the object is a container for hazardous material;

the attribute is at least one of a hazardous material attribute selected from the list consisting of: flammability, toxicity, corrosiveness, combustibility, explosiveness, and radioactivity; and

the change in state of the stimuli-responsive material of at least one of the first area and the second area in response to the trigger reveals an indicia indicative of the hazardous material attribute.

**12**. The graphically encoded icon of claim **11**, wherein the indicia is a Department of Transportation approved indicia for the hazardous material attribute.

**13**. A graphically encoded icon, comprising:

a label attached to an object, the label comprising a static portion and an intrinsic portion;

wherein:

the static portion comprises static machine-readable indicia;

the intrinsic portion comprises a first area comprising stimuli-responsive material and a second area comprising stimuli-responsive material, the stimuli-responsive material being configured to change from a first state to a second state in response to a trigger, the change in state being based on an attribute about the object;

the change in state of the stimuli-responsive material in the first area results in machine-readable indicia; and

the change in state of the stimuli-responsive material in the second area results in human readable indicia.

**14**. The graphically encoded icon of claim **13**, wherein the change in state of the stimuli-responsive material of at least one of the first area and the second area is a change in reflection of the stimuli-responsive material.

**15**. The graphically encoded icon of claim **13**, wherein the change of the stimuli-responsive material of at least one of the first area and the second area is state is a change in the transparency of the stimuli-responsive material.

**16**. The graphically encoded icon of claim **13**, wherein the trigger is a change in temperature, wherein the trigger occurs when the change in temperature is above a predetermined threshold.

**17**. The graphically encoded icon of claim **16**, wherein the label is placed on a container for a food item, and wherein the predetermined threshold is based on a safe handling temperature of the food item.

**18**. The graphically encoded icon of claim **13**, wherein the trigger occurs automatically based on a predetermined condition.

**19**. The graphically encoded icon of claim **13**, wherein the trigger is manual.

**20**. The graphically encoded icon of claim **19**, wherein:

the object is a container for hazardous material;

the attribute is at least one of a hazardous material attribute selected from the list consisting of: flammability, toxicity, corrosiveness, combustibility, explosiveness, and radioactivity; and

the change in state of the stimuli-responsive material of at least one of the first area and the second area in response to the trigger reveals an indicia indicative of the hazardous material attribute.

**21**. The graphically encoded icon of claim **20**, wherein the indicia is a Department of Transportation approved indicia for the hazardous material attribute.

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